Chapter One

Introduction

1.1 Background to the Study

Schistosomiasis, a neglected tropical disease (NTD) is the second most devastating parasitic disease, causing significant morbidity and mortality worldwide [1]. It is most widespread across the world's tropical regions, mainly Sub-Saharan Africa. In the recent past, it has also been observed in the Caribbean, South America, the Middle East, and Asia [2]. Schistosomes' larvae develop into adult Schistosomes in the human body. Adult worms live in the blood vessels, where the females produce ova while some eggs of the parasite are expelled in the faeces or urine, continuing the parasite's life. Others become trapped in the body tissues, producing immunological reactions and organ damage[1]. There are two significant forms of schistosomiasis: intestinal and urogenital, which are caused by five distinct types of blood fluke: *S. haematobium, S. mansoni, S. japonicum, S. mekongi* and *S. intercalatum.* The first three pose serious public health concerns and each of the species differs in the diseases they cause and in their geographical distribution [3].

Transmission of the infection requires freshwater snails as intermediate host; therefore, the disease thrives in regions with poor sanitation and hygiene, poverty, especially where rivers, lakes, and irrigation schemes supporting its transmission are abundant [4]. Inadequate basic social amenities, primary health-care, and poor infrastructure contribute significantly to the spread of schistosomiasis in Nigeria and control measures have been ineffective due to a lack of comprehensive information on the disease distribution [5].

Globally, about 779 million people are said to be at risk of schistosomiasis, with 207 million infected with the disease [6]. Africa alone accounts for more than 85% of all infections and

Nigeria has the greatest number of persons infected with or at risk of schistosomiasis (29 million people are infected among which 16 million are children and around 101 million people are at risk) [7]. Urinary schistosomiasis is endemic in Nigeria with substantial transmission in most states of the federation. Though remarkable progress has been made in the effort against urinary schistosomiasis, this disease persists among vulnerable populations in the country. The South-western part of Nigeria appears to be most affected with prevalence ranging from 44.8-71.5% in endemic areas of Osun and Ogun states [3]. This infectious disease still ravages many rural communities because of ignorance and inability to identify and treat it [8]. Moreover, the under-reporting and focal clustering of this disease further makes the accurate enumeration of the disease burden difficult [9].

Schistosomiasis is more common among school-age children (SAC) because of their lack of hygiene and certain play habits such as swimming or fishing in infested water which make them especially vulnerable to the infection [1]. The presence of freshwater bodies often used for recreational activities such as swimming, bathing and agricultural activities including fishing, irrigation for farming purposes makes children in Otamokun, Ogo-Oluwa LGA particularly vulnerable to schistosomiasis.

The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015 is a universal call to action, to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. These 17 SDGs are integrated as they recognize that action in one area will affect outcomes in the other areas. Goals 1: No poverty, 3: Good health and well-being, 6: Clean water and sanitation and 9: Industry, innovation and infrastructure are principally related to schistosomiasis [10]. Furthermore, in 2021, the World Health Organization (WHO) launched a new road map for 2021-2030 that aims to end the suffering

from NTDs by 2030, in line with the SDGs. The road map specifically targets the elimination of schistosomiasis as a public health problem, globally. This roadmap provides evidence-based recommendations in these areas: prevalence thresholds, target age groups and frequency of preventive chemotherapy (PC), establishment of WASH and snail control activites [11].

1.2 Statement of the Problem

Nigeria is the world's most endemic country for schistosomiasis and has up to 20 million people who require schistosomiasis preventive chemotherapy [4]. Prevalence can be as high as 70% in school children (SAC) and 20% in a population previously assumed to have low-risk[9]. *S. haematobium* is more common in Southern Nigeria while *S. mansoni* variant is more common in Northern Nigeria but, the third species, *S. intercalatum* is uncommonly reported and often confused with *S. haematobium*[5]. For the overall burden, schistosomiasis is Nigeria's second most parasitic infection but, Nigeria unlike Brazil and China lacks National Reference laboratories for diagnosis. Therefore, monitoring current transmission foci for schistosomiasis and accurate MDA evaluation in the country is difficult [6]. So even though, several efforts have been directed towards schistosomiasis control since the World Health Assembly (WHA) Resolution in 2001, transmission has been continuous [6].

Notably, Nigeria has a mass drug administration (MDA) coverage index of 74% and is on track to fulfilling the minimum 75% threshold set by the World Health Organization (WHO) for endemic countries [7]. Inspite of this commendable achievement, schistosomiasis appears to be a disease that Nigeria will have to still contend with for at least another decade [6]. In Nigeria, the MDA may not produce long-term effects for various reasons; firstly, some parts of the country fail to adhere to the WHO treatment guidelines. For instance, in south-western

Nigeria, visible hematuria is often used to guide MDA in some cases but this inevitably leaves a considerable proportion of children with covet infection untreated. Also, suboptimal dosages were given in some centers with no weighing scale or praziquantel (PZQ) dose pole to calculate the ideal treatment dosage for the individuals [6]. With decades of ongoing MDA not yielding the desirable result, adequate water supply, and an understanding of the social context within the community contributing to transmission may provide a long-term solution[6]. According to the 2021 Water Sanitation and Hygiene National Outcome Routine Mapping (WASH-NORM) estimates, only 10% of Nigerians have access to basic water, sanitation, and hygiene services. Two-thirds (67%) use basic drinking water services, less than half (46%) use basic sanitation facilities and 48 million people (23%) still practice open defecation [11]. In Oyo State, more than three-quarters (79%) had access to basic water supply services but, less than one-third (29%) had access to basic sanitation service [11]. Oyo state was ranked third in Nigeria for the prevalence of open defecation (54%) and no LGA achieved an Open Defecation Free (ODF) Status that year [12]. Only less than one-tenth (8%) of Oyo state population had access to basic hygiene services[11]. Ogo-Oluwa LGA is no exception in the inadequate WASH problem, this community like most other rural communities in Oyo State is plagued by inadequate access to improved water sources for both drinking and other household use. Sanitation facilities is grossly inadequate while hygiene is also a problem in the community.

1.3 Justification for the Study

In May 2012, the World Health Assembly (WHA) announced schistosomiasis elimination in some member countries by the year 2030 and promoted WASH as a key component of the comprehensive schistosomiasis control strategy since there is a strong association between

schistosomiasis and poor sanitation [13]. Furthermore, in 2015, Schistosomiasis and soil-transmitted helminths (STHs) were mapped in 19 Nigerian states and the Federal Capital Territory (FCT) and the results showed that the overall prevalence of schistosomiasis is 9.5% in Nigeria and 5.4 % for Oyo state [3]. Of the thirty-three LGAs in Oyo state surveyed, two LGA had no schistosomiasis endemicity, 27 had low endemicity, while four LGAs (Ogo-Oluwa, Iwajowa, Saki West, and Saki East) had moderate endemicity [14].

Otamokun, a small densely populated rural community in Ogo-Oluwa LGA Oyo State with up to three river bodies was reported to have the highest endemicity of schistosomiasis in Ogo-Oluwa LGA during the last WHO/FMOH surevy [15]. The community is made up of mostly Type C buildings made with bricks and concrete with the majority not having sanitary requirements required to fulfil or complete a healthy living [16]. The community has three boreholes providing water for households in the entire community. Nevertheless, the impact of household water sources, sanitation and hygiene facilities on the prevalence of schistosomiasis in Otamokun has not been studied before this time. Majority of the studies on schistosomiasis carried out within Oyo State prior to this research work were mostly school-based [17-20]. A few other studies were carried out among a migrant population living in a rehabilitation home, and among women in a hospital-based study [21-22]. Moreover, the phylogenetic analysis of the *S. haematobium* species in the community that can aid precise species identification and group hybrids has not been documented in Otamokun, Ogo-Oluwa, LGA before this study [23].

Furthermore, disease mapping, a core component of any NTD programme is needed to quantify the burden of disease, understand its geographic spread and then design public health interventions tailored to each epidemiological context [24]. The mapping of

schistosomiasis in the study community is an important step in understanding where at-risk populations live in order to target intervenntions effectively. This study therefore sought to estimate the prevalence of schistosomiasis in Otamokun, Ogo-Oluwa LGA, and carry out a molecular characterization of the *S. haematobium* species in the study area. It also assessed the WASH conditions of houses in the community, and determined the spatial distribution of schistosomiasis within households in the community as well as identified factors associated with schistosomiasis in the study area using a household survey.

1.4 Aim and Objectives of the Study

The aim of the study was to investigate the prevalence, geospatial distribution of schistosomiasis and identify factors associated with schistosomiasis within Otamokun, Ogo-Oluwa LGA Oyo State, Nigeria.

The Objectives were to:

i. assess the WASH conditions of households in the study area.
ii. determine the prevalence of schistosomiasis in the study area.
iii. determine the geospatial distribution of schistosomiasis within the study area.
iv. identify the phylogeny of *Schistosoma haematobium* among children within the study area
v. Identify the factors associated with schistosomiasis in the study area.

1.5 Research Questions

1. What is the Water, Sanitation and Hygiene (WASH) condition of households in the study area?
2. What is the prevalence of schistosomiasis in the study area?
3. What is the geospatial distribution of schistosomiasis in the study area?
4. What is the phylogeny of *S. haematobium* among children in the study area?

5. What factors are associated with schistosomiasis in the study area?

1.6 Significance of Study

Understanding the proportion of school-age children in the population living with schistosomiasis can help quantify the 'burden' of the disease in the population and support planning for the delivery of local health and social care services [25]. Moreover, the phylogenetic analysis of the *S. haematobium* species in the community can allow for the determination of the genetic relatedness of the parasite strains from different sources, geographic locations, or even different time periods. This will infer evolutionary relationships and is important to understand the spread of the disease [23].

Furthermore, reliable mapping of a disease is an essential part of the integrated approach to control the disease [23]. Knowing the geospatial distribution of schistosomiasis can provide an understanding of the transmission dynamics of *S. haematobium* within the study area and thus form a basis for designing, and implementing better control efforts and evaluating intervention strategies [25].

Finally, if the data available for a disease targeted for elimination in year 2030 dates as far back as the year 2013 more than a decade ago, then it is imperative to re-evaluate the status quo in communities reported to be formerly endemic. Re-valuating the prevalence of the disease is necessary to aid the equitable allocation of resources to genuinely endemic communities and curb wastages (occurring from misallocation of resources). This is because, the drug praziquantel effective for the treatment of the disease is not readily available over the counter or in health facilities but is mainly donated by funding partners who give priority

to states with recent data and evidence-based claims. This research work will also help identify other priority areas in the study community needing intervention towards the elimination of the disease. Accurate data is essential for evidence-based decision-making and will significantly enhance the effectiveness and efficiency of public health strategies aimed at eliminating the disease by the year 2030.

1.7 Scope of the Study

This study estimated the prevalence of schistosomiasis in the community using urine microscopy as well as identified the genetic strains of *S. haematobium* parasite within the community. It also determined the geospatial distribution of schistosomiasis and identified the factors within the community that were associated with the disease. The survey was conducted among SAC and adults in the community. Adults and children answered the survey questions but only urine samples of SAC were examined for *Schistosoma haematobium* eggs.

1.8 Limitation of the Study

This study has a lot of additions to knowledge, however has this limitation:

There was a delay in the DNA extraction from the urine samples collected at the first visit to the study community. The storage conditions of the samples may have affected the result of the molecular assay. *S. haematobium* DNA could not be isolated from any of those samples even though they were positive for *S. haematobium* eggs after urine microscopy.

1.9 Operational Definition of Terms

S. haematobium*:* This is the parasite causing urinary schistosomiasis

Schistosome: This is the genus of the parasite causing schistosomiasis

Urinary Schistosomiasis: a disease caused by *S. haematobium* characterized by deposition of eggs in the ureter and bladder

Intestinal Schistosomiasis: a disease caused by *S. mansoni* characterized by deposition of eggs in the stomach and intestine.

Urogenital Schistosomiasis: *S. haematobium* infection affecting the urinary and genital tracts

Household Study: This refers to a study carried out 52within households in a community where respondents were visited at homes and data collection was done in the homes as opposed to gathering the respondents in a central place like the market square, health centre, town hall

Household Characteristics: includes characteristics such as toilet type, water source, and handwashing facilities ─ soap and water

Household: refers to a family or group of people living together. It's a social unit under one roof who share a common pot

Sanitation facilities: Toilet facilities

Hygiene: Conditions or practices conducive to maintaining health and preventing disability including handwashing

Endnotes

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Chapter Two

Literature Review

2.1 Description of Disease

Schistosomiasis is both an acute and chronic parasitic disease caused by blood flukes (trematode worms) of the genus *Schistosoma and* is found in many developing countries in tropical and sub-tropical Africa, the Middle East, Asia, and Latin America [1, 2.] The infection is acquired through contact with fresh water infested with cercariae i.e. the larval forms of parasitic blood flukes called schistosomes. The adult worms live and lay eggs in the veins causing draining of the urinary tract and intestines. The eggs laid are trapped in body tissues and cause massive damage as a result of the body's reaction to these eggs [3]. There are up to

five major species of schistosoma causing schistosomiasis but the two major species that infect humans are *Schistosoma haematobium*, the causative agent for urogenital schistosomiasis and *Schistosoma. mansoni* that causes intestinal schistosomiasis [4]. Others including *Schistosoma intercalatum, Schistosoma japonicum and Schistosoma mekongi* are less common in sub-Sahara Africa. The main schistosome species found in animals are S. *mattheei, S. bovis* and *S. currassoni* and more recently, hybridization events between human and animal schistosome species are leading to the emergence of novel zoonotic diseases [5].

Schistosomiasis mainly affects impoverished and rural communities, particularly farming and fishing populations and rural communities who have limited access to potable water, improved sanitation and hygiene [6]. Moreover, women who perform domestic tasks in contaminated water, such as washing clothes, are also at risk of developing female genital schistosomiasis while children are more susceptible to infection because of poor hygiene and frequent contact with infested water [3].

2.2 History and Burden of Schistosomiasis

2.2.1 Brief History of Schistosomiasis in Africa

Schistosomiasis in Africa dates back more than 4000 years [7]. Symptoms characteristic of urinary schistosomiasis were first described in early Egyptian papyri, and the eggs of *S. haematobium* were identified in the urinary tracts of mummies from 1250-1000 BC [7]. Symptoms were described as urological problems such as enlarged prostate, bladder stones, cystitis, changes in urinary frequency, and discharge from the penis; this has been interpreted as blood, although it could have also indicated semen or purulent discharge from sexually transmitted diseases [8]. There were also reports of persistent hematuria recorded by members of Napoleon's army in Egypt in 1798 and in forces involved in the Boer war (1899-1902) [7].

Furthermore, schistosomiasis was first recorded in the Eastern Cape of South Africa in 1863, after Dr J Harley diagnosed endemic hematuria with unknown cause in residents. He later diagnosed this as Bilharziasis after observing eggs in the urine eleven years after the official identification of the parasite [9]. It was described as typical in the Cape and thought to be due to contact with fresh water [9]. Cases of hematuria later identified as schistosomiasis based on the presenting symptoms were widespread in South Africa between 1864 and 1899, with children particularly affected. The geographical distribution of urogenital schistosomiasis in South Africa was later described, and efforts were made to recognize the disease as a serious public health issue from the 1960s onwards [9]. However, government-run-control programmes were essentially non-existent until the 1990s when the first helminth control program, targeting soil-transmitted helminths and *S. haematobium*, was set up in the KwaZulu-Natal province of South Africa in 1997[10].

2.2.2 Burden of Schistosomiasis in Africa

Figure 2.1 shows the distribution of schistosomiasis infection in Africa. *S. haematobium* is the most prevalent schistosoma species in sub-Saharan Africa with an estimated 112 million individuals infected [11]. Nearly 71 million individuals experience haematuria, half of which have dysuria. Around 18 million infected individuals suffer from urinary bladder pathology annually, and deaths resulting from kidney failure due to *S. haematobia*um are estimated to be around 150,000 annually [11]. There is an estimated 54 million individuals infected with *S. mansoni* with around 4 million people experiencing diarrhea and 8.5 million hepatomegaly, with deaths resulting from haematemesis estimated to be around 130,000 per year[11].

After Nigeria, Tanzania has the second highest prevalence of schistosomiasis in Africa and is co-endemic with *S. haematobium* and *S. mansoni* [12]. Approximately 23 million individuals

are infected, and *S. hematobium* is more common throughout the country, particularly in coastal areas [11]. At the same time, *S. mansoni* is more focal and extensively dispersed along the shores and islands of large bodies of water, notably Lake Victoria [13]. Due to the disease's widespread dissemination, the Tanzanian population is at risk of the infection [14]. Furthermore, the Democratic Republic of the Congo (DRC) in Central Africa and Ghana have the third most significant schistosomiasis cases (15 million) in Africa [15]. In Ghana both *S. haematobium and S. mansoni* are prevalent [16]. A recent longitudinal study in Ghana including 2,623 individuals comprising pre-SAC, SAC, and adults, found an overall prevalence of 44.2% for *S. mansoni* and 11.9% for *S. haematobium*, with SAC having the most significant prevalence of *S. haematobium* [17]. Adult participants in this study had a considerably higher prevalence of *S. mansoni* throughout the three sample sites [17].

In North Africa and the Middle East, Schistosomiasis is estimated to affect 12.7 million people [14]. Egypt formerly had the highest number of recorded schistosomiasis cases in northern Africa for a long time but has seen a decrease in prevalence in recent years because of successful control and elimination programs [18]. Notably, Morocco and Tunisia have successfully stopped the disease's propagation, and this was accomplished through the implementation of effective chemotherapeutic treatment programs and targeted snail control programs and molluscicides [19-20]. There have been no recent reports of schistosomiasis in Algeria, and it is unclear whether surveillance for the disease is ongoing; hence, the actual status of schistosomiasis in Algeria remains unknown [14]. *S. mansoni* is the most common high species in East and Southeast Africa, *S. mansoni* was initially recorded in Uganda in 1902 , occurrences of *S. mansoni* infection were also reported in 1924, and infection rates

remained high till 1958 [21-22]. Similarly, in 1949, an extraordinary 95.2% prevalence of *S. mansoni* prevalence of 95.2% was documented in men near Lake Mobutu in Uganda, with all fishermen testing positive [23.] *S. haematobium* and *S. mansoni* are highly prevalent in Uganda, and *S. intercalatam* was discovered in some places in 1978 [24]. The prevalence of *S. mansoni* in Ethiopia has also remained high, with recent surveys estimating prevalence levels ranging from 24-76.3% [14]. On the other hand, Mozambique, like Tanzania, is endemic for both *S. mansoni* and *S. haematobium*; but *S. haematobium* is more abundant in Mozambique, while *S. mansoni* is more widespread in Tanzania [13].

Furthermore, in South Africa, the prevalence of schistosomiasis is normally high among SAC, while it is low among pre-SAC: cross-sectional investigation found a 37.5% prevalence among SAC [14]. Whereas, a 2018 survey in KwaZulu-Natal found a 1% prevalence of *S. haematobium* and a 0.9% prevalence of *S. mansoni* among pre-SAC [25]. Another study published in 2014 found a high prevalence of *S. haematobium* by urine microscopy among girls aged 10-12 years [26]. While a report published in 2020 found a slightly lower prevalence of 19.8% by urine microscopy and 23.1% by qPCR among young women aged 16 to 23 years [26]. Swaziland and Zambia have a high prevalence of *S. haematobium*, while *S. haematobium* and *S. mansoni* are endemic in Zimbabwe, Namibia, and Malawi [14].

Moreover, another major impediment to schistosomiasis control is the critical lack of accurate and reliable information on the prevalence, severity of infection, epidemiology, and geographic spread of schistosomiasis in many Sub-Saharan countries. This is partly due to insufficient or non-existent disease surveillance and monitoring, making it impossible to predict transmission areas and identify vulnerable populations [25].

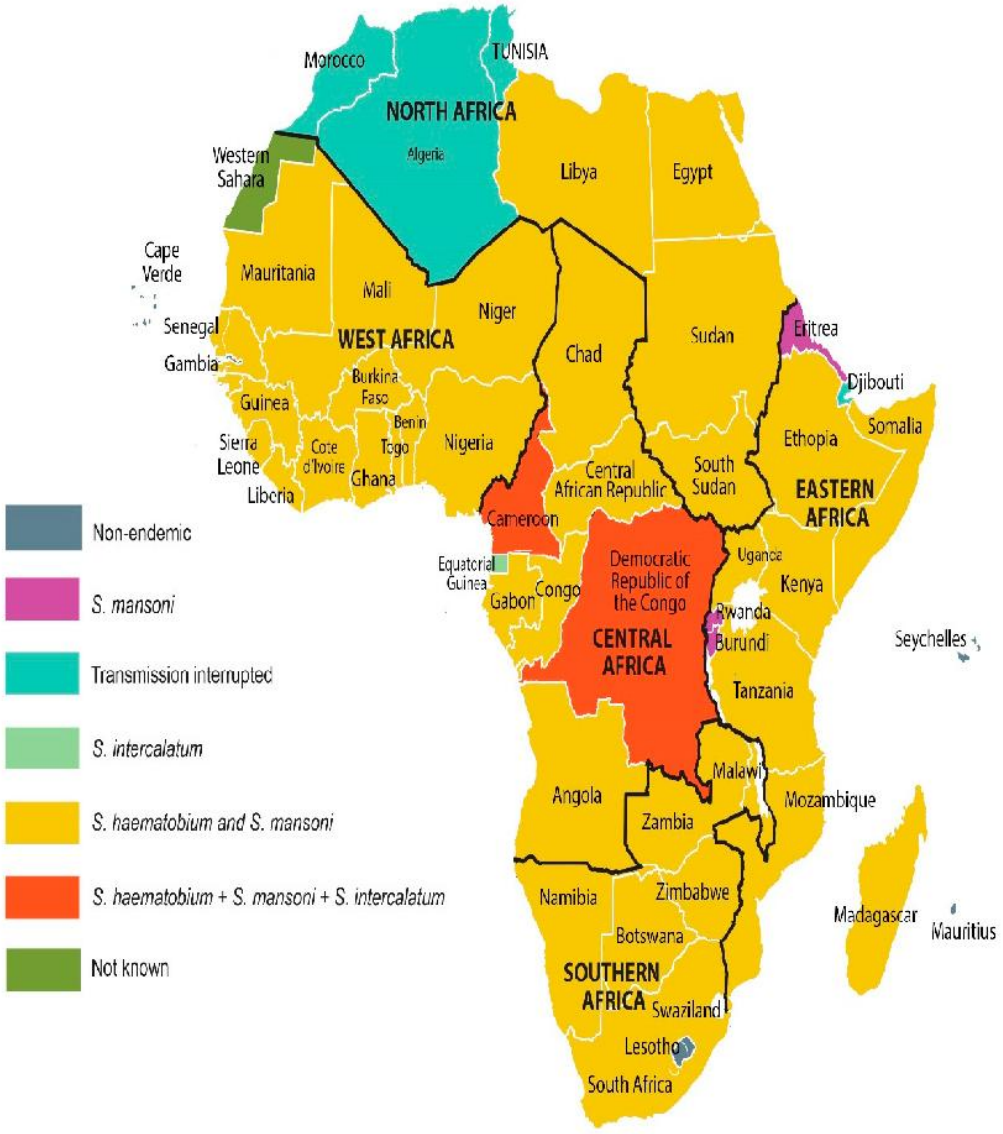

Figure 2.1 Distribution of Schistosome Infections in Africa [14]

2.2.3 Burden of Schistosomiasis in Nigeria

Schistosomiasis has been reported in Nigeria before independence, with historical maps and statistics indicating *S. haematobium infection* [14]. In 1984, a comprehensive distribution map of *S. haematobium* and *S. mansoni* including locations of reported cases in Nigeria was published [14.] However, a nationwide schistosomiasis control program was not developed until 1988, when there was increased interest in the control of diseases [14]. Due to lack of funding, only a few surveys and control activities were carried out until 2000, when several non-governmental organizations (NGOs) began to support the implementation of nationwide mapping surveys for onchocerciasis, lymphatic filariasis, schistosomiasis and soil-transmitted helminthiasis [27]. These maps have been used to produce model-based estimates of the population affected and transmission risk factors. These models have estimated that up to 11.3 million Nigerian SAC were infected with at least one species of schistosome, and a follow-up study showed an increase to 22.6 million among the SAC and a total of 45.5 million needing PZQ annually in Nigeria [28].

Furthermore, after the London Declaration on NTDs in the year 2012 to eradicate and prevent transmission of NTDs by the year 2020, twenty-two pharmaceutical companies and partners committed to supplying PZQ for as long as necessary. This provided an avenue to increase control efforts through epidemiological data [27]. Subsequently, a national coordinated mapping was carried out among in-school children in 19 Nigerian states and the federal capital territory (FCT) using the WHO mapping protocol [28]. This effort reported prevalence rates and risk classification at the LGA, and of the 774 LGA surveyed, 582 were reported to

be endemic for schistosomiasis (Figure 2.2a).

The schistosomiasis risk classification reported during the survey were:

- Low risk (<10% prevalence) reported in 279 LGAs
- Moderate risk (10-50% prevalence) reported in 293 LGAs
- High risk (>50% prevalence) reported in 10 LGAs
- Non-endemic (0% prevalence): reported in 191 LGAs [29].

The National Schistosomiasis and Soil-transmitted Helminthiasis control programme in Abuja coordinates schistosomiasis intervention in Nigeria. Still, each state has either a local or international partner supporting PC implementation there. Some of the partners working at the state level include Evidence Action in Ogun, Oyo, and Rivers states; Helen Keller International supporting Katsina, Borno, Adamawa, and Akwa-Ibom states. Amen Health Foundation works in Osun and Gombe; Sight Savers work in Sokoto, Kebbi, Zamfara, Kaduna, Kwara, Kogi, and Benue states [28-29]. School-based interventions are administered at the LGA level based on the endemicity classification, as indicated in the fig 2.2a below. Figures 2.2b and 2.2c show all LGAs in Oyo state and LGAs in Oyo state according to the level of schistosomiasis endemicity.

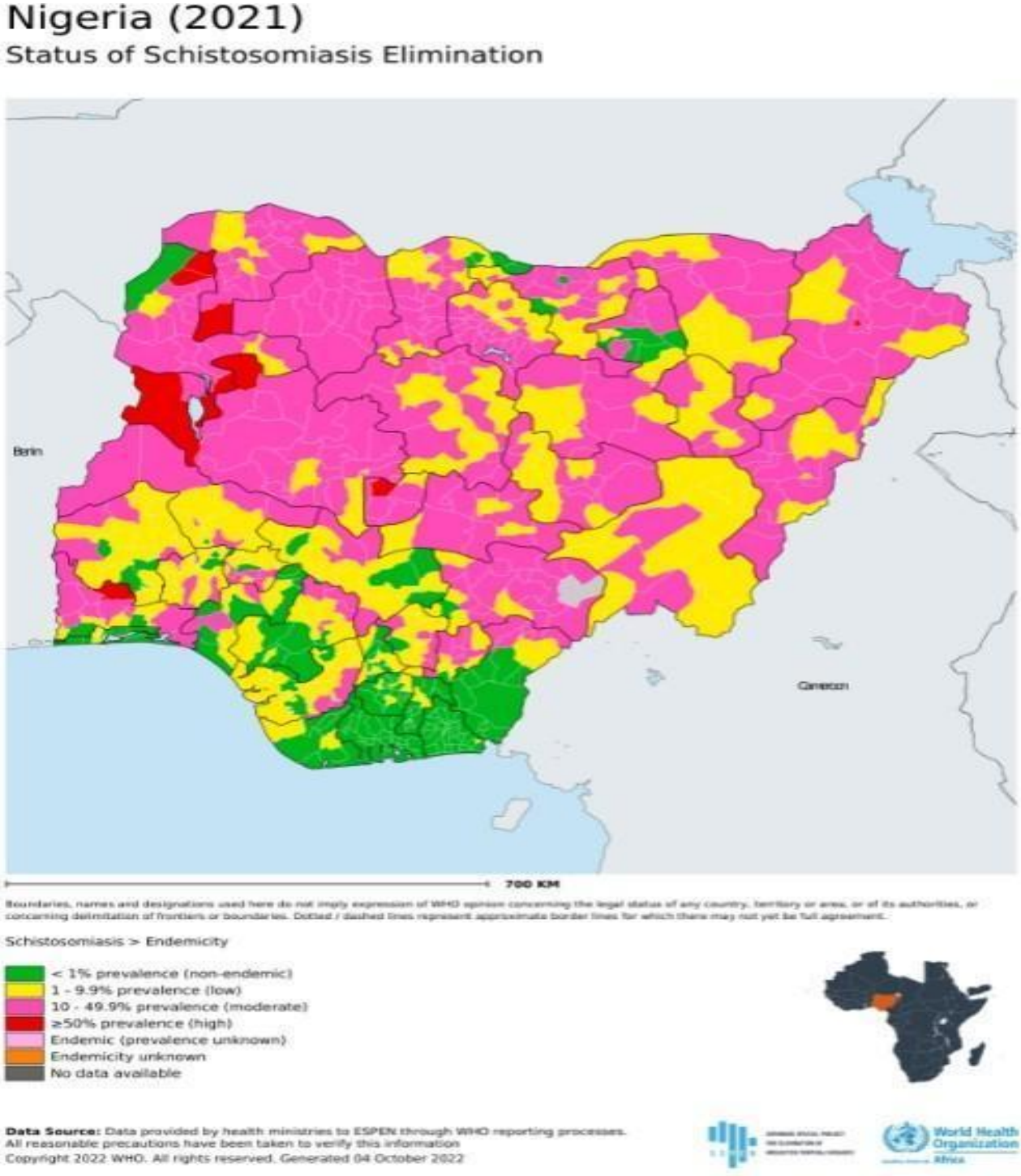

Fig 2.2a Current Status of Schistosomiasis Endemicity in Nigeria by LGA as at 2021 Source [29]

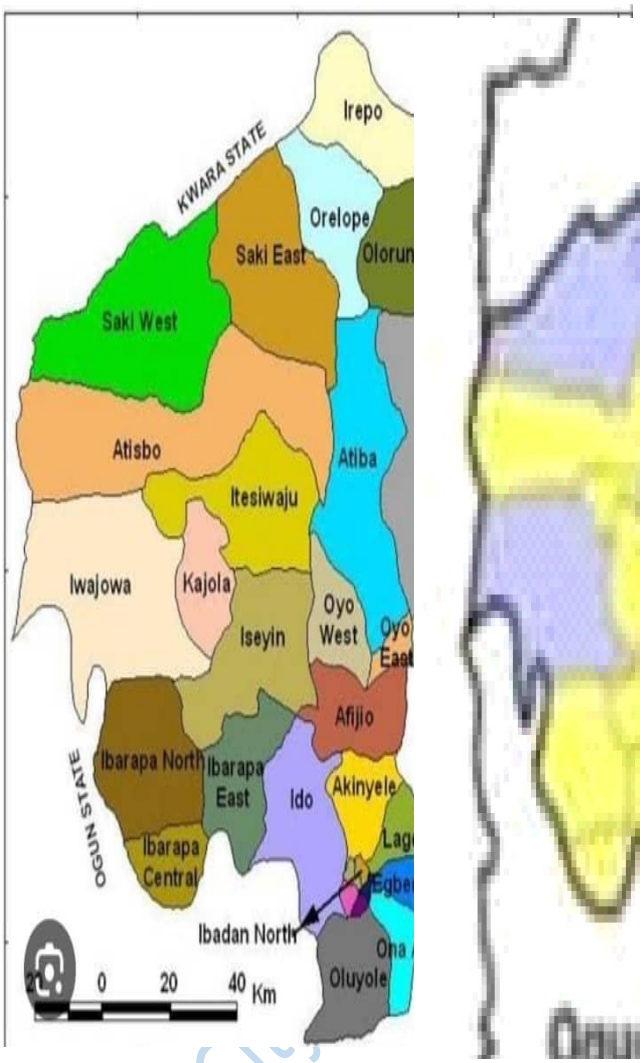

Figure 2.2b: Map of Oyo State Showing LGAs
Source [27]

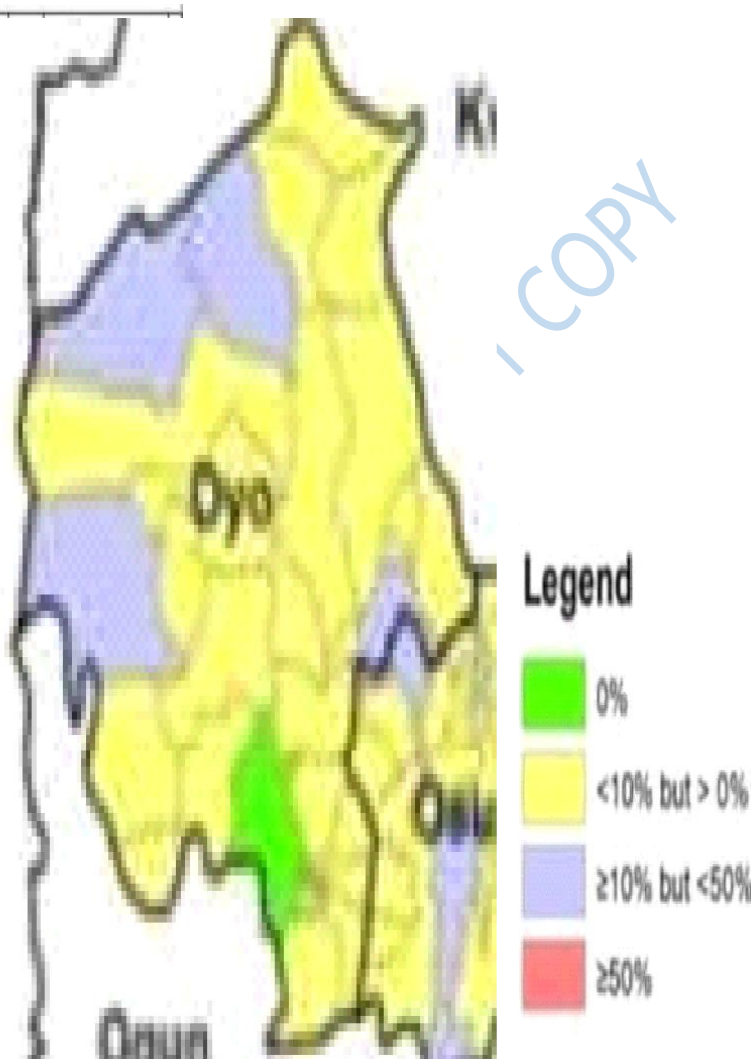

Figure 2.2c: Map of Oyo State Showing LGA with SCH Endemicity Levels
Source: [28]

2.3 Pathogenesis of Schistosomiasis

The life cycle of the Schistosoma parasite is complex (Figure 2.3) and involves two hosts: snails and mammals. Asexual reproduction occurs in freshwater snails, while sexual reproduction occurs in mammals [14]. The eggs are produced in mammals (such as humans, dogs, or mice) are the final hosts and are excreted into the environment via feces for *S. mansoni* and urine for *S. haematobium*. The eggs hatch upon contact with water to produce miracidia, which are then released to infect freshwater snails which are the intermediate host. *S. haematobium* infects Bulinus snails, *S. japonicum* infects Oncomelania snails, *S. mekongi* infects Neutricula snails while *S. mansoni* infects snails the Biomphalaria snails [30-31.] In the snail, miracidia mature into mother sporocysts which then undergo asexual reproduction to produce daughter sporocysts that metamorphose into cecariae [32]. Snails can shed hundreds of cercariea daily; *S. haematobium* shed about 200, *S. japonicum* shed between 15 to 160, and *S. mansoni* shed between 250 to 600. The cercariae permeate the skin when they find an appropriate mammalian host [30]. Furthermore, in humans, the cercariae shed their forked tails and change into schistosomula which then move via the circulatory system to the heart, lungs, and liver, developing into schistosome and adult worms. The worms in humans exist in various locations depending on the schistosome species. *S. haematobium* exists in the bladder, ureters, and rectum. *S. japonicum* exist mainly in the small intestine, while *S. mansoni* worms can be found in the large and small intestine[33]. The bloodstream takes some of the eggs to other body parts, where they might be deposited in tissues and cause inflammatory responses, resulting in acute or chronic disease (Figure 2.3). Schistosomes have an average life span of 3-10 years but can live for up to 40 years in human hosts when in constant copulation [34].

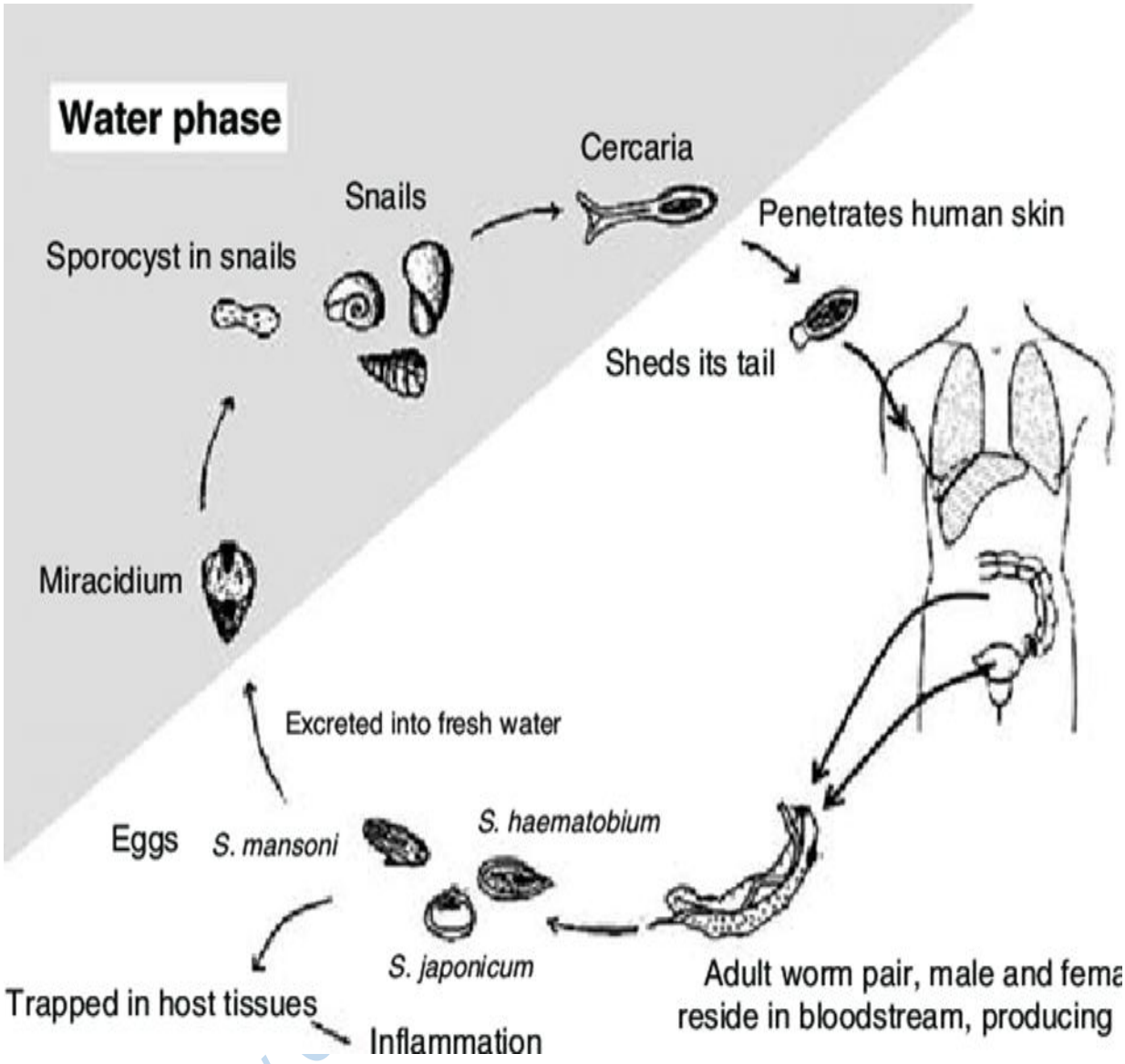

Figure 2.3: Schematic Life-Cycle of Schistosomiasis.
The trematode parasites of Schistosoma spp. divide their lifecycle between water bodies and the venous circulation of their definitive human hosts.
Source: [35]

2.4 Clinical Manifestation of Schistosomiasis

Symptoms of schistosomiasis occurs as a result of the body's reaction to the eggs and not by the worms themselves [1]. Eggs shed by the adult worms that do not pass out of the body can become lodged in the intestine or bladder, causing inflammation or scarring [5]. Most people show no symptoms in the early stages of infection. Clinical manifestations of schistosomiasis can be both acute and chronic. Acute schistosomiasis, also called Katayama syndrome, has a 14 to 84-day incubation period. Fever, headache, rash, myalgia, and respiratory problems are some of its symptoms [6].

2.4.1 Urogenital Schistosomiasis (UGS)

Urogenital schistosomiasis (UGS) is caused by *S. haematobium* worms living within the veins of the main pelvic organs, including the bladder, uterus, and cervix. The worms migrate into the circulation, mature, and lodge within the venous plexus of the bladder, where they reproduce. Females release up to 3000 eggs per day. Only half of these eggs are excreted in the urine to propagate the parasite's life cycle. In contrast, the remaining eggs become entrapped within capillary beds of the pelvic end organs, especially in the bladder, ureters, and genital tract [36]. The classic sign of urogenital schistosomiasis is hematuria (blood in urine). Other manifestations of the disease include dysuria, genital tract infections, and susceptibility to other infections. Chronic infections may result in bladder cancer, kidney damage, and bladder and ureter fibrosis [1].

2.4.2 Intestinal Schistosomiasis

Intestinal schistosomiasis is caused by *S. Japonicum* and *S. mansoni*, and its chronic manifestation includes blood in stool, constipation, diarrhea, chronic inflammation, bowel wall ulceration, and fibrosis, accumulation of peritoneal fluid and portal hypertension [14]. This

is often associated with spleen enlargement. Liver enlargement is common in advanced cases and is frequently associated with an accumulation of fluid in the peritoneal cavity and hypertension of the abdominal blood vessels [14].

2.4.3 Female Genital Schistosomiasis (FGS)

The presence of *S. haematobium* eggs in the vagina and cervix is the classical sign of female genital schistosomiasis (FGS), and this disease affects around 20 million women in Sub-Saharan Africa and the Middle East [14]. In women, the eggs enter the urogenital system, causing enlargement of the uterus and cervix, menstrual disorders, and infertility [37]. Other presentations include genital sores, vaginal bleeding, and pain during sexual intercourse [3]. In pregnancy, schistosomiasis affects the uterine environment and can result in severe anemia, low birth weight infants, and increased risk of infant and maternal mortality. Women living with FGS are at more at risk of HIV infection because of the increased formation of vaginal mucosal sores surrounding the eggs [1.] The body's immune response to these eggs can lead to genital epithelial hemorrhage and sandy patches in the cervix and vagina and if left without treatment, can become the entry point for the Human Immunodeficiency Virus (HIV) [38]. An association has been established between schistosomiasis and HIV because of the increase in HIV RNA level in the blood plasma during schistosomiasis infection [39.] Moreover, more than 70% of people infected with HIV globally occur in sub-Saharan Africa, and this makes HIV a cofounding factor for schistosome infection [14].

Furthermore, cases of infertility that have been linked to schistosomiasis have been reported in Africa [40.] In Nigeria, a case study of a woman's inability to conceive a second pregnancy despite a regular menstrual cycle was associated with lesions and blockages in her fallopian tubes because of the presence of *S. haematobium* eggs in them [41]. Ectopic pregnancies have

also been linked to schistosomiasis due to blockage of the fallopian tubes [42]. Sadly, because of the stigma against sexually transmitted diseases (STDs) young women are hesitant to seek medical attention while experiencing FGS symptoms [14].

2.4.4 Male Genital Schistosomiasis (MGS)

This refers to *S. haematobium* eggs in the male genital organs and the seminal secretions. The frequency and severity of this disease are often overlooked and under-reported, especially in endemic areas. Urogenital schistosomiasis in men can cause disease in the seminal vesicles and prostate organs [3]. Symptoms of MGS are often similar to sexually transmitted infections (STI) symptoms, including painful urination, irregular ejaculation, and hermatospermia makes it often misdiagnosed as STI [43]. MGS may also lead to irreversible long-term consequences such as infertility [3].

2.4.5 Bladder Cancer in *S. haematobium* Infections

Bladder cancer is one of the foremost complications of chronic haematobium infection with an incidence of up to 3-4 cases per 100,000 infections [44]. Bladder cancer caused by squamous cell carcinoma (SCC) is a long-term complication of chronic schistosomiasis and is prevalent in many parts of Africa endemic with schistosomiasis. SCC occurs due to damages caused by immune responses when *S. haematobium* eggs are deposited in the bladder [45]. Painful hematuria, and persistent inflammation with necroturia are usually the aftermath of such immune responses [45]. SCC shows symptoms mostly at a later stage and can be very difficult to treat with chemotherapy or surgery [14].

2.5 Effect of Schistosomiasis

Schistosomiasis has significant economic and health consequences, and the disease disables more people than it kills [3]. Schistosomiasis may lead to anemia, stunting, and decreased capacity to learn in children, but the consequences are usually reversible with treatment. Chronic schistosomiasis can impair people's capacity to work and, in severe cases, cause death. Estimating the number of deaths from schistosomiasis is tough because associated diseases such as liver and renal failure, bladder cancer, and ectopic pregnancies caused by female genital schistosomiasis are usually hidden and underestimated[3]. However, schistosomiasis deaths are estimated to be 11,792 globally per year, although these statistics are likely underestimated and should be revised [3].

2.6 Diagnosis

2.6.1 Urine Microscopy

Schistosomiasis is often diagnosed by examining stool or urine samples for schistosoma eggs, and the detection of antibodies or antigens in the blood or urine samples can also indicate the disease. Filtration methods that use nylon or polycarbonate filters are the gold standard for urogenital schistosomiasis. Usually, about 10ml of urine sample is centrifuged and filtered, and the sediment is then examined for parasite eggs. Infection intensity is determined by the number of eggs found in 10ml urine sample [46]. This method is often effective in areas with high and medium-intensity infection [47]. Still, it lacks sensitivity in low-intensity infection since only a small amount of eggs are shed in the urine samples. Moreover, the eggs are not excreted in the stool or urine until about two months after exposure [43].

Another pitfall of this method is that the approach is not sensitive enough to assess the efficiency of praziquantel (PZQ) treatment during MDA activities because of its inability to detect early infection and hence affect the administration of praziquantel [48]. Another limitation of microscopy is the tediousness of the process, as manpower, logistics, and materials are involved in the method [49]. Microscopy results can be improved by repeating the screening, but this will translate to more cost. The burden of the disease will, therefore be underestimated in a given population if repeated testing cannot be carried out, hence the need for a more sensitive diagnostic and cost-effective approach in such a situation [50]. Since hematuria is a classical sign of the disease, macro and micro-hematuria can be determined using dipstick [51]. Nevertheless, a large proportion of microhematuria in low prevalence settings may be from causes other than *S. hematobium* infection [49].

2.6.2 Circulating Anodic Antigen Assay (CAA)

CAA is a susceptible quantification test that detects all Schistosoma spp. in blood, urine, or any other bodily fluid. CAA uses luminescent quantitative up-converting phosphor (UCP) reporter particles and a rapid, user-friendly lateral flow (LF) test format [52]. This method has shown a much higher sensitivity for *S. haematobium* than a single urine filtration in Zanzibar [53]. This technique has also been proven useful to estimate the prevalence of disease and drug efficacy during MDA campaigns and re-infection because serum levels are expected to decline shortly after praziquantel use [53]. The CAA has been reported to be a true measure of schistosomiasis infection because of its ability to detect a pair of worms although its applicability in field setting is still minimal because of its cost [49].

2.6.3 Circulating Cathodic Antigen Assay (CCA)

The point of care (POC) - circulating cathodic (CCA) antigen test is an immunological test that has been proposed for the detection of schistosomiasis especially for people living in non-endemic or low transmission areas, but unfortunately, this method has been reported to be more effective at detecting *S. mansoni* than *S. haematobium* [49]. It is a user-friendly, affordable, highly sensitive, and specific alternative for microscopy [54]. CCA test has been reported to have a higher sensitivity than the kito-Katz (KK) test (even on three thick smears). It is more effective in measuring the effectiveness of PZQ for schistosome clearance in primary school children [49]. POC-CCA can also examine urine instead of stool, giving it a wider acceptability among patients [49.] A study among school-age children in Cameroon reported a higher prevalence of POC-CCA when compared with the KK method [55]. POC-CCA combined with serology for *S. mansoni* showed 100% sensitivity compared to 95.7% in serology only and 91.3% on POC-CCA independently. This sensitivity makes it useful for detecting schistosomiasis in non-endemic settings [55]. A study in Brazil reported limited sensitivity when used alone in a low-infection-intensity area. A significant limitation of POC-CCA, despite its reliability, is its inability to detect *S. haematobium*, the primary schistosome species prevalent in sub-Sahara Africa. Another drawback of POC-CCA is its high cost, and each test costs up to $1.75, which is expensive, especially for resource-limited settings [49].

2.6.4 DNA Assay

A method that can be applied in settings with low parasite density and chronic infection became necessary due to the inability of earlier diagnostic techniques to assess schistosomiasis in these settings correctly. For several years, molecular techniques

comprising standard and real-time schistosomiasis cases have been utilized in the identification of schistosomiasis cases [56]. Molecular techniques have been reported to be more sensitive than other methods, especially in low-density schistosome infection. Therefore it can be used for case surveillance in endemic area [57]. DNA assay aims to identify schistosome DNA by employing DNA amplification techniques such as polymerase chain reaction (PCR). This method can detect early infections because of its accuracy and high sensitivity thus making it almost impossible to miss anyone with schistosomiasis infection when utilized [57].

Additionally, for direct PCR, DNA isolation needs to be carried out first; this requires more cost, time, and added complexity, which many times delays obtaining the result [58]. Moreover, the outcome of the amplification process is determined by the quality of the DNA used and is the most expensive part of DNA-based diagnostics, especially with the use of commercial extraction kits [58]. Also, the method of sample collection and sample preservation significantly affect DNA extraction and amplification outcomes. Since DNA extraction from fresh samples is not feasible in the field, there is a need to properly preserve the samples and also remove the preservative agent before carrying out the DNA extraction in laboratory. These processes require automated machines, which are very costly and unsuitable for field use in settings with limited resources [58].

Furthermore, recent developments in DNA amplification tests involve the use of real-time quantitative PCR (qPCR) and droplet digital PCR (ddPCR) to identify circulating cell-free parasite DNA (cfDNA). This method uses various clinical samples and the development of isothermal amplification tests such as loop-mediated isothermal amplification (LAMP) and recombinase polymerase amplification (RPA) techniques [58]. Cell free DNA (cfDNA) is

mainly found in body fluids such as plasma and can be used directly, and this eliminates the challenge of first isolating the DNA from schistosome eggs in urine or stool. Also, parasite cfDNA can be detected in bodily fluids such as urine, saliva, and cerebrospinal fluid and can be measured using qPCR and ddPSR assays [58]. However, accuracy measures such as sensitivity and specificity of DNA detection assays may differ depending on the type of assay, target gene sequence used, and the type of sample tested [59]. Therefore, to achieve a suitable DNA amplification assay, choosing a specific amplification sequence with many copies is paramount. A target gene sequence for diagnostic DNA amplification should be abundant and very specific for the target specie; this is to ensure that the final test is susceptible and specific [60].

2.7 Control Measures for Schistosomiasis

The World Health Assembly (WHA) adopted the new NTD road map 2012-2013 and is set to eliminate schistosomiasis as a public health concern in all endemic countries by the year 2030 while also interrupting its transmission in some selected countries [1]. The control focuses on reducing the disease through periodic large-scale treatment of the population at risk with PZQ, increasing accessibility to safe drinking water, and improving sanitation and hygiene education for impoverished communities. Snail control, environmental monitoring, and behavioral change are also essential to disease control [1].

2.7.1 Preventive Chemotherapy (PC)

The WHO has a strategy to control schistosomiasis by focusing on lowering disease prevalence and transmission with PZQ on a regular, targeted basis. Praziquantel is the medicine recommended against all forms of schistosomiasis as it can reverse the disease and reduce the severity of the disease in children. It is less costly, safe, and effective against

adult worms of all Schistosoma species although the disease may re-occur after treatment [1]. Re-infection is a massive challenge to controlling schistosomiasis in Africa for many reasons, including re-contacting contaminated water, non-compliance with treatment, and seasonal factors [14]. Preventive chemotherapy involves the regular treatment of all at-risk groups. Thefrequency of treatment in a particular area will be determined by the prevalence of infection in school-age children. PZQ cannot be relied on for chemoprophylaxis due to its short half-life and ineffectiveness against schistosomula because of its constant movement [14].

2.7.1.1 Groups Targeted for Treatment

WHO categorizes the target group for schistosomiasis as follows:

i. Pre-school age children: WHO recommends that treatment of preschool-aged children be based on diagnostic and clinical judgment and should be included in the large-scale treatment using pediatric PZQ formulation [61].

ii. School-aged children (SAC): These are the age group mostly targeted for control because they are considered to have the greatest risk of schistosomiasis as they are more likely to engage in activities such as swimming, farming, bathing in open water sources that put them at increased risk of the disease [14]. The SAC is often reached through school programs, and the prevalence of the disease is usually measured first treatment because this should inform the need for treatment in a given area [62].

iii. Adults considered to be at risk in endemic areas: Untreated adults are not only reservoirs of infection in a community; they are also at high risk of developing severe chronic forms of the disease [63].

iv. People whose occupations involve frequent contact with infested water: Occupations such as fishing, farming, and irrigation put workers at increased risk of schistosomiasis [1]

v. Women carrying out domestic chores in and around infested water: Studies in Egypt have shown that women are at increased risk of schistosomiasis when they engage in washing of clothes, and utensils, mats, grains and blankets in open water sources [64.]

vi. Entire communities living in highly endemic areas [1.]

Remarkably, numerous countries, including Brazil, Cambodia, Egypt, China, Iran, Morocco, Tunisia, and a host of others, have successfully controlled schistosomiasis over the last four decades[14.] In the past ten years, efforts have been made to scale up treatment in some sub-Saharan countries, including Burundi, Ghana, Niger, Rwanda, and Sierra leone where the majority of the populations at risk live. This effort has caused a reduction in the prevalence of schistosomiasis among school-age children by almost 60% [29.]

In the year 2022, WHO recommended that endemic communities with ≥10% prevalence should have annual preventive chemotherapy with a single dose of PZQ at ≥ 75% treatment coverage in all age groups from 2 years old, including adults, pregnant women after the first trimester and lactating women, to control schistosomiasis morbidity and advance towards eliminating the disease as a public health problem [64]. In endemic communities with < 10% prevalence, where there is regular preventive chemotherapy (PC) program, PC should be continued or reduced. However, if there is no regular preventive chemotherapy program, then test and treat is the approach to use [64].

However, in the year 2023, the treatment strategy was reviewed. Table 2.1 below shows the recommended treatment strategy for schistosomiasis in preventive chemotherapy [65.] High-risk communities with ≥50% prevalence should have annual PC treatment for all SAC, pre-school children, and adults at risk. Those with ≥10% and <50% prevalence should have biennial

treatment for all populations at risk, and those with <10% treatment should have their SAC treated twice in primary school [65].

Table 2.1: Recommended Treatment Strategy for Schistosomiasis in Preventive Chemotherapy

Category	Prevalence among school-aged children	Type	Frequency	
High-risk community	≥50% [a]	Preventive chemotherapy	Once a year	All school-aged children, preschool children and adults at risk
Moderate-risk community	≥10% and <50%	Preventive chemotherapy	Once every 2 years	All school-aged children, preschool children and adults at risk
Low risk	> 0 % and < 10%	Preventive chemotherapy	Twice during their primary schooling age (ex. once on entry and once on exit)	All school-aged children

Source: [65]

2.7.1.2 Preventive Chemotherapy (PC) in Nigeria

In Nigeria, a recent mapping results estimated that, 139,645,032 people lived in schistosomiasis-risk areas in 2017, with 41,033,925 SAC and 1,396,203 adults requiring PZQ treatment regularly [66]. In 2020, the National Control Programme provided 9,558,570 and 6,636,532 treatments to SAC and adult populations, respectively, implying that more than half (55%) of SAC and almost three-quarters (73%) of people in the country require PC [67]. Furthermore, a recent modeling study found significant evidence that scaling up PC interventions with PZQ had a favorable impact on schistosomiasis prevalence among SAC in Nigeria, with prevalence decreasing by almost half (44.9%) in 2011-2014 and two-thirds (67.1%) in 2015-2019 compared to baseline prevalence in 2000-2010 [27.] The overall morbidity control strategy aims to achieve and maintain 100% geographic coverage and at least 75% treatment coverage of eligible populations. More targeted and precise interventions are required to achieve these targets if eradication will be possible by 2030 [28.]

Moreover, since schistosomiasis transmission has been observed to be focal, different transmission intensities may coexist within a defined implementation area [68.] Therefore, developing treatment plans based on average prevalence for large areas may result in both overestimating and underestimating treatment needs. This fact has resulted in a shift in the current treatment approach from 'district-level' interventions to a community-centered strategy, which will help provide treatment to where it is required, hence lowering the treatment gap and preventing over- or under-treatment [69].

2.7.2 Water Sanitation and Hygiene (WASH)

Although hand washing after defecation may not affect schistosome transmission, the use of soap after exposure to contaminated water sources may help to reduce the infectivity of cercariae which might infect people during water contact activities [70]. This is because soap is toxic to cercariae, miracidia, and specific freshwater snails [71]. A study has shown that people with access to safe water and adequate sanitation had a significantly lower risk of schistosomiasis when compared to those with inadequate water and sanitation [70, 72]. The success of the improvement in water supply in preventing the disease in endemic communities will therefore be dependent on the prevention of water contact and especially the prevention of contamination of open water sources with human excreta [70].

In addition, though the provision of safe water may significantly reduce human contact with contaminated water, other factors, including the host's immunity and skin thickness, also contribute to infection prevention since humans get infected with schistosomiasis through skin penetration [51]. However, experiments with schistosome in monkeys and *S. bovis* in goats suggest drinking schistosome infested water can also cause schistosomiasis infection [14]. Some studies have reported that cercariae could pass through sand filters but would not survive chlorination and flocculation with *Moringa Oleifera;* therefore, storing water for between 2-3 days before use has been proposed as a means of preventing schistosome infection since 1915[7]. This is because the cercariae are non-feeding, and so they cannot survive for more than two days without infecting a specific host [70].

Generally, the provision of water from improved sources free of contamination and unlikely to contain cercariae or snails may reduce human contact with the disease. Still, activities such as fishing and car washing are sources of occupational exposure to schistosomes that cannot

be prevented by simply providing safe water [70]. Furthermore, a study in China reported that workers in flood relief, irrigation, cleaning, and tourism were exposed to infested water on the job [73].

Similarly, in Brazil, a study found that crossing streams was associated with a higher risk of *S. mansoni* infection. It thus concluded that providing water supplies was not sufficient to interrupt schistosomiasis transmission [70]. In addition, types of activities engaged during river visits have been reported to have significant implications for schistosomiasis. Activities such as laundry, bathing, and swimming may cause the highest exposure to cercariae-infested water, while fetching water may not cause as much exposure. Therefore, the provision of adequate amenities such as sinks, laundry drains, and safe recreational swimming areas is critical in addition to safe areas for recreational swimming to prevent the disease transmission [70].

More so, some studies carried out in South Africa in the late 1960s have shown that the provision of showers, sinks for washing, and swimming pools drastically reduced visits to the river for these purposes and was shown to decrease the prevalence of schistosomiasis in the nine years following the study [74]. A study in North-West Ethiopia reported that lack of water suitable for bathing, swimming, and washing poor sanitation and hygiene increased the risk of schistosomiasis [75]. Related studies in Amibera district, Southern Ethiopia, and North-eastern Nigeria, reported similar findings between swimming in surface water and increased risk of schistosomiasis. Another study in Ghana evaluating the impact of swimming pools on schistosomiasis infection in school children showed the potential of swimming pools to prevent reinfection of the children with schistosomiasis after using praziquantel [70].

Figure 2.4 below is a flow diagram demonstrating the roles of human water contact and

immunological and physiological factors in determining schistosome infections. Point 1 demonstrates that since water from safe sources should be free from cercariae, provisions of such water should prevent schistosome infections. Still, in Point 2, the provision of water often does not prevent all contact with infested water. Point 3 shows another barrier to schistosome infections i.e. the host's immune system and physiology, which may kill invading cercariae before they develop into adult worms and cause anthology. Despite the host's immunological and physiological defenses, some cercariae will develop into adult worms (Point 4). The relative importance of water versus immunology and physiology in preventing schistosome infections is poorly understood [70].

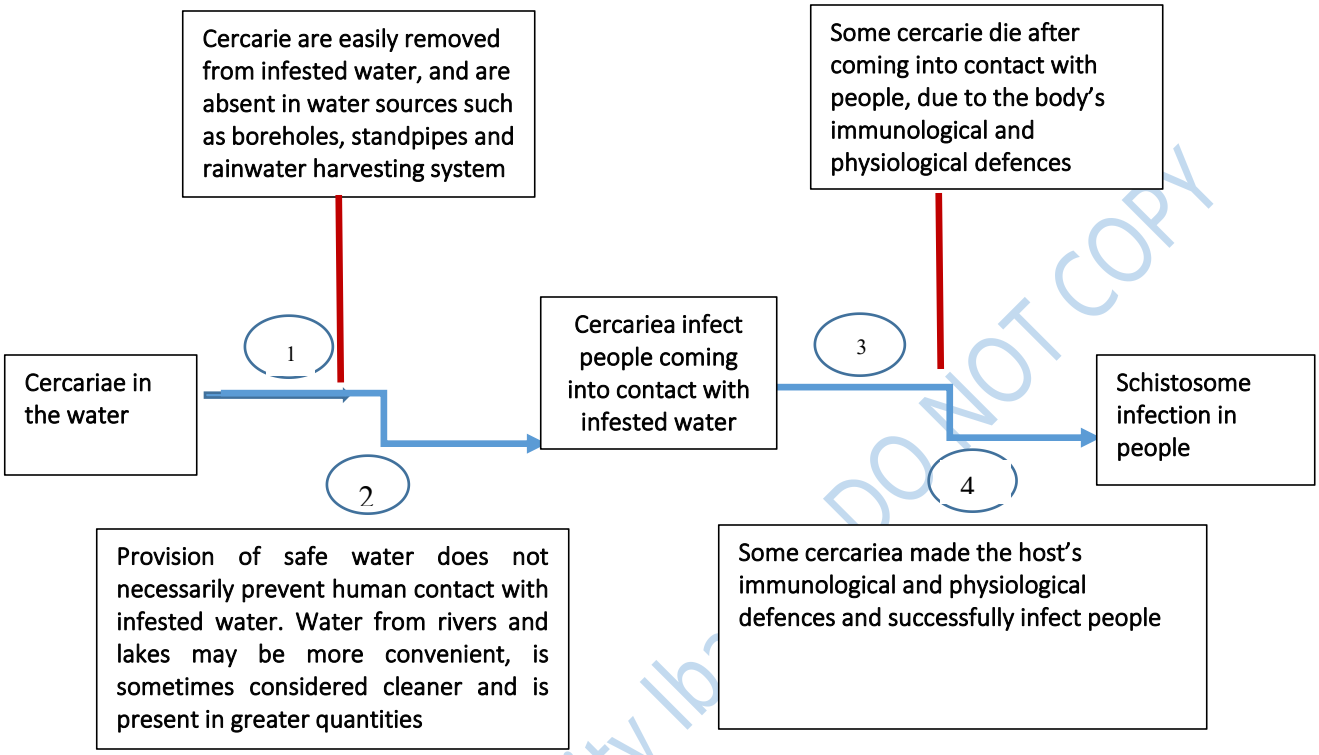

Figure 2.4: Flow diagram demonstrating the roles human water contact and immunological and physiological factors play in determining schistosome infections. Source: [70].

2.7.3 Environmental Monitoring

Schistosomiasis transmission is mainly dependent on the availability of fresh, sufficient water contact activities by infected humans and the presence of appropriate snail intermediate hosts. Nevertheless seasonal fluctuations in snail populations, infection rates, cercarial production, and water levels all influence the likelihood of infection. At the same time, flooding disasters may also cause a transient increase in infection rates in human populations [14]. The distribution of cercariae and information on snail hosts are useful tools in the prevention and control of schistosomiasis. However, using morphological identification for miracidia and cercariae taken from water sources may be inaccurate due to incorrect identification of human and non-human cercariae, which coexist in most endemic places [78]. Hence, developing PCR-based detection methods for cercariae in water samples and schistosome species in snail hosts has effectively discovered and monitored schistosomiasis transmission areas in Africa [79]. For instance, the DraI PCR was used in Moroccoto track snail transmission of *S. haematobium* cercariae because of its abundance in the *S. haematobium* genome. The DraI ribosomal sequence is exclusive to the *S. haematobium* group and can identify modest levels of DNA [80].

2.7.4 Mapping Studies and Snail Control

Mapping and geospatial analysis of schistosomiasis are also vital for tracking transmission trends and prevalence as this will bring an understanding of the disease burden and factors associated with infection. This understanding could translate to better surveillance processes and more effective control efforts [81]. Mapping research is therefore becoming a growing trend in Africa and consequently, communities that have used mapping have been able to

scale up treatment better and monitor control efforts [14]. Although most studies focus on SAC, a few studies on pre-SAC and adults have shown that these age groups (outside the school age bracket) are also at high risk of infection since they are frequently exposed to cercariae-infested water bodies as well [14]. Besides, prevalence studies that exclude pre-SAC and adults may result in inadequate treatment levels during MDA; these individuals remain potential reservoirs of schistosomiasis, thereby increasing the risk of transmission to all ages [14]. In recent times, it is commonly recognized that integrated schistosomiasis control strategies and multisectoral approaches are required to achieve elimination [82]. Therefore, reliable data on prevalence, parasite distribution, populations at risk, and other vulnerable populations, including pre-SAC children, is essential to designing effective control strategies. However, in resource-limited endemic areas, disease surveillance is limited by low-quality data. Nevertheless, predictive modeling can help design strategies for action for combined and targeted control in endemic areas [69].

Moreover, snail control is critical in preventing schistosomiasis spread; snail control with chemical molluscicides was invented and widely used in Asia, South America, and Africa from the 1950s to the 1970s, until the introduction of oral drugs for humans, led to its demise [83]. Niclosamide is the most widely used molluscicide. It is effective against all phases of the snail reproduction cycle and has been demonstrated in schistosomiasis control and elimination efforts in numerous African nations, especially Morocco [14]. The disadvantage of niclosamide is that it harms the environment and other animals, is costly, time-consuming, and does not prevent snail repopulation after treatment [14]. Hence, it has been discovered that an integrated control approach involving mass chemotherapy, snail control, increased access to potable water and sanitation, environmental and behavioral modification, and health

education is more appropriate in schistosomiasis control and can lead to elimination. This approach has resulted in the disruption of disease transmission and a significant reduction in disease prevalence in formerly endemic areas of China [14]. In Sub-Saharan Africa, the Zanzibar Elimination of Schistosomiasis Transmission (ZEST) project, which ran from 2011 to 2017, reported a significant decrease in schistosomiasis prevalence and successful elimination of the disease as a public health concern in most of its study areas [84]. Another study found a community-based MDA and snail control program in rural Kenya reduced schistosomiasis prevalence and intensity [85]. Biological control, such as introducing snail competitors or prawn species to consume the snail host populations, should also be studied [86].

2.7.5 Education and Knowledge

Poverty, a lack of adequate facilities, and a low level of awareness are major factors influencing the prevalence of schistosomiasis in Africa. In addition to MDA and WASH operations, the WHO has highlighted education as a significant part of its strategic plan for schistosomiasis control in Africa [14]. Lack of adequate information about schistosomiasis and its transmission in endemic areas is a significant risk factor that can limit the effective implementation of control measures [8]. Similarly, despite earlier control measures, a study in Zanzibar targeted at behavior change intervention in a population found that the people's awareness of schistosomiasis symptoms, transmission, and prevention was low [14]. In Malawi, children in school refused treatment during an MDA program because they were uncertain of the medication. Some of the children were terrified by the huge size and odor of the PZQ tablet and the experience of vertigo among colleagues after taking the drug. There was also skepticism in the community, with some assuming that the pill was a contraceptive or that the

medication was largely unsafe. Others kept their children at home on treatment days because they thought schistosomiasis was expected and did not see the need for treatment [87]. Compliance increased after educating and engaging the community in the MDA program, reiterating the need for community involvement in any control program [87]. This implies that frequent health education in schools can have a significant impact on health-seeking behavior and can help reduce disease prevalence among SAC [14].

Furthermore, Schisto and Ladders [TM], an interactive board game that contained information on the route of transmission, symptoms, and risk factors related to transmission, prevention of reinfection, treatment, and control efforts for schistosomiasis was developed and tested in schools in an endemic area in Ogun state Nigeria [88]. Besides improving MDA compliance, adequate knowledge of disease transmission will help the community prevent re-infection, and this is critical because there is currently no schistosomiasis vaccine [14]. Misconceptions can also arise from poorly understood education or beliefs existing in society: schistosomiasis as a sexually transmitted disease is a frequent myth that may prevent women from seeking treatment due to the associated stigma [89]. A Ugandan study found that the majority of the students knew about schistosomiasis but had no understanding of how it was transmitted [90]. However, a more recent study in Uganda showed improved knowledge of schistosomiasis and its transmission shortly after a countrywide health education campaign [91]. It is therefore critical to combine education with the provision of safe drinking water and sanitation facilities to reduce egg contamination in the environment. Some studies have reported that prevention programs successfully implemented among vulnerable groups, particularly women and children, could reduce the rate of transmission of schistosomiasis and invariably the disease's prevalence in the general population [14].

2.8 Factors Associated with Schistosomiasis Distribution and Transmission

Schistosomiasis transmission is multifaceted and influenced by individual, household, and environmental factors [92].

2.8.1 Ecological and Climatic Factors

Climatic conditions such as Rainfall, temperature, and altitude are all critical factors in Schistosoma species distribution, and understanding these factors is fundamental for effective control efforts [14]. When temperatures rise, the growth, existence, and distribution of the parasite and the snail host will be affected [78]. However, infections may reduce in particular locations when temperatures rise, creating unfavorable environments for the schistosomes and their snail hosts [60]. For instance, a study in Zimbabwe observed a three-decade decline in schistosomiasis infections during a warmer and drier climate, even though MDA and behavioral changes may have also played a significant role in the decline [93]. An Ethiopian study also reported that elevations less than 800 m above sea level support the spread of *S. haematobium* while elevation between 1300 and 2000 m above sea level favor *S. mansoni* spread [94].

Furthermore, because schistosomiasis is a water-based illness, distance from a body of water may influence its spatial distribution and transmission [95.] A study in two Chinese provinces, Hunan and Jiangxi, found that schistosomiasis prevalence was negatively associated with distance to water body, distance to nearest health facility (in minutes), and altitude (in meters) in Hunan Province. Distance to a water body was shown to be adversely associated with schistosomiasis prevalence in Jiangxi Province, but temperature was found to be positively associated with schistosomiasis prevalence [96]. Other ecological level factors studied, such as distance to health care facilities and altitude, were not associated with schistosomiasis

prevalence in this study. Similarly, a study in Anambra State, Nigeria, found that the prevalence of urinary schistosomiasis had a strong negative linear association with distance to a water body [97]. It is, therefore, important to evaluate ecological-level factors related to schistosome infection in a local setting when conducting public health interventions in that setting.

2.8.2 Socio-economic Factors

A recent study in the People's Republic of China found schistosomiasis to be related to poor wealth index [92]. Another earlier research in Kenya reported that individual-level factors such as poor sanitation, a shortage of drinking water, low socioeconomic situations, and demographic factors are closely associated with schistosome infections [98]. Similarly, a study conducted in South-West Nigeria discovered associations between schistosomiasis and low family income, a higher number of older children in the household, not living with biological parents, and living near bodies of water. Education of the household heads was a protective factor against schistosomiasis [99].

2.8.3 Artificial Activities

Growth in population size and the corresponding needs for power and water result in the need for the establishment of dams or irrigation channels and other environmental modifications [100]. Dams are critical infrastructure in many ways, including water preservation and the production of hydroelectric power. On the other hand, dams can disrupt ecosystems by disrupting the life cycles of natural schistosome intermediate snail host predators such as *Macrobrachium* spp and river prawns, resulting in increased schistosomiasis spread [14]. For example, in Senegal, the construction of a dam led to the introduction and spread of schistosomiasis into surrounding villages: the dam construction disrupted the reproduction

of river prawns, (the predators of these snails), female prawns were not able to migrate downstream for mating while young prawns were unable to move upstream to complete their life cycle [101.] However, there was a reduction in schistosomiasis prevalence immediately after these river prawns were restored to the area [101]. Similarly, in Cote d'Ivoire, there was reduced schistosomiasis prevalence during the building and operations of a dam in Raffierkro[17].

2.8.4 Human Migration

Human Migration involving the movement of people from endemic communities to new areas is introducing schistosomiasis to new areas. The rise in ecotourism and travel to remote areas put tourists at increased risk of contracting the disease, and sometimes, these tourists present with serious infection [100]. For instance, schistosomiasis has also been reported among refugees in Corsica, France in Europe coming from Africa [102]. Furthermore, in a study involving refugees and asylum seekers from Sub-Saharan Africa, many cases of urogenital schistosomiasis were recorded among the migrant population, especially those from West Africa, and many of these migrants contracted the infection as children while in Africa [39.]

2.8.4.1 Case Studies of Urinary Schistosomiasis among Migrants

There was a case study in Spain of a patient who migrated from the Dominican Republic who was diagnosed with *S. haematobium* without any history of visit to schistosomiasis endemic countries. The patient had suffered chronic symptoms since childhood, suggesting the likely source of infection was the Dominican Republic, where immigrants from Lebanon may have unknowingly introduced the infection in the 1980's. This implied that the infection had lasted more than 30 years. This patient also had a travel history of visiting south Portugal, where Bulinus snails are present, and had swum in local water bodies in Spain in a more recent travel where *Planorbarius metidjensis*, (another snail host that can transmit *S. bovis*) occurs.

This signified Europe as the more recent place of infection [14].

Similarly, long-term Barcelona inhabitants have also been diagnosed with schistosomiasis in a study carried out between the years 2002 and 2016 among people who had recently traveled to schistosomiasis-endemic countries. The study reported that in addition to 90% of the population who had symptoms of schistosomiasis, sixty-one were positive for *S. haematobium* under microscopy and antibody detection [14]. Schistosomiasis is frequently neglected in initial medical examinations of refugees and immigrants from schistosomiasis-endemic countries because signs and symptoms may not appear until much later, thereby delaying the time of diagnosis [7].

There is another case study of a 23-year-old Korean woman who lived in Kenya and Malawi for about two years, presenting with gross hematuria for one month. Her blood tests were within normal range except for eosinophilia, and thickening and calcification of her bladder were observed on the CT scan. Many *S. haematobium eggs* were seen in the bladder, and the patient was diagnosed with schistosomiasis-related cystitis and treated with praziquantel (40 mg/kg/day) twice before and after transurethral resection. This case suggests that *S. haematobium i*nfection should be considered a cause of hematuria in Korea when the patient had a history of traveling to areas endemic with schistosomiasis [103].

2.8.5 COVID-19

The world was recently ravaged by the COVID-19 pandemic, and in April 1, 2020, the WHO guidance to member states advocated deferring community surveys, active case-finding operations, and MDA outreaches in NTD programs to conform with public health measures for COVID-19 treatment and prevention [104]. Nevertheless, the WHO recommended continuous support for NTD patients who present in health facilities and the

continuation of crucial vector control efforts when possible [104]. However, people in many countries, including those in NTD-endemic countries, were hesitant to visit health care centers for fear of contracting COVID-19 [105]. Many health-care workers who were previously involved in NTD activities were co-opted into COVID-19 programs, thereby rendering portions of NTD control and treatment inoperable [14.] NTD interruptions have primarily been reported in middle- and low-income countries, where health systems are already under pressure, with South-East Asian, American, Eastern Mediterranean, and African countries being the most hit by these disruptions [105].

The public health consequences of these disruptions include, rise in the burden of NTDs in terms of both mortality and morbidity; delay in meeting public-health targets for relevant NTDs, especially elimination and eradication goals; Reduced collection, analysis, and use of epidemiological data for planning reasons [106.] Nonetheless, WHO proffered measures to tackle the impact of COVID-19 on NTD services by adapting NTD platforms to support COVID-19 tasks. Measures such as community hand washing, contact tracing, increasing awareness, resolving misconceptions, and providing sanitation supplies were adopted while following up with all necessary actors on the production, transport, delivery, and distribution of NTD medications and other medical commodities [106].

2.9 Hybrid Schistosomes

Interrogating the genetic makeup of schistosome larvae (i.e., eggs, miracidia, and cercariae) originating from definitive or intermediate snail hosts with molecular DNA methods started a revolution in the appraisal of African schistosomiasis [107.] Hybridization occurs when there is interbreeding between individuals or populations that differ in one or more inheritable characteristics. This hybridization could cause the propagation of new species, introgression,

and adaptation of the hybrids. Therefore, hybridization can be regarded as an essential evolutionary event that can have either positive or negative consequences depending on the taxa [108]. Hybridization and introgression events have been identified in a variety of species, including schistosomes, and new genes acquired during hybridization can cause the formation of novel phenotypes that can change the parasite's pathophysiology, virulence, host, and resistance [14.] The demands of some intermediate snail and final hosts make some schistosome species limited to ecological niches, thus affecting hybridization events [109]. Nevertheless, some natural and man-made activities can break down these ecological barriers, introducing these parasite species to new areas. This would lead to novel interactions between the hosts and parasites, thereby causing hybridization events [14.] Moreover, advancement in molecular technologies has allowed for the examination of interaction between species, especially *S. haematobium* in humans and its sister species *S. bovis* in cattle. These species are phylogenetically similar, and both have freshwater snails of the genius Bulinus as intermediate host [108.] This can lead to hybridization between these two species, which may contribute to disease transmission [110.]

Furthermore, several studies on *S. haematobium* and *S. bovis* have been conducted. For instance, molecular sequencing of eggs obtained from human feces and urine in northern Senegal found that 15% had hybrid genotypes, with fragments resembling *S. haematobium* and *S. bovis* [110]. Another Senegalese study involving three closely related species: human *S. haematobium*, ruminant *S. bovis,* and *S. curassoni* found *S. haematobium/S. curassoni* hybrids in nearly 90% of the children surveyed; no *S. haematobium* hybrids were found in ruminants, but *S. bovis/S. curassoni* hybrids were found in these animals [14]. The hybridization events were believed to have happened in this area due to ecological and

climate changes that resulted in overlapping distribution areas of these schistosome species and their intermediate and final hosts [14]. Similarly, in the Benin Republic, *S. guineensis* genes were found in *S. haematobium* samples taken from school children[7]. Some other studies have shown *S. haematobium* and *S. bovis* hybrids have been found in the urine samples of SAC in Niger, Senegal, Benin, Côte d'Ivoire, Malawi, France, and Cameroun[14, 111-114, 108]. Although the biological and epidemiological effects of the hybridization are not widely known yet, one of its effects is an increase in the potential for novel zoonotic forms to evolve. This has substantial implications for disease control and changes in virulence, drug sensitivity, and parasite transmission [108].

2.10 Use of Geospatial Information System in Schistosomiasis Control

Geospatial information systems (GIS) **provide** an answer to the question of where diseases are prevalent, locations of vulnerable populations, and where resources required to improve health conditions are needed the most. GIS has never been more relevant than now [115]. The global schistosomiasis control approach needs to focus on disease reduction through periodic and targeted praziquantel treatment of affected populations [116]. Understanding the spatial distribution of schistosomiasis is critical for implementing these strategies for intervention. In addition, risk maps depicting the geographical distribution of schistosomiasis might help policymakers make logical resource allocation decisions for targeted interventions. Risk mapping has been used for schistosomiasis management programs in the People's Republic of China and elsewhere, as the focus shifts from morbidity control to eradication, thereby breaking transmission [117]. Similarly, in the Philippines, GIS and remote sensing were used to demonstrate the effect of land use and topography on the spatial distribution of malaria and schistosomiasis [118]. GIS has also been used to determine the relationship between different

schistosomiasis determinants contributing to the disease transmission and high-risk areas in an endemic municipality in the Philippines [119]. Furthermore, maps generated through the application of GIS technology are helpful in guiding program policy and planning at the local level for effective and sustainable schistosomiasis control and prevention [119]

2.11 Empirical Findings

Summary of Factors Associated with Schistosomiasis in Literature

A research in Malawi found that children of rice farmers were at a higher risk of schistosomiasis than children of those working in other occupations [120]. Another study in Zanzibar revealed that male gender, closeness to river bodies, and regular water contact (washing and bathing in river bodies) were risk factors for schistosomiasis [14]. Similarly, in Mali, a study found that bathing and urinating in rivers, as well as having farming parents, were risk factors for schistosomiasis [121].

In Jigawa State, Nigeria there was an association between schistosomiasis and the male gender, age, and water contact activities such as fishing, irrigation, and swimming [107]. A similar study in Bauchi State, Nigeria, reported that risk factors associated with schistosomiasis were: male gender, 10-14 years of age, playing in shallow water, fishing, blood in urine, use of borehole water for drinking and river water for domestic purposes [122]. Similarly, another study in Eastern and Western Nigeria found that regular contact with freshwater bodies for washing/swimming, age group 12-14 years, and fathers with a primary education increased the prevalence of schistosomiasis [123]. In Nassarawa State, Nigeria, male gender, fetching from rivers, and swimming in river bodies were found to be risk factors associated with schistosomiasis [124]. A study among pregnant women in Jos, Nigeria, showed

no association between schistosomiasis and water source, water contact activities, or drug usage during MDA [125].

2.12 Theoretical and Conceptual Framework Guiding the Study Design and Analysis

This study examines factors associated with the prevalence of schistosomiasis in Ogo-Oluwa LGA, Oyo State Nigeria. The Prevalence of a disease is specifically useful to health system planners and public health professionals. Knowledge of the disease burden in a population, whether global or local, is crucial to securing the resources required to fund interventions or health-promotion programs [126]. The study aims to determine the prevalence of schistosomiasis as well as identify factors associated with the disease. The exploration of different factors—from individual, social and environmental including both natural and human moderated environments— associated with schistosomiasis are important to achieving the elimination of the disease targeted for the year 2030.

The theoretical framework offers a broad perspective on the research problem. It comprises a set of concepts, theories, ideas, and assumptions that help to understand a specific phenomenon or problems. It can be considered as a roadmap borrowed by researchers to develop their own research inquiry. A theoretical framework in research helps researchers to design and conduct their research as well as analyze and interpret their findings. The theoretical framework explains the relationship between variables, identifies gaps in existing knowledge, and guides the development of research questions, hypotheses, and methodologies to address that gap [127].

Conversely, the conceptual framework provides a narrower focus on the specific research. It is usually based on the concepts that are the main variable in the study and helps to visualize the relationships between the concepts and variables based on exiting literature. Visualizing

these possible causal relationships and pathways allows researchers to anticipate findings based on their comprehension of the theoretical literature and existing empirical studies [128].

The Social-Ecological Framework (SEF), also known as the Social-Ecological Systems Framework, is a theoretical model used in behavioral science and public health to understand the complex interactions between various factors that affect human behavior and health outcomes [129]. The SEF is a comprehensive framework for identifying relationships and outcomes within social-ecological systems [130]. It emphasizes the importance of understanding multiple levels of influence, including individual, interpersonal, and organizational, community, and policy levels [129].

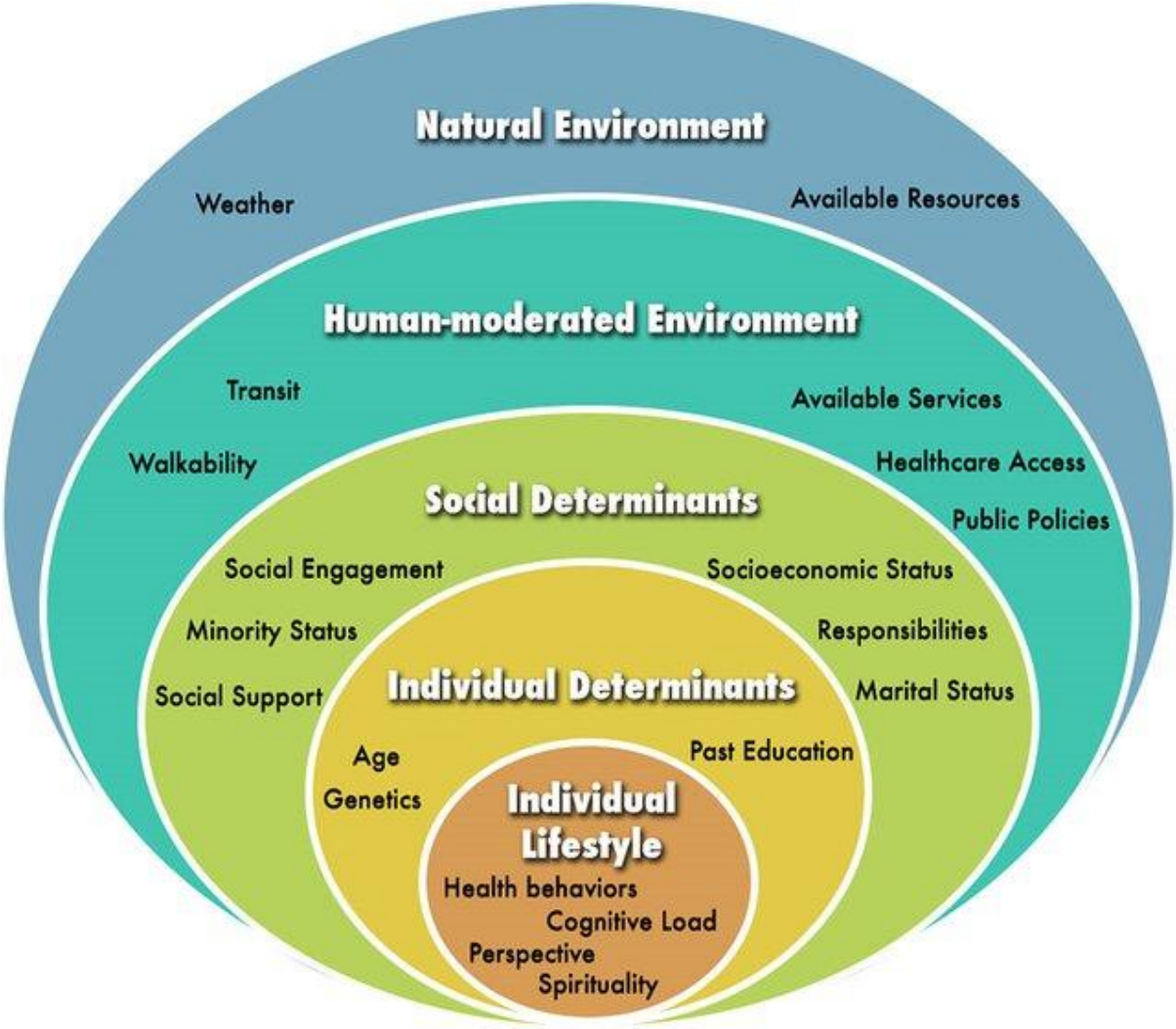

Figure. 2.5: Socio-ecological Framework (SEF). Source: [131]

Figure 2.5 shows the socio-ecological model and the five spheres (or levels) of influence (i.e., individual lifestyle, individual determinants, social determinants, human-moderated environment, and natural environment) on health behaviors and outcomes. Individuals are nested within a larger ecosystem and their embedded risks are influenced by factors within and outside of their control at each sphere of influence. This figure was adapted from a study on health promotion [132].

The SEF applied to factors associated with schistosomiasis: the first sphere embodies individual lifestyle such as visit to the river, water contact activities, and hygiene habits. Next, the second sphere includes individual determinants that are outside the individual's direct control, such as age, knowledge, attitudes and perception, past education, and occupation that affect how people may experience stressful community events [133]. Third, we include the social realm, quantifying elements such as social norms and practices[134]. Fourth is the built environment where both children and adults live, including aspects that support the nested systems, such as water sources, sanitation and hygiene facilities. Finally, the natural environment, such as the presence of water bodies, geospatial distribution of houses, and proximity to water bodies.

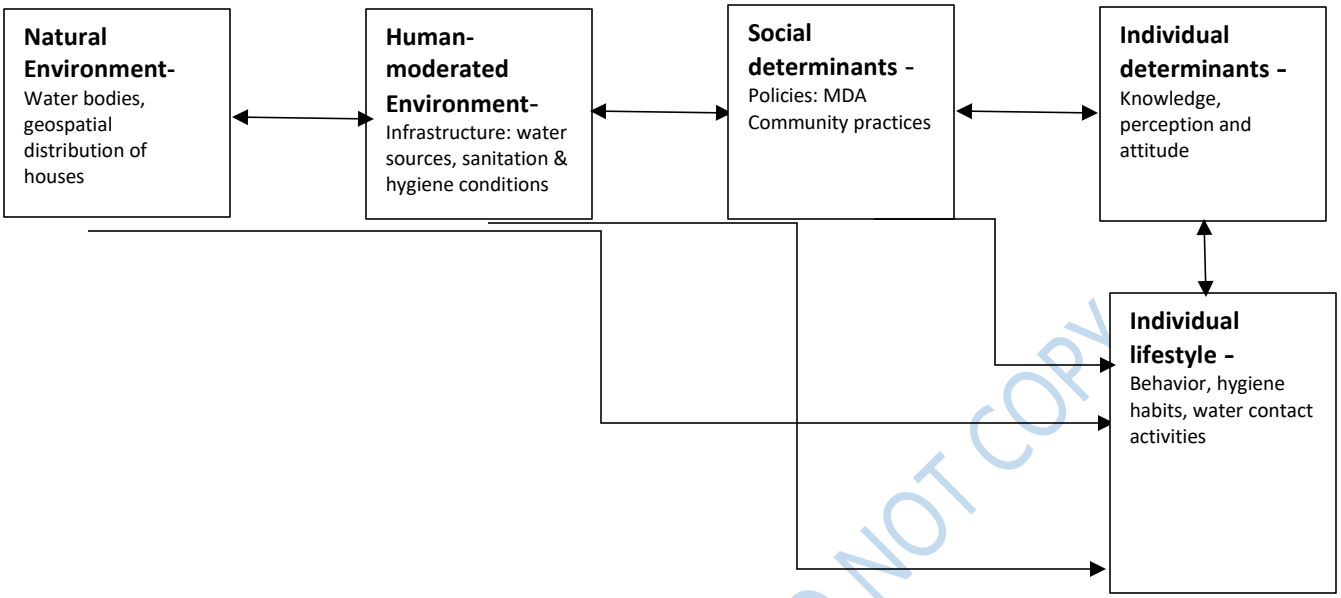

Fig 2.6: Conceptual Framework
Schistosomiasis Prevalence Framework (SPF)
Source: Researcher's work

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Chapter Three

Methodology

3.1 Research Design

A cross-sectional design was adopted for the study. Data was obtained from the study population without influencing the variables collected. Data on sociodemographic characteristics of school-age children and adult caregivers, WASH conditions of respondents' housholds, water contact activites of children, geographical coordinates of households visited, and urine samples of SAC were collected in the household settings.

3.2 Study Area

The study was carried out in Ogo-Oluwa local government area (LGA), Oyo State South-west Nigeria. The LGA was purposively chosen for the study because it was one of the four LGAs reported to have a moderate prevalence of schistosomiasis in Oyo State during the last epidemiological mapping of Schistosomiasis and Soil Transmitted Helminthiasis in Nigeria[1-2]. Ogo-Oluwa LGA was created on the 3rd of May, 1989 and its headquarters is in the town of Ajaawa located a few kilometers from Ogbomoso. The Local Government shares borders with Ejigbo LGA of Osun State in the east, Oyo East LGA and Afijio LGA in the south, Ogo-Oluwa West Local Council Development Area in the north, and Oriire LGA in the west [3, 4]. Ogo-Oluwa LGA covers a total area of 369 square kilometers and has an average temperature of 28°C. The LGA witnesses two distinct seasons annually: dry and wet seasons with an average humidity level estimated at 57% [4]. The LGA currently has ten political

wards: Ajaawa I, Ajaawa II, Ayede, Ayetoro, Idewure, Lagbedu, Iwo-Ate, odo-oba, Opete and Otamokun. The estimated population of Ogo Oluwa LGA was 65,184 during the 2006 census inhabitants [5].

Otamokun was purposively chosen for the work because of its high schistosomiasis endemicity [2]. Otamokun is located in the rural area of Ogo-Oluwa with geographical coordinates 7° 57' 0" North, 4° 11' 0" East [6]. Otamokun has a primary health center located close to the entrance of the community that offers antenatal care services, immunization, HIV/AIDS services, family planning, community mobilization for mass drug administration of medicine, and some other services. Agriculture is the major economic activity of community's inhabitant – cattle and goat farming, and food crops farming. Trading in raw food items and cooked food is also a common means of livelihood in the community. Yorubas form the majority of the area's inhabitants with the Yoruba language commonly spoken in the community while Christian and Islamic religions are practiced in the area. The entire area is well drained by seasonal rivers including rivers Amuro, Igbo, and Owo and their tributaries. The Amuro River is the largest of all and it flows around the community. The rivers are used mainly for agricultural purposes including irrigation during dry season, cattle grazing and watering. Children also engage in recreational activities such as swimming, bathing, fishing, fetching water especially during the dry season. Young women also visit the rivers for laundry purposes. Boreholes and wells are the major sources of drinking water. Otamokun has wet and dry seasons and most rains fall from March to October. Most households in Otamokun exist according to their family names, there are 16 families and a small settlement named Oguoo.

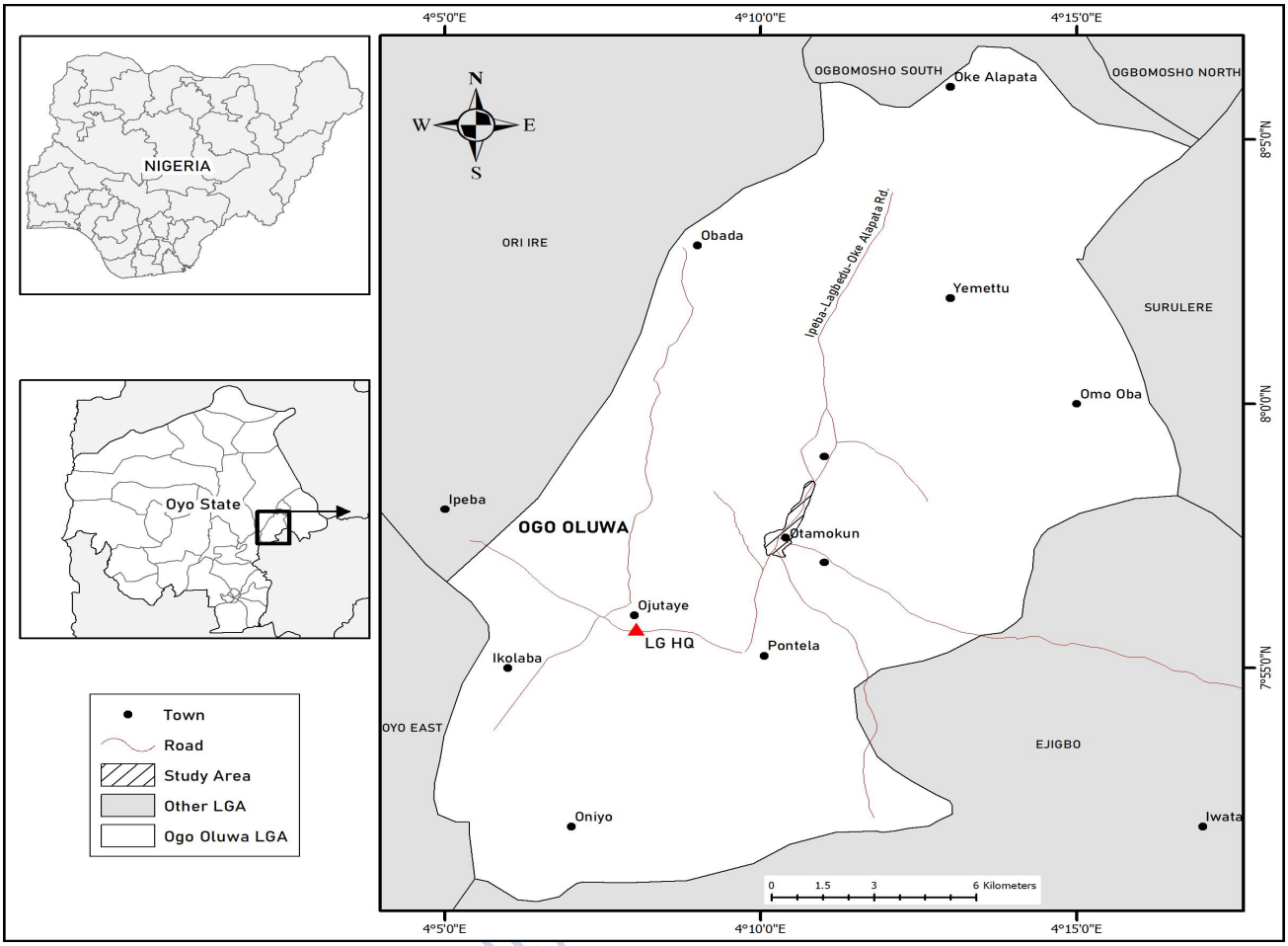

Figure 3.1: Location Map of Study Area [6]

3.3 Population and Sample

The study population comprised of school-age children and an adult member of the same household residing in Otamokun. The children were between ages 5-17 years and the adult household members were age 18 years and above.

3.4 Sample Size Determination

The sample size was determined using the online Raosoft sample size calculator [7]

x = $Z^2 r(100 - r)$

E = $\sqrt{\frac{(N-n)x}{n(N-1)}}$

n = $\frac{Nx}{((N-1)E^2+x)}$

Where

n = Sample size

N = population size = 20,000

E = Error margin 5%

r = Prevalence 21.2% [8]

Z = critical value for the confidence level c 1.96

The minimum sample size calculated was 279.

10% Non-response rate = $\frac{1}{1-f}$

= $1/(1 - 0.1)$ = 1.11

Total sample size = 279 X 1.11 = 309.6 ~310

A minimum of 310 children-adult pairs were targeted and a total of 321 children-adult respondents were selected from the community

3.5 Sampling Technique

A multistage sampling technique was used to sample the study respondents.

Stage 1: Ogo-Oluwa LGA was purposively selected from the four moderately endemic LGAs in the state [9] (Table 3.1)

Table 3.1: Grouping of LGA by schistosomiasis endemicity

No (0%)	Low (>0<10%)	Moderate (>10<50%)
Ido	Afijio	Iwajowa
Ibadan north-west	Akinyele	Ogo-Oluwa
	Atiba	Saki East
	Atisbo	Saki West
	Egbeda	
	Ibadan North	
	Ibadan North-East	
	Ibadan South-East	
	Ibadan South-West	
.	Ibarapa Central	
.	Ibarapa East	
.	Ibarapa North	
.	Irepo	
.	Iseyin	
.	Itesiwaju	
.	Kajola	
.	Lagelu	
.	Ogbomoso North	
.	Ogbomoso South	
.	Olorunsogo	
.	Oluyole	
.	Ona ara	
.	Orelope	
.	Orire	
.	Oyo East	
.	Oyo West	
.	Surulere	

Source: [2]

Stage 2: All ten wards in Ogo-Oluwa LGA were grouped into Low, Moderate and High level of endemicity as recorded by the health district which served as the Implementation Unit (IU) during the FMOH survey (Table 3.2).

Stage 3: Otamokun ward was purposively selected because of its high level of endemicity[9].

Table 3.2: List of wards in Ogo-Oluwa LGA according to level of endemicity

Low	Moderate	High
Iwoate	Ayede	Otamokun
Opete	Ayetoro	
	Idewure	
	Lagbedu	
	Odo-oba	
	Osupa	

Source: [9]

NB: Data was not available for Ajaawa during the FMOH mapping

Stage 4: Household listing

Listing of eligible household was carried out and a total of 705 households were found to be eligible

Stage 5: Selection of Study Participants

Systematic sampling was used to select study participants using every second household but only children who had adults at home at the time of visit were recruited into the study. An adult and a child were selected from each household visited and for households with more than one child in the age group targeted, the one with the most frequent water contact activities was selected as the index child. Water contact activities referred to bathing, swimming, fishing, washing, and fetching water in open water sources such as rivers.

3.6 Inclusion Criteria

i. School-age children who had not taken any anthelminthic (whether orthodox or traditional) medications six months before the study

ii. Both children and adult pairs who had lived in the community for at least 6 months.

3.7 Exclusion Criteria

i. Children who were apparently ill

ii. Children whose parents did not agree to participate in the survey

3.8 Research Instruments

3.8.1 Questionnaire

A semi-structured questionnaire was designed to elicit information from children and adults in the household. The children's questionnaire consisted of five sections:

A: Socio-demographic characteristics

B: History of Migration and consumption of drugs during MDA activities

C: Water contact activities

D: Self-report on signs and symptoms of schistosomiasis

E: Laboratory information

The adult questionnaire consisted of three sections:

A: Socio-demographic characteristics,

B: Water, Sanitation, and Hygiene Practices

C: Hand washing practices

3.8.2 Checklist: This was used to assess the sanitation, and hygiene conditions of the household visited including designated place for hand washing, availability of detergent and water for hand washing, availability of sanitary facilities.

3.8.3 Kobocollect app for Android devices v 2021.3.4: was used to collect data from the respondents. The questionnaire and checklist were scripted initially on the kobocollect software and the app was installed on Android devices and then tested by trained research assistants before use. At the end of each interview; coordinates of the household visited were captured by the kobocollect app and stored with the other data collected on the android devices. Each participant's form was submitted to the kobocollect server every day.

3.9 Procedure for Data Collection

3.9.1 Advocacy Visit

Advocacy visits were first made to necessary stakeholders including Ogo-Oluwa LGA's Primary Health Care coordinator, the LGA NTD coordinator and the community leaders- Baale, and Chiefs- to communicate the purpose of the study and seek their approval to carry out the study. The Baale gave information that households in the community exist in clusters

according to their family structure and the community has a total of 16 families and one small settlement- Oguoo. Three of the families Omo Ade, Eniola and Lagunju did not give consent to participate in the study. The sample size was thus obtained from the 13 consenting families and Oguoo. Unique codes were assigned to houses with children within the target age group within each cluster. After the community entry, visits were made to the household, and the purpose of the study was communicated to respondents after which Adults were required to give written informed consent and the children gave verbal permission before participating in the study.

3.9.2 Survey Data Collection

Data were collected by the principal investigator and four research assistants who were trained with the data collection tools on kobocollect app in May, 2022. A dry run was conducted to test their efficiencies which was reviewed before the data collection. The adult in each household was interviewed first before the child. The checklist was then used to assess the sanitation and hygiene conditions of the houses.

3.9.3 Urine Sample Collection

After the survey, each child was asked to produce their fresh urine samples in a clean dry container between the hours of 10:00 am-2:00 pm which is the peak period when *the S. haematobium* eggs are shed by infected people. Each bottle was labeled with the unique ID assigned to each child. Urine samples were stored and transported in giostyle boxes with ice packs to the laboratory where the urine microscopy was carried out.

3.9.4 GPS Data Collection

The geographic coordinates (Latitude and Longitude) of the houses visited were taken at the end of the interviews with the kobocollect app and each interview was saved on the Android

devices.

Data collection was carried out between July-September, 2022.

3.10 Validity of Research Instruments

To ensure the instrument's validity, most of the questions were adapted from the schistosomiasis manual and other previous studies on schistosomiasis [10-12]. The content validity was ensured by review from subject experts. Adjustments made to the tool included-removing irrelevant questions, simplifying ambiguous questions, and adding some pertinent questions. All questionnaires were translated into Yoruba for ease of administration in the community. The tool was pretested before the commencement of the study.

3.11 Reliability of Research Instruments

The consistency of the items within the test instrument was checked using about 10% of the sample size calculated i.e 30 residents of Olosun, a community with similar characterisitics with the study area and endemic with schistosomiasis in Ibadan, Akinyele LGA. The Cronbach alpha score obtained for each section of the questionnaire are presented in table 3.3 below:

Table 3.3: Reliability Coefficient of Research Instrument

	Section	No. of items	Cronbach alpha
1	WASH	16	0.73
2	Prevalence of SCH	3	0.78
3	GIS	4	0.80
4	Factors associated with USCH	9	0.82

Source: Researcher's field survey, 2022

3.12 Data Analysis and Management

Data were downloaded from the kobo-collect server in CSV format and exported to IBM-SPSS version 20 (International Business Machine-Statistical Product and Service Solution version 20. They were cleaned and analyzed using descriptive and inferential statistics. Descriptive statistics used included: frequencies, percentages and means for the socio-demographic characteristics, WASH conditions of households, urinalysis results, geospatial distribution etc. Inferential statistics such as chi-square tests, and binary logistic regression analysis were used to test associations between dependent variables (age, gender, education, occupation of respondents, household size etc) and independent variables (household WASH conditions, schistosomiasis status, water contact activities etc). Statistical significance was set at 5% and confidence interval at 95%.

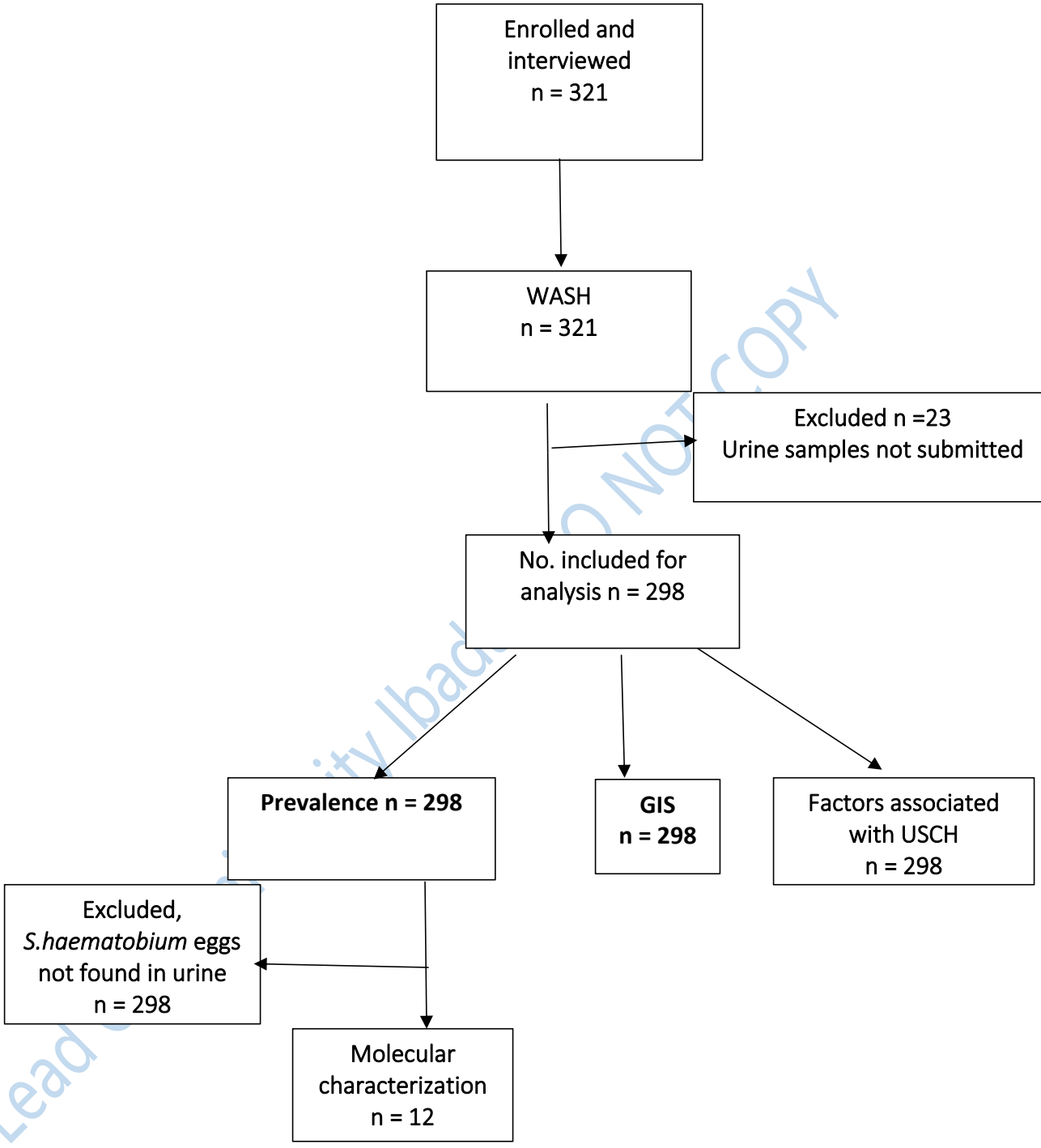

Figure 3.2: Consort diagram showing sample size for each study objective analysed **Source: Reearcher's Field Survey, 2022**

3.13.1 Assessment of the Water, Sanitation, and Hygiene (WASH) Conditions of Households

3.13.1.1 Water Source

The water sources for both drinking and other household purposes for the study population were collected by a questionnaire and reported in frequencies and percentages. According to the WHO classification, water sources were classified as improved and unimproved. Improved drinking water sources are defined as those that are likely to be protected from outside contamination, especially fecal matter. Improved water sources include: household water connections, public standpipes, boreholes, protected dug wells, protected springs, and rainwater collection. Unimproved water sources include those that were likely to be unprotected from outside contamination, especially fecal matter e, g. unprotected wells, unprotected springs, surface water (e.g., river, dam, or lake), vendor-provided water, and tanker truck-provided water [10]. Drinking water from an improved source is so classified, provided that the water source is free of contamination and collection time is at most 30 minutes for a roundtrip, including queuing [10].

3.13.1.2 Sanitation facility

Information on the availability and type of sanitary convenience and waste disposal methods used in the households was obtained through the questionnaire and a checklist. Sanitation type was classified as improved and unimproved according to the WHO classification. Improved sanitation facilities are those that hygienically separate human waste from human contact. Improved sanitation included: flush or pour-flush to piped sewer systems, septic tank or pit latrines, ventilated-improved pit latrines, or pit latrines with a slab or composting toilets. Shared or public-use sanitation facilities are not considered to be improved.

Unimproved sanitation referred to sanitation facilities where there is possible contact between humans and human waste and this includes: flush or pour-flush to elsewhere, pit latrines without slabs or open pits, bucket latrines, hanging latrines, or open defecation [10.] Results are presented as frequency and percentages in tables.

3.13.1.3 Hygiene Condition

The hygiene condition of the households visited were assessed by the checklist consisting of the presence of a place designated for hand washing, the availability of soap and water. Handwashing practice was asesssed with the questionnaire. Results are presented as frequency and percentages in tables and bar charts.

3.13.2 Urine Sample Analysis

Urine assay were performed by two trained laboratory scientists using standard procedure for examining urine samples for *S. hematobium* eggs [11]. 10ml of each urine sample were measured into plain tubes and centrifuged at 400× g, and each sediment was examined by wet mount [11]. Using the microscope under 10x and 40x objective lenses. *S. hematobium* eggs, red blood cells (RBCs), pus cells, epithelial cells, yeast cells, and crystals were observed and counted where present. Where *S. haematobium* eggs were present, infection was categorized as: light (1-9 eggs/10ml sample), moderate (10-49 eggs/10ml sample), and heavy (≥50 eggs/10ml sample). The prevalence of the disease in the study population was calculated by dividing the total number of children positive for the disease after urine microscopy by the total number of children examined.

3.13.3 Geospatial Distribution of Schistosomiasis in Otamokun

To arrive at the geographical distribution of the disease in the study area, an open-source GIS software (QGIS 3) was used to generate a map of the outcome of the survey conducted. The

unique identification numbers of the houses and the children and the geographical coordinates of the sampled houses collected were exported to Excel. Urine microscopy results: whether positive or negative for schistosomiasis of each child screened was entered against the child's details. The data were put on the QGIS software and used to map the disease distribution in the community.

To report the prevalence of schistosomiasis in Otamokun, OOLGA a mesh of 100 m by 100 m grids was developed. The grid sampling method was adopted as in previous studies [12, 13]. Each grid contains a sample of children from the study population. The algorithm in the QGIS software used the total number of entries within each cell with the total number of children positive with the disease in each cell to calculate the proportion of children with SCH within the cell and assigned the value in percentage. The grids were classified into four categories based on the percentage of children with 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%).

3.13.4 Molecular Characterization of *Schistosoma haematobium* in the Study Population

To determine the phylogeny of *S. haematobium* in the study population, all the positive samples for *S. haematobium* eggs after urine microscopy were sent for molecular characterization. The PCR assay was used to detect the DNA of *S. haematobium* in the urine samples. All molecular work was done in the Bioinformatics lab, Mokola, Ibadan.

3.13.4.1 DNA Extraction Using Modified Dellarporta Procedure

To 5ml of each urine sample, 5ml of DNA Extraction Buffer (DEB) containing proteinase K (0.05mg/ml) and the vortex was added and the mixture was transferred to a 25ml falcon tube. 20% Sodium Dodecyl Sulphate (SDS) was added and the mixture was incubated in a water bath at 65°C for 30 minutes. Tubes were allowed to cool to room temperature after which 1000µl of 7.5M Potassium Acetate was added and the solution was mixed briefly. The mixture was centrifuged at 13000rpm for 10 minutes after which the supernatant was transferred into new fresh autoclaved tubes. 2/3 volumes of cold Isopropanol / Isopropyl alcohol was added to the supernatant; tubes were inverted 3-5 times gently and incubated at -20°C for 1 hour after which the solution was centrifuged at 13000rpm for 10 minutes and the supernatant was discarded. 3ml µl of 70% ethanol was added and centrifuged for 5 minutes at 13000rpm. The supernatant was carefully discarded with the DNA pellet intact. Traces of ethanol were removed and the DNA pellets were dried at 37°C for 10-15 minutes. DNA pellets were resuspended in 100µl of Tris-EDTA (TE) buffer, DNA was aliquot, and stored at -20°C for further lab analysis [14]

3.13.4.2 Electrophoresis for DNA

1% agarose was prepared by dissolving 1g of agarose with 100ml 1xTAE in a microwavable flask. The solution was put in the microwave for 1-3 mins until the agarose was completely dissolved (but caution was taken to avoid overboiling the solution, as some of the buffer will evaporate and thus alter the final percentage of agarose in the gel. The agarose solution was allowed to cool down to about 50°C (when hands can comfortably be kept on the flask), for about 5 mins. 10µl EZ vision DNA stain was added so to visualize the DNA under ultraviolet

(UV) light. The agarose was poured into a gel tray with the well comb in place at 4°C for 10-15 mins and allowed to sit at room temperature for 20-30 mins until it completely solidified [15]. See appendix VI

3.13.4.3 PCR

A PCR targeting the Schistosoma-specific COX-1 gene sequences of *S. hematobium* was done for the identification of specific Schistosoma spp. DNA in urine specimens [16]. Each PCR run was done in duplicate and included negative control and positive *S. haematobium*. The PCR condition was done following Hove's procedure [16]. The multiplex PCR products were examined on agarose gel and were visualized under ultraviolet light. Table 3.4 shows the primers used and their sequences.

Table 3.4: Used primers and their sequences

Primers	Sequence	Expected product size (bp)	Annealing temperature (°C)
CytochromeOxidase 1 gene	5′-TTT TTT GGT CAT CCT GAG GTG TAT-3′	543	58˚C
CytochromeOxidase 1 genereverse primer	(5′-TGA TAA TCA ATG ACC CTG CAA TAA-3′	375	

Source: Researcher's Field Survey, 2022

3.13.4.4 PCR Mix Components

The PCR mix is made up of 12.5µl of Taq 2X Master Mix from New England Biolabs (M0270); 1µl each of 10µM of Cytochrome Oxidase 1 gene forward (5′-TTT TTT GGT CAT CCT GAG GTG TAT-3′) and reverse primer (5′-TGA TAA TCA ATG ACC CTG CAA TAA-3′); 2µl of DNA template and then made up with 8.5µL Nuclease free water [17].

3.13.4.5 Cycling Conditions

Initial denaturation was carried out at 94˚C for 5mins, followed by 36 cycles of denaturation at 94˚C for 30secs, annealing at 58˚C for 30secs, and elongation at 72˚C for 45secs and finally followed by a final elongation step at 72˚C for 7 mins and with temperature held at 10 ˚C forever [1].

3.13.4.6 Electrophoresis for PCR

The same procedure for DNA electrophoresis was repeated for PCR electrophoresis except that 2% agarose gel and not 1% was used [15].

3.13.4.7 Loading Samples and Running on Agarose Gel

Loading buffer was added to each of the DNA samples or PCR products. Once solidified, the agarose gel was placed into the gel box (electrophoresis unit). The gel box was then filled with 1xTAE (or TBE) until the gel was covered. The molecular weight ladder was carefully loaded into the first lane of the gel and other additional wells. The gel was run at 80-150 V for about 1-1.5 hours. The gel was removed after the power was turned off and the electrodes have been disconnected from the power source. DNA fragments or PCR products were visualized under a UV transmunator [15]. See appendix VII

3.13.4.8 DNA Sequencing

The amplified fragments were sequenced using a Genetic Analyzer 3130xl sequencer from Applied BiosyZazw278 cstems using the manufacturers' manual while the sequencing kit used was that of Big Dye terminator v3.1 cycle sequencing kit. Bio-Edit software and MEGA X were used for all genetic analyses [17].

3.13.4.9 Evolutionary Relationships of Taxa

Phylogenetic tree is an evolutionary relationship among a set of organism or group of organisms [18]. The homology of the pathogen isolated from the urine samples was queried on NCBI using BLAST. BLAST is an algorithm and program for comparing primary biological sequence information such as the amino-acid sequence of proteins or the nucleotide of DNA and or /RNA sequences. BLAST searches for regions of local similarity between protein or nucleotide sequences. The program compares nucleotide or protein sequences to database sequences and computes the statistical significance of the matches, known as the expect value [19]. BLAST "query" sequences are given as character strings of single letter nucleotide or amino acid codes, preceded by a definition line, beginning with a ">" symbol and containing identifiers and descriptive information [20].

The evolutionary history was inferred using the Neighbor-Joining method [20]. The Phylogenetic tree is shown (next to the branches). The evolutionary distances were computed using the Maximum Composite Likelihood method and are in the units of the number of base substitutions per site. This analysis involved 16 nucleotide sequences [21]. Codon positions included were 1st+2nd+3rd+Noncoding. All ambiguous positions were removed for each sequence pair (pairwise deletion option). There were a total of 475 positions in the final dataset. Evolutionary analyses were conducted in MEGA11 [22].

3.13.5 Factors Associated with Schistosomiasis

Factors associated with schistosomiasis were divided into three categories including socio-demographic, behavioral, and environmental factors.

Socio-demographic characteristics examined were gender, age, and father and mother's occupation

Behavioral factors included: the child's visit to the river, and activities carried out when at the river such as swimming, playing, fetching water, urinating in the river, fishing, farming, and crossing water.

Environmental factors examined included: the use of improved/ unimproved water sources for other household needs, the use of improved/ unimproved sanitation, the availability of water, and the availability of soap in the household for hand washing at the time of visit.

The Chi-square test was initially used to determine the association of these factors with schisosomiasis after which logistic regression was carried out to determine the degree of association. The level of significance, odds ratio, and confidence interval for each variable are presented in tables.

3.14 Ethical Considerations

Ethical clearance/ Approval for the study was obtained from the Ethical Review Board of the Oyo State Ministry of Health with the approval number AD 13/479/44519[B].

Confidentiality of data: All research materials were properly kept on computers where only research team had access to them.

Translation of study tool to local language: The survey questionnaire was translated into Yoruba.

Beneficence to participants: The study had no financial benefits to participants, but study findings provide information on the geographical distribution of schistosomiasis by identifying endemic foci of schistosomiasis within the community studied. The study also delineates factors associated with schistosomiasis. This study provides empirical data on the prevalence of schistosomiasis in the community and would perhaps influence health interventions for schistosomiasis control in the state.

Non-maleficence. The study posed no harm to the respondents, the Research assistants were of good conduct and did not act coercively or in any unethical manner towards the research participants.

Right to decline/withdraw from study: Participation in the research was voluntary; no one was coerced to participate. Respondents were free to withdraw from the study at any time during the study period.

Informed consent: An informed consent form was prepared for adult respondents to sign as an indication of their consent after explaining the purpose of the research's purpose. Verbal consent was obtained from children before participation in the study.

Voluntary Participation: No respondent was coerced to participate in the study, only those who volunteered were surveyed.

Right to decline/ withdraw from the study: All respondents had the right to discontinue or withdraw at any time without any penalty or adverse effects.

Endnotes

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Chapter Four

Results and Discussion of Findings

4.1 Socio-demographic Characteristics of the Respondents

A total of three-hundred and twenty-one (321) children-adult pairs were sampled for the survey however, 298 (92.8%) children returned the sample bottle. The mean age of the children was 9.98 ±2.99 years. One hundred and twenty children (37.4%) were in the 5-8 years' age bracket, and almost one-quater (24.0%) were between ages 13-17 years old. More than half of the children surveyed were males 192 (53.6%) and almost two-fifth had lived beyween 6-10 years in the community studied (Table 4.1a). The mean number of years lived in the community by the children surveyed was 7.8± 4.14 years. Almost half 151 (47%) had fathers who were farmers; very few had fathers working as civil servants 28 (8.7%), other fathers worked as traders 66 (20.6%) and artisans 48 (23.7%). Concerning the mothers' occupation, over half 171 (53.3%), were traders, less than one-quarter (23%) were farmers, 48 (15%) worked as artisans and a few 12 (3.7%) were unemployed (Table 4.1a).

Of the adult respondents (Table 4.1b), more than two-thirds 224 (69.8%) were females, about one-third 104 (32.6%) were between ages 35-49 years old while slightly above 10% were aged 50 years and above. The mean age of the adult population was 32.20± 14.97 and almost three-quarter were married 234 (72.9%). Concerning the educational level of the adults surveyed, about half 178 (55.2%) had no education or primary education. More than one-third had only secondary education 116 (36.1%). Two-thirds 217 (67.6%) were Christians. More than half 184 (57.3%) had a family size of six or less. The mean number of years lived in the community was 18.47 ± 15.91 years and most of them had spent ten years or more in

the study community, 210 (65.4%). Less than half, 146 (45.5%) of the respondents were from the study community

Table 4.1a**: Socio-demographic Characteristics of Children aged 5-17 years**

	Frequency n =321	Percentage (%)
Age		
5-8	120	37.4
9-12	124	38.6
13-17	76	24.0
Gender		
Male	172	53.6
Female	149	42.4
Time lived in community (Years)		
0-1	28	8.7
2-5	71	22.1
6-10	128	39.9
11-16	94	29.3
Father's Occupation		
Civil/public servant	28	8.7
Farming	151	47.0
Trading	66	20.6
Artisan	76	23.7
Mother's Occupation		
Civil/public servant	74	5.0
Farming	74	23.1
Trading	171	53.3
Artisan	48	15.0
Unemployed	12	3.7

Source: Researcher's Field Survey, 2022

Table 4.1b: Socio-demographic Characteristics of Adult Respondents

	Frequency n = 321	Percentage (%)
Gender		
Male	97	30.2
Female	224	69.8
Age group		
18-24	89	27.9
25-34	86	26.8
35-49	104	32.6
≥50	40	12.5
Marital status		
Never married	69	21.5
Married	234	72.9
Widowed	16	5.0
Seperated/ divorced	2	0.6
Highest Education		
None/primary	178	55.2
Secondary	116	36.1
Tertiary	27	8.4
Religion		
Christianity	217	67.6
Islam	104	32.4
Household size		
≤6	184	57.3
>6	137	42.7
Years lived in community		
<1	6	1.9
1-4	59	18.4
5-9	46	14.3
≥10	210	65.4
Native of community		
No	175	54.5
Yes	146	45.5

Source: Researcher's Field Survey, 2022

4.2 Water, Sanitation and Hygiene (WASH) Condition of Respondents' Households

4.2.1 Water Sources of Respondents' Households

From Table 4.2 below, the majority 202 (62.8%) of the respondents got drinking water from improved sources. However, only about half of the respondents 165 (51.4%) obtained water for other household purposes from improved sources. A few respondents visited the river for drinking water 37 (11.5%) and other household purposes 62 (19.3%) respectively. The majority of the study participants 280 (87.2%) had the water source located outside of their houses and the water collection time for a round trip for most of them 227 (70.7%) was less than five minutes, only a few of the respondents will spend up to thirty minutes to collect water 22 (6.9%). Concerning water treatment, only a little above one-third 116 (36.1%) carried out any treatment before drinking the water. Treatment carried out included: the addition of alum 52 (44.8%), filtration 25 (28.3%), and chlorination 16 (13.9%), while a few 13 (11.3%) purified their water for drinking by adding salt or kerosene.

Table 4.2: Water Condition of Respondents' Households

Drinking Water source	Frequency n = 321	Percentage %
Improved sources	202	62.9
Unimproved sources	119	37.1
Water for other household use		
Improved sources	165	51.4
Unimproved sources	156	48.6
Location of water source		
In Own Dwelling Yard/Plot	41	12.8
Elsewhere	280	87.2
Water collection Time (minutes)		
≤5	227	70.7
6-15	72	22.4
>15 mins	22	6.9
Water treatment before use		
Yes	115	35.8
No	206	64.2
Types of Water treatment		
Addition of Alum	51	44.3
Addition of chlorine	16	13.9
Boiling	10	8.6
Strain with cloth	25	21.7
Addition of salt/kerosene	13	11.3

Source: Researcher's Field Survey, 2022

4.2.2 Sanitation Conditions of Respondents' Household

About three-quarters of the population studied 242 (75.4%) had no toilet facility at the time of visit and practiced open defecation. Of the one-quarters 79 (24.6%) who had a toilet facility, two out of every five of households in the survey community shared the toilet facility with some other households. The average number of households who shared a toilet facility for the population studied was 4.8±2.2. More than half, 19 (57.6%) of the 33-toilet facilities in the study population were shared by five or more households. The majority, 259 (81.0%) of the respondents dumped their waste in bushes/ vacant land areas, 94 (29.3%) burnt their waste. Overall, the majority 245 (76.3%) of the households studied practiced unimproved sanitation (Figure 4.1).

Table 4.3: Sanitation Conditions of Respondents' Household

	Frequency	Percentage (%)
Presence of toilet facility n = 321		
Yes	79	24.6
No	242	75.4
No. of HHs Sharing toilet n = 79		
Yes	33	41.7
No	46	58.2
No. of HH sharing a toilet n = 33		
≤4	14	42.2
≥5	19	57.6
Type of toilet facility n = 321		
Improved		23.2
Unimproved		73.6
Waste disposal method		
Burning	94	29.4
Burying	10	3.1
Dumping in bush/ deserted land	259	80.9
Dumping in river	6	1.9

Source: Researcher's Field Survey, 2022

4.2.3 Hygiene Conditions of Household and Respondents' Hand Washing Practice

Only about 20% of the respondents had a place designated for hand washing in their homes (Figure 4.2).). Less than one-third 104 (32.6%) washed their hands in different places around their houses including outside, in a bowl, etc. while others 198 (61.9%) did not show where they washed their hands. About two-thirds 213 (66.3%) had water available for hand washing and over half, 182 (57.0%) had soap available for hand washing at the time of carrying out the study and slightly above half (55.1%) have both soap and water available for handwashing at the time of visit (Figure 4.1)

Concerning respondents' hand washing practice, majority washed their hands before and

after eating 312 (97.5%); before, during and after food preparation 235 (73.4%), after toilet use 231 (72.2%), and after touching garbage 200 (62.5%). About one-third reported washing their hands after sneezing, coughing or blowing their nose 107 (33.4%). Less than one-third of the respondents reported washing their hands after leaving a public place 68 (21.3%), and after touching pets or animal waste 92 (28.8%) (Table 4.4)

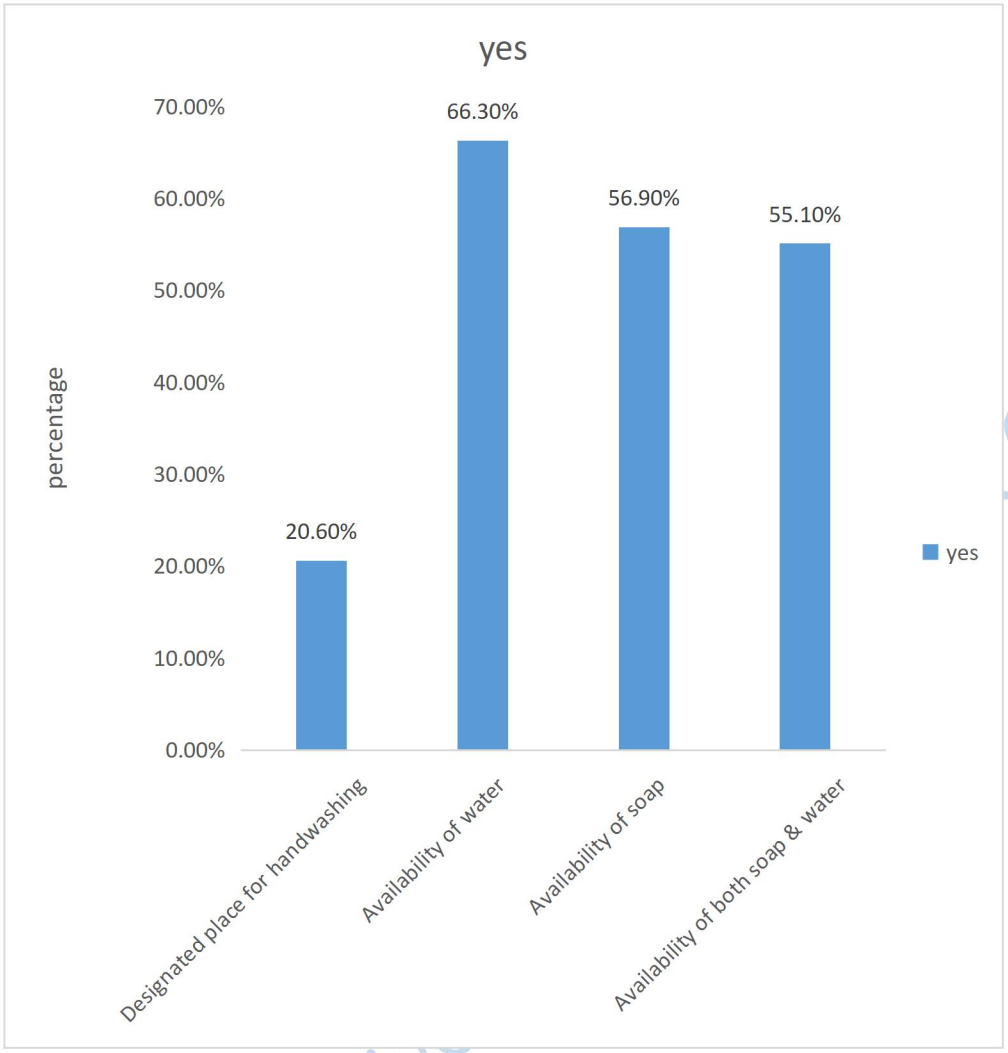

Figure 4.1: Hygiene Conditions of Respondents' Households

Source: Researcher's Field Survey, 2022

Table 4.4: Hand Washing Practice of Respondents

Periods of Hand washing	Frequency n = 321	Percentage 100%
Before, during and after preparing food		
Yes	236	73.5
No	85	26.5
Before and after eating		
Yes	302	94.1
No	19	5.9
Before and after caring for a sick person		
Yes	135	42.1
No	186	57.9
Before and after treating a cut or wound		
Yes	133	41.4
No	189	58.6
After using the toilet		
Yes	232	72.3
No	89	27.7
After cleaning up a child who used the toilet		
Yes	125	38.9
No	197	61.1
After blowing nose, coughing, or sneezing		
Yes	108	33.6
No	213	66.4
After touching an animal, animal feed, or animal waste		
Yes	93	29.0
No	228	71.0
After touching garbage		
Yes	200	62.3
No	121	37.7
After leaving a public place		
Yes	68	21.2
No	253	78.8

Source: Researcher's Field Survey, 2022

4.2.4 Factors Associated with Water, Sanitation and Hygiene in Respondents' Household

4.2.4.1 Factors Associated with Water Availability in Respondents' Household

Following binary logistic regression, age of respondents was found to be significantly associated with water availability in the household with respondents aged 18-24 (sig: 0.029, aOR: 3.48, 95CI: 1.137-10.63) and 25-34 (sig: 0.009, aOR: 3.96, 95CI: 1.42-11.08) years having a 3 or more times higher odds of having water in their houses compared to those older, aged 50 years and above. For education, respondents with no education were three times less likely (sig: 0.005, aOR: 0.287, 95CI: 0.37-0.78) and those with primary education were two times (sig: 0.035, aOR: 0.50, 95CI: 0.26-0.95) less likely to have water in their households when compared with those with secondary education. House hold size was not significantly associated with water availability in the house holds. For marital status, the unmarried were 3 times less likely to have water when compared to the married (sig: 0.016, aOR: 0.325, 95CI: 0.13-0.81). Years lived in the community was also found to be significantly associated with water availability: those who had lived in the community for less than five years had a 43% lower odds of having water compared to those who had lived up to 10 years (sig: 0.026, aOR: 0.438, 95CI: 0.21-0.91). Christians were found to have a 3 times higher likelihood of having water when compared to Muslims (sig: 0.001, aOR: 0.2.76, 95CI: 1.5-5.03) (Table 4.5)

Table 4:5: Factors Associated with Water Availability in Respondents' Household

	n	Sig	Crude OR	95CI		Sig.	aOR	95% CI	
				lower	Upper			Lower	Upper
Age group									
18-24	89	0.892	1.064	0.437	2.59	**0.029***	3.476	1.137	10.629
25-34	86	**0.022**	2.727	1.159	6.42	**0.009***	3.961	1.416	11.080
35-49	104	0.074	2.153	0.929	4.99	0.170	1.967	0.748	5.177
≥50	40		1						
Highest education									
None	65	**<0.001***	0.236	0.119	0.468	**0.005***	0.287	0.373	0.782
Primary	113	0.290	0.727	0.403	1.312	**0.035***	0.499	0.261	0.951
Secondary or more	143		1						
Household size									
≤6	184	0.794	1.064	0.666	1.701	0.976	0.992	0.580	1.695
>6	137		1						
Marital status									
Unmarried	87	**0.001**	2.88	1.574	5.252	**0.016***	0.325	0.130	.810
Married	234		1						
No of years lived in community									
<1	6	0.216	0.341	0.062	1.874	0.631	1.563	0.252	9.685
1-4	59	0.238	0.353	0.063	1.991	**0.026***	0.438	0.212	0.906
5-9	46	0.526	0.591	0.116	3.000	0.110	0.517	0.230	1.161
≥10	210		1						
Religion									
Christianity	217	**<0.001***	2.87	1.640	5.001	**0.001***	2.756	1.510	5.029
Islam	104		1				1		

Source: Researcher's Field Survey, 2022

4.2.4.2 Factors Associated with Availability of Sanitation Facilities in Respondent's Household

Following binary logistic regression (Table 4.6), age of respondents was significantly associated with availability of sanitation facility in the house: respondents aged 25-34 years had a 27% lower odds of having a toilet facility when compared to those aged 50 years and above (sig: 0.038, aOR: 0.266, 95%CI: 0.076-0.931). Respondent's level of education was also found to be significantly associated with toilet availability: Those with no education had a 38% lower odds of having a sanitation facility when compared with those with secondary education (sig: 0.024, aOR: 0.383, 95%CI: 0.166-0.883). Household size was not significantly associated with availability of sanitation facility in the household. For marital status, respondents who were not married were twice more likely to have a sanitation facility when compared to those who were married (sig: 0.039, aOR: 2.12, 95%CI: 1.04-4.29). Number of years lived in the community also significantly affected availability of sanitation facility: respondents who had lived between 4-9 years (sig: 0.004, aOR: 2.74, 95%CI: 1.37-5.49) and ≥10 years (sig: 0.017, aOR: 2.54, 95%CI: 1.17-5.48) respectively were more likely to have sanitation facilty compared to those who had lived less than a year. Religion was not found to be significantly associated with the availability of sanitation facilities in the household (sig: 0.165, aOR: 0.673, 95%CI: 0.384-1.177).

Table 4:6: Factors Associated with Availability of Sanitation Facility in Respondents' Household

				95% C.I				95CI	
	n	Sig.	Crude OR	Lower	Upper	Sig	Adjusted OR	Lower	Upper
Age Group									
18-24	89	**0.016***	0.393	.183	0.842	**0.038**	0.266	0.076	0.931
25-34	86	0.955	0.982	.527	1.832	0.467	0.623	0.174	2.230
35-49	104	0.622	0.808	.346	1.888	0.423	0.563	0.138	2.298
≥50	40		1						
Education									
None	65	0.145	0.583	.282	1.204	**0.024***	0.383	0.166	0.883
Primary	113	0.461	0.808	.459	1.424	0.142	0.608	0.313	1.182
Secondary or more	143		1						
HH Size									
≤6	184	0.851	1.051	.628	1.757	0.716	0.902	0.519	1.569
>6	137		1						
Marital status									
Unmarried	87	0.451	1.240	0.709	2.168	**0.039***	2.112	1.04	4.291
Married	234		1						
Years lived in community									
<1	6								
1-4	59	0.999	.000	0.000		0.999	0	0	.
5-9	46	**0.041***	1.935	1.027	3.645	**0.004***	2.742	1.371	5.486
≥10	210	0.092	1.826	.906	3.677	**0.017***	2.54	1.179	5.475
Religion									
Christianity	217	0.224	.719	.423	1.223	0.165	0.673	0.384	1.177
Islam	104		1						

Source: Researcher's Field Survey, 2022

4.2.4.3 Factors Associated with Hygiene in Respondents' Household

Availability of Water and Soap for handwashing was used to assess the hygiene conditions of the households. Following binary logistics regression (Table 4.7), the age of the respondents was found to be significantly associated with availability of soap and water for handwashing in their homes: respondents aged 25-34 (sig: 0.018, aOR: 0.28, 95CI: 0.10-0.81) and 35-49 years old (sig: 0.017, aOR: 0.314, 95CI: 0.12-.81) had a 28% and 31% lower odds respectively of having water at home when compared to those aged 18-24 years old. Similarly, respondents with six or less household size were two times more likely to have soap and water for hand washing when compard to those with a family size of six or more (sig: 0.046, aOR: 1.7, 95CI: 1.01-2.88). Respondent's level of education was equally found to be significantly associated with availability of soap and water for hand washing with respondents with atleast a secondary school education having a three times higher likelihood of having water and soap for handwashing when compared to those with no education at all (sig: 0.017, aOR: 2.87, 95CI: 1.55-.5.29). For marital status, unmarried respondents were 3 times more likely to have soap and water for hand washing when compared to the married (sig: <0.013, aOR: 2.65, 95CI: 1.23-5.71). For religion, those in the Islamic faith had a 2 times higher likelihood of having both soap and water for hand washing when compared to Christians (sig: 0.003, aOR: 2.32, 95CI: 1.341-4.116).

Table 4.7: Factors Associated with Water and Soap Availability in Respondent's Household

	n	Sig.	Crude Odds Ratio	95% CI.		Sig	Adjusted Odds ratio	95%CI	
				Lower	Upper			Lower	Upper
Age group									
18-24	89	1							
25-34	86	**0.004***	0.401	0.217	0.741	**0.018***	.284	0.100	.807
35-49	104	**0.011***	0.465	0.259	0.836	**0.017***	.314	0.121	.814
≥50	40	0.088	0.518	0.244	1.102	0.322	.640	0.265	1.548
HH Size									
≤6	184	0.138	0.714	0.457	1.115	**0.046***	1.705	1.010	2.880
>6	137	1	1						
Education									
None	65	1							
Primary	113	0.985	1.006	0.558	1.814	0.096	0.535	0.256	1.116
Secondary or more	143	**<0.001***	3.596	1.885	6.861	**0.001***	2.872	1.559	5.291
Marital Status									
Unmarried		**<0.001***	2.763	1.618	4.72	**0.013***	2.65	1.229	5.707
Married	1								
Years lived in community									
<1	6		1				1		
1-4	59	0.216	2.933	0.534	16.125	0.321	2.54	0.407	15.673
5-9	46	0.133	1.647	0.859	3.158	0.782	1.30	0.209	8.126
≥10	210	0.945	0.944	0.186	4.787	0.699	0.71	0.121	4.116
Religion									
Christianity	217	**1**							
Islam	104	**0.001***	2.4	1.464	3.934	**0.003***	2.323	1.341	4.022

Source: Researcher's Field Survey, 2022

4.3 Prevalence of *Schistosoma haematobium* among SAC

4.3.1 Prevalance of *Schistosoma haematobium* among SAC after Urine Microscopy

Two hundred and ninety-eight (92.8%) children returned the sample bottles and were included in the analysis. The prevalence of schistosomiasis in the population studied was 4.03% with more males (2.3%) than females (1.7%) affected. More than half, 7 (2.3%) of the infected children were between ages 13-17 years old. As regards the intensity of infection, the majority 11 (3.7%) had a light infection (≤10 eggs) and 1 (0.3%) had a moderate infection (>10-50 eggs). The child who had moderate infection was a male. The mean egg count for the population studied was 5.67±2.83 per 10ml urine sample and the range of eggs was between 2-12. A total of 18 (6.0%) children had microscopic hematuria including all 12 children with *S. haematobium* and six other children with no *S. haematobium* eggs in their urine samples (Table 4.8). Figure 4.2 shows a typical *S. haematobium* egg from one of the urine samples examined.

Figure 4.2: A *Schistosoma haematobium* egg with the terminal spine
Source: Researcher's Laboratory Assay Result, 2022

Table 4.8: Prevalence, Intensity of infection and Hematuria by age and gender

	Total n = 12 (4.0%)	Light n = 11 (3.7%)	Moderate n = 1 (0.3%)	Hematuria n= 18 (6.0%)
Males	7 (2.3)	6 (2.0)	1 (0.3)	12 (4.0)
Females	5 (1.7)	5 (1.7)	0 (0)	6 (2.0)
Age group				
5-8	2 (0.7)	2 (0.7)	0 (0)	2 (0.7)
9-12	3 (1.0)	3 (1.0)	0(0)	6 (2.0)
13-16	7 (2.3)	6 (2.0)	1(0.3)	10 (3.4)

Source: Researcher's Field Survey, 2022

4.3.2 Self Report on Signs and Symptoms of Schistosomiasis among School Age Children

Figure 4.3 below shows the signs and symptoms of schistosomiais experienced by the SAC in the one month before the survey. Over two-thirds of the children reported having fever 201 (67.4%), almost half reported having cough 141 (47.3%), two out of five reported abdominal pain 120 (40.3%), and vomiting 120 (40.3%), almost one third had diarrhea 92 (30.9%) and itching 96 (32.2%). Other symptoms reported were: Haematuria 22 (7.4%), burning urination 46 (15.4%), fatigue 49 (16.4%) and loss of appetite 45 (15.1%).

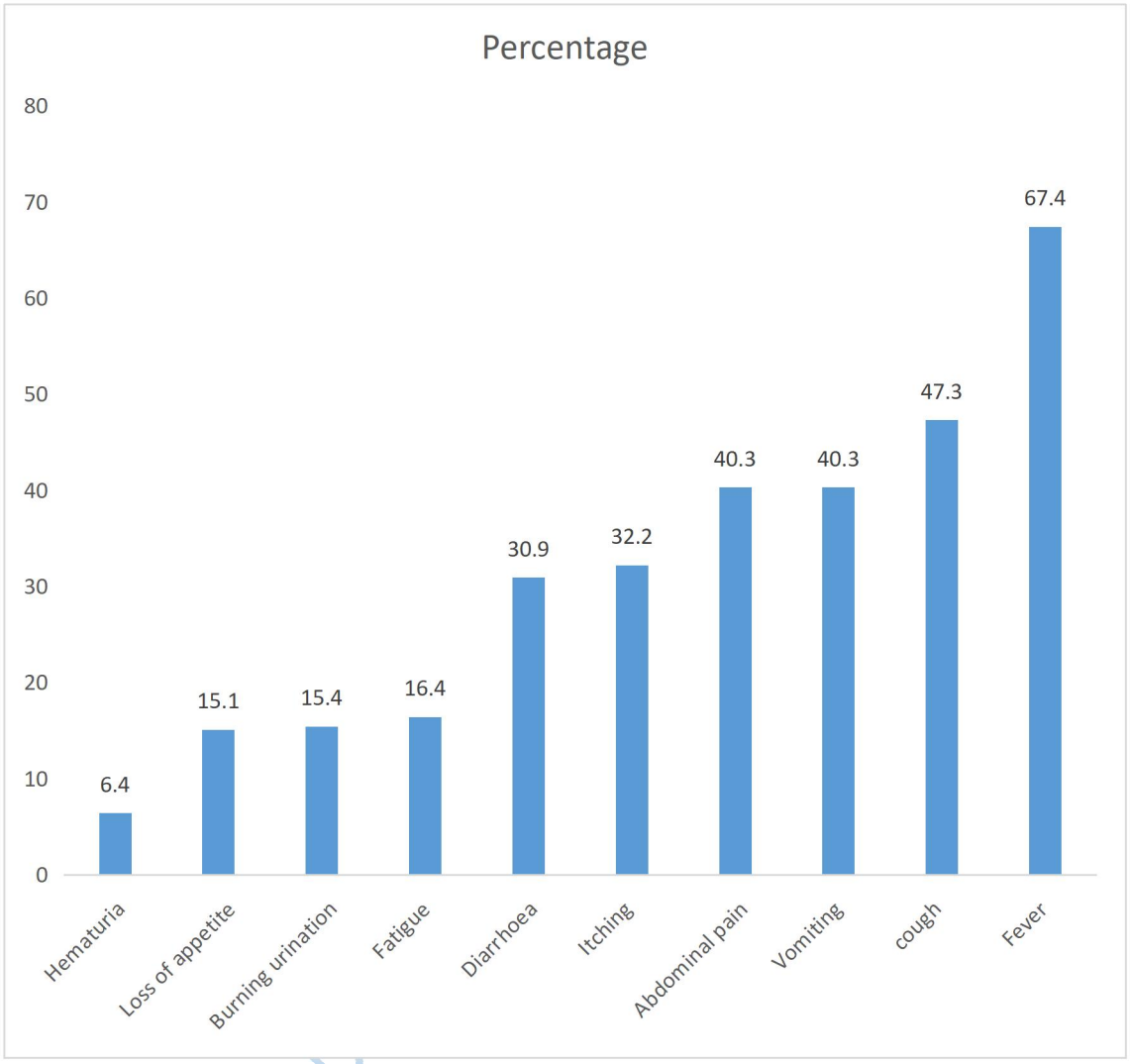

Figure 4.3: Self Reports on Signs and Symptoms of Schistosomiasis among SAC
Source: Researcher's Field Survey, 2022

4.4 Geospatial Distribution of Schistosomiasis in Otamokun

Figure 4.4 below shows the geographical distribution of 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 categorized as: No endemicity (0%), Low endemicity (1 - 10%), Mild endemicity (10.1 - 25.0%), and High endemicity (25.1 - 40.0%). Schistosomiasis is endemic in houses located towards the southern part of Otamokun. No endemicity was found in Asipa while low endemicity was observed in households in Oguoo, a small settlement on the outskirts of the community.

High endemicity was observed among SAC living in the eastern part of the Lagbedu/Ipeba road, the town hall and the left side of the mosque. However, mild endemicity was observed among SAC residents in the south-western part of the town hall and the western part of the mosque. Low endemicity was observed among SAC living around the Baptist church and the Baptist basic school 1.

From Table 4.9 below, the majority 233 (78.2%) of the SAC surveyed lived within 500m of the river, while less than one-tenth 19 (6.4%) were far from the river (above 1km). The proximity of the house to the river was not found to be significantly associated with schistosomiasis in the population studied ($X^2 = 8.57$, $P = 0.805$, $df = 1$) (Table 4.9).

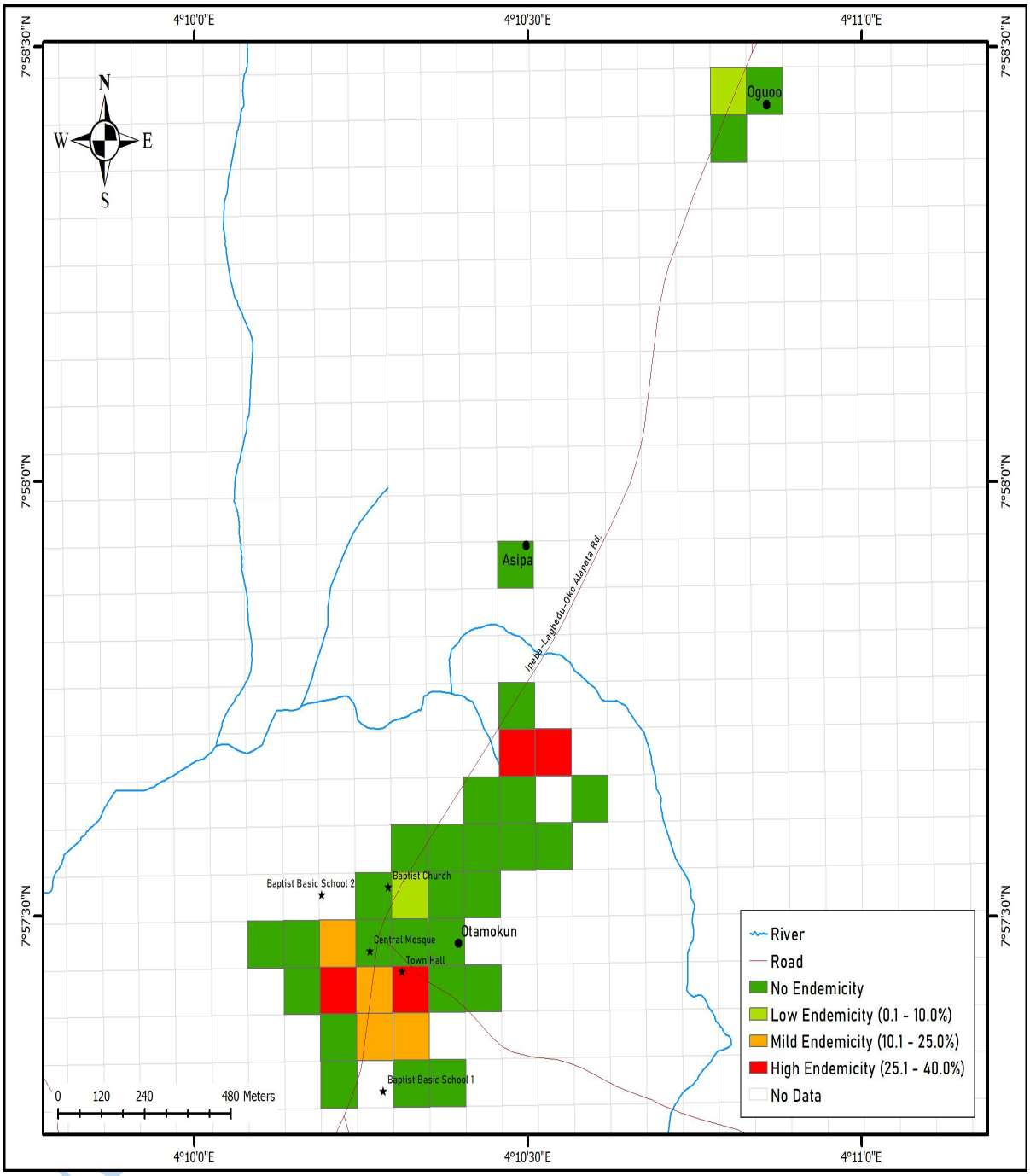

Figure 4.4: Geospatial Distribution of Schistosomiasis in Otamokun

Source: Researcher's Field Survey, 2022

Table 4.9: Distance of Respondents' Houses to River and Prevalence of Schistosomiasis

Distance of HH to River (m)	Confirmed SCH		Total n = 298	Sig.	X^2
	No n (%) n = 286	Yes, n (%) n = 12			
Near (≤500m)	224 (74.2)	9 (3.0)	233 (78.2)	0.805	8.57
Not so far (500-700)	45 (15.1)	1 (0.3)	46 (15.4)		
Far (≥ 1000)	17 (5.7)	2 (0.67)	19 (6.4)		

Source: Researcher's Field Survey, 2022

4.5 Molecular Assay of positive *S. haematobium* samples

All of the 12 samples containing *S. haematobium* eggs after urine microscopy were assayed for *S. haematobium* DNA. There was DNA amplification in 9 of the 12 urine samples (Appendix VII) but only six of the sequences aligned with *S. haematobium* in the NCBI database. (Table 4.10).

4.5.1 BLAST Results

>1_ has 100% pair wise similarity with *S. haematobium* isolate RT16_TG399.8 with NCBI accession number MT579449 (Table 4.10a)

CTCCTATGGGTGGTGGTGATCCATTATTATTTCAGCACTTATTTTGATTTTTTGGT
CATCCAGAGGTGTATGTTTGGTAATTTTACCTGGATTTGGAATAGTTAGTCATAT
ATGTATGAGGATAAGTAAAATAATGATTCATCGTTTGGGTATTATGGATTGATTT
GTGCTATGGCTTCGATAGTGGTTCGG

>3_has 98.32% pair wise similarity with *Schistosoma haematobium* isolates RT16_TG399.8 with NCBI accession number MT579449 (Table 4.10a)

AGCCTTATGGGTGGTGGTGATCCATTATTATTTCAGCACTTATTTTGATTTTTTGG
TCATCCAGAGGTGTATGGGTTTTAATTTTACCTGGATTTGGAATAGTTAGTCATA
TATGTATGAGGATAAGTAATAATGATTCATCGTTTGGGTATTATGGATTGATTTG
TGCTATGGCTTCGATAGTTTGAAAATT

>5_ has 97.81% pairwise similarity with *Schistosoma haematobium* isolate RT16.1_NdgR.5 with NCBI accession number MT579447.1 (Table 4.10a)

CCAATTAAAATTGATTTTTGGCATCCAAGGTGTATGTTTTAATTTTACCTGGATTT
GGATAGTTAGCCATATATCTATGAGGGAAGAAACCCATAGGATCGCTTGTGCTC
ATCCAAAGATTACTATCGAAGCCATAGCACAAATCAATCCATAATACCCAAACG
ATGAATCATTATTACTTATCCTCATACATATATGACTAACTATTCCAAATCCAGG
TAAAATTAAAACATACACCTCTGGATGACCAAAAAATCAAAATAAGTGCTGAAA
TAATAATGGATCACAACCCCATAGGACTGTCAATTTGGCTGGTTTTTAAAACCCT
GAACGACCCGGCGGTTGGCAAACGTTGATAAGATATTTTGCCAACCCTTCGTACG
CCGCGGCGGGCAGTTTTACTTCAACTCGATTCGCGAATCCACCCCCCAAGGGAG

>7_has 92.35% pairwise similarity with *Schistosoma haematobium isolates* BK17_BB7.2 which has NCBI MT579428 (Table 4.10a)

GCACCCCCAGCGGTTGAACTTCTTGCCTTCACTCGATCAGATAGCTATGTTACCC
GTATGGAAGTCCCTGATTCAGAGATATCATAACGGTCTTTTGGCTCCAAATTGCA
CTTCGTTTGCCAACTATCAAAGCCAAGGGACTCATCACTCAATAATACCCAAACG
ATGAATCATTATTACTTATCCTCATACATATATGACTAACTATTCCAAATCCAGG
TAAAATTAAAACATACACCTCTGGATGACCAAAAAATCAAAATAAGTGCTGAAA
TAATAATGGATCACCACCCATAGG

>8__ has 100% pairwise similarity with *Schistosoma haematobium* isolate BK17_BB7 which has NCBI accession number MT579428.1 (Table 4.10a)

AAAAAAAAAATRTAGGTACAATTGWRTRCAAAGGAGMGGCAGGGGGACTGCTC
AGCGTAGTGAGGCTATCCMWAGGTTTATGAGTGAGCAAGTTCGGGTAGTGACTC
TATGGGTGGTGGTGATCCATTATTATTTCAGCACTTATTTTGATTTTTTGGTCATC
CAGAGGTGTATGTTTTAATTTTACCTGGATTTGGAATAGTTAGTCATATATGTAT
GAGGATAAGTAATAATGATTCATCGTTTGGGTATTATGGATTGATTTGTGGCTGT
ACTGAKGGGTGCAATAAAGATATGTGTAATGCCCCTGCCCCCGCGTGCCCAMCG
TCGWTCCCACCCCCATTGCCTGACRGTCCTGTGCAATTCTTAGAAATGGCATTCA
GTGCGGTWCACCACWCCCCAGAAAAA

>9_ has 100% pairwise similarity with *Schistosoma haematobium* isolate BK16.2_Nk2.7 which has NCBI accession number MT579421 (Table 4.10a)

AAACCTTAAAACCCTAAAATTTTGTTTTTCGAAGAGGTTTTGAAAAAAGGAGAAT
AACTATGGGTGGTGGTGATCCATTATTATTTCAGCACTTATTTTGATTTTTTGGTC
ATCCAGAGGTGTATGTTTTAATTTACCTGGATTTGGAATAGTTAGTCATATATGT
ATGAGGATAAGTAATAATGATTCATCGTTTGGGTATTATGGATTGATTTGTGCTA
TGGCTTCGATAGTATAGGGGGGGGGGAAGTTTTGTAGGGGGTGGAGCTATGGCA
AAAATTAAAACGGAAGGGGGGGTTGAAACCGGAAGATCAACATCTTGATTGGTT
TACCTATGGCGCGGTCT

The results of the BLAST query showed that three (50%) of the six samples queried had 100% pairwise similarity. Two (33.3%) had more than 97% and one (16.7%) had 92%

pairwise similarity (Table 4.10a) All the sequences have been deposited in the NCBI genebank and the ascension numbers are shown in Table 4.10b

Table 4.10a: The Urine Sample Isolates and their BLAST results

Urine sample codes	Pairwise similarity	SH Isolate	Accession number
>1	100%	RT16_TG399.8	MT579449
>3	98.32%	RT16_TG399.8	MT579449
>5	97.81%	RT16.1_NdgR.5	MT579447.1
>7	92.35%	BK17_BB7.2	MT579428
>8	100%	BK17_BB7	MT579428.1
>9	100%	BK16.2_Nk2.7	MT579421

Source: Researcher's Molecular Assay Result 2022

Table 4.10b: Ascension Number From NCBI After Depositing Sample Nucleotide Sequences

Sample id	Scientific Name	Max Score	Total Score	Query Cover	E value	Per. Ident	Accession
1	Schistosoma haematobium	348	348	100%	5.00E-91	100.00%	PQ373998
3	Schistosoma haematobium	531	531	99%	8.00E-146	99.32%	PQ374000
5	Schistosoma haematobium	577	577	100%	1.00E-159	100%	PQ373999
7	Schistosoma haematobium	577	577	100%	1.00E-159	99.68%	PQ374001
8	Schistosoma haematobium	545	545	99%	3.00E-150	100.00%	PQ374002
9	Schistosoma haematobium	542	542	100%	4.00E-149	100.00%	PQ374003

Source: Researcher's data deposited on NCBI

4.5.2 Phylogenetic Tree

The tree (figure 4.5) shows the evolutionary relationships among the *S. hematobium* strains that are believed to have a common ancestor. In this tree, each node with descendants represents the most recent common ancestor of the descendants, while the edge lengths correspond to time estimates. This diagram essentially represents how closely related or far apart the SH species in the children examined are related to species in the NCBI gene bank i.e. their ancestral descent. The closer the strains are, the more closely related they are but the farther apart they are, the more diverse they are in their origin. The phylogenetic relationship between the isolates from the study area showed that the isolates from the study community are closely related to the aligned sequences from NCBI data base.

Isolates 5 and 7 are closely related to SH haplotype H4 cytochrome oxidase (MT579447.1:478-599); MT579428.1:446-640 and hybrid *S. haematobium and S. bovis* isolates (MT579443.1:437-615).

Isolate 8 is closely related with SH isolate (MT579428.1:438-599) and hybrid *S. haematobium and S. bovis* (MT579442.1:437-615)

Isolate 3 is closely related to SH isolates (MT579499.1:437-615) and (MT579447.1:437-615)

Isolates 1 and 9 are related to SH isolate MT579449.1:437-615 and 9 is also related to SH isolate (MT579421.1:343-520). All related isolates are from Northern Senegal

The branch length for the tree is 1.6711

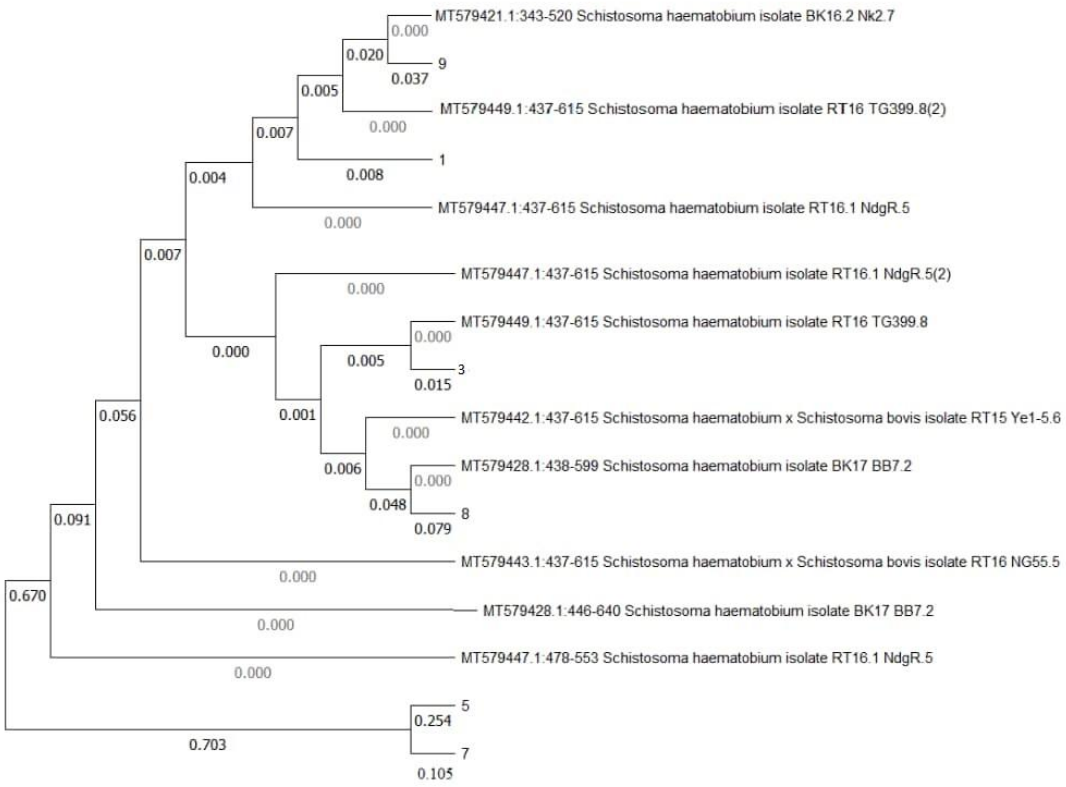

Figure 4.5: Showing the Phylogenetic Tree

Source: Researcher's Molecular Assay Results compared with nucleotide sequences in the NCBI database, 2022

4.6 Factors Associated with Schistosomiasis

4.6.1 Socio-demographic factors and Schistosomiasis

Seven (2.3%) of the children with urinary schistosomiasis were males and between ages 13 and 17 years 7 (2.3%). There was no statistically significant difference in the prevalence between sexes (X^2 = 0.16, d.f = 1, P = 0.689) but there was a statistically significant difference between age groups (X^2 = 8.04, d.f = 1, P = 0.018). Father (X^2 = 4.10, d.f = 1, P = 0.393) and mother's occupation (X^2 = 7.67, d.f = 1, P = 0.264) were not found to be significantly associated with schistosomiasis (Table 4.12)

Table 4.11: Socio-demographic factors and Schistosomiasis

Gender	Confirmed SCH n (%)		Total n = 298	X^2	Sig
	Yes (n=12 (4.03%))	No (n=286 (95.97%)			
Male	7 (2.3)	150 (50.3)	157 (52.7)	0.16	0.689
Female	5 (1.7)	136 (45.6)	141 (47.3)		
Age (years)					
5-8	2 (0.7)	106 (35.6)	108 (36.2)	8.04	**0.018***
9-12	3 (1.0)	115 (38.6)	118 (39.6)		
13-16	7 (2.3)	65 (21.8)	72 (24.2)		
Father's Occupation					
Civil/Public servant	1 (0.3)	26 (8.7)	27 (9.1)	4.10	0.393
Farming	3 (1.0)	137 (46.0)	140 (47.0)		
Trading	5 (1.7)	56 (18.8)	61 (20.5)		
Artisan	3 (1.0)	66(22.1)	69 (23.2)		
Mother's Occupation					
Civil/Public Servant	0 (0)	14 (4.7)	14 (4.7)	7.67	0.264
Farming	4 (1.3)	64 (21.5)	68 (22.8)		
Trading	5 (1.7)	160 (53.7)	165 (55.4)		
Artisan	2 (0.7)	41 (13.8)	43 (14.4)		
Unemployed/ student	1 (0.3)	7 (2.3)	8 (2.6)		

* P <0.05.

Source: Researcher's field survey, 2022

4.6.2 Behavioral Factors and Schistosomiasis

From Table 4.13, child's visit to the river was significantly associated with Schistosomiasis (X^2 = 4.59, d.f = 1, P = 0.032). More than half 157 (53%) of the children in the study population engaged in swimming during river visits and this was significantly associated with schistosomiasis: eleven (11) out of the tweleve SAC with schistosomiasis swim at the river (X^2 = 7.49, d.f = 1, P = 0.006). Similarly, more than half 172 (57.7%) of the SAC in the population surveyed played at river bodies and this was also found to be significantly associated with schistosomias: eleven (11) out of the tweleve (12) children with schistosomiasis played at the river, (X^2 = 5.91, d.f = 1, P = 0.015). Less than half (44.6%) of the population studied fetched water from the river, but fetching from the river was not found to be significantly associated with schistosomiasis (X^2 = 2.46, d.f = 1, P = 0.117). Less than 20% of the children carried out farming and fishing in the river bodies and these activities: farming/irrigation in the river (X^2 = 0.41, d.f = 1, P = 0.682), and fishing (X^2 = 0.43, d.f = 1, P = 0.61) were not found to be significantly associated with schistosomiasis. The use of medicine for schistosomiais during the last mass drug administration (MDA) round was not significantly associated with schistosomiasis in the population studied (X^2 = 0.91, d.f = 1, P = 0.34).

Table 4.12: Behavioural Factors and Schistosomiasis

	Confirmed SCH				
	Yes, n (%) n = 12 (4.0)	No n (%) 286 (95.9)	Total n=298	X^2	P-Value
Child's visit to river					
Yes	12 (4.0)	168 (56.3)	180 (60.4)	4.59	**0.032***
No	0 (0)	118 (39.6)	118 (39.6)		
Activity at River Swimming/ bathing					
Yes	11(3.7)	146 (49.3)	157 (53.0)	7.49	**0.006***
No	1(0.3)	138 (46.6)	139 (47.0)		
Playing in river					
Yes	11 (3.7)	161(54.0)	172 (57.7)	5.91	**0.015***
No	1 (0.3)	125 (41.9)	126 (42.3)		
Fetching from river					
Yes	8 (2.7)	125 (41.9)	133 (44.6)	2.46	0.117
No	4 (1.3)	161 (54.0)	165 (55.4)		
Crossing water					
Yes	10 (3.4)	183 (61.4)	193 (64.8)	1.89	0.169
No	2 (0.7)	103 (34.7)	105 (35.2)		
Fishing					
Yes	3(1.0)	47 (15.8)	50 (16.8)	0.61	0.437
No	9 (3.0)	239 (80.2)	248 (83.2)		
Farming					
Yes	1 (0.3)	50 (16.8)	51 (17.1)	0.68	0.410
No	11 (3.7)	236 (79.2)	247 (82.9)		
Child used Drugs during MDA					
Yes	4 (1.3)	62 (20.8)	66 (22.1)	0.91	0.341
No	8 (2.7)	224 (75.2)	232 (77.9)		

* P <0.05 Source: Researcher's field survey, 2022

4.6.3 Environmental Factors and Schistosomiasis

About half 153 (51.3%) of the study population had access to improved water sources for their household needs, and up to two-thirds of the children infected with schistosomiais (2.7%) in the survey population had access to improved water sources for their household needs but the source of water for respondents' household needs was not found to be significantly associated with schistosomiasis (X^2 = 1.23, d.f = 1, P = 0.379). For sanitation, almost all (11 (3.7%)) of the children with schistosomiasis used unimproved sanitation nonetheless, this was not found to be significantly associated with schistosomiasis (X^2 =1.71, d.f = 1, P = 0.305) in the study population (Table 4.14).

Concerning hygiene, three-quarters of the children living with schistosomiasis did not have water and soap available for hand washing in their homes at the time of the survey and this was found to be significantly associated with schistosomiasis in the population studied (X^2 = 5.12, d.f = 1, P = 0.024) (Table 4.14).

Table 4.13: Environmental Factors Associated with Schistosomiasis

	Confirmed SCH		Total n = 298 100%	X^2	P-Value
	Yes, n = 12 (4.0%)	No, n = 286 (%) 95.9%			
Water Source for other HH purposes					
Improved water source	8 (2.7)	145 (48.7)	153 (51.3)	1.18	0.278
Unimproved water source	4 (1.3)	141 (47.3)	144 (48.3)		
Sanitation					
Improved	1 (0.3)	71 (23.8)	72 (24.2)	1.71	0.191
Unimproved	11(3.7)	215 (72.1)	226 (75.8)		
Hygiene					
Presence of both water and soap for hand washing					
Yes	3 (1.0)	166 (55.7)	169 (56.7)	5.12	**0.024***
No	9 (3.0)	120 (40.2)	129 (43.3)		

* P <0.05 Source: Researcher's field survey, 2022

4.6.4 Predictors of Schistosomiasis

After the chi-square test, the multivariate logistics regression analysis (Table 4.14), showed that age of child, visit to the river, swimming in river, playing at the river and non-availability of soap and water for hand washing were factors found to be significantly associated with schistosomiasis. Children aged 13-17 years were found to be 7 times more likely to have schistosomiasis (aOR: 7.42, 95CI: 1.54-35.8 P = 0.011) when compared to those aged between 5-8 years old. Children aged 9-12 years were not significantly different from those aged 5-8 years in their risk of having the disease. Children who swam in rivers were 10 times more likely to have schistosomiasis (aOR: 9.86, 95CI: 1.12-86.5, P = 0.039) when compared to those who did not swim. Children who played in the river had 6 times higher odds of having schistosomiasis (aOR: 6.23, 95CI: 2.57-10.65 P = 0.041) than those who did not play at the river. Children who had no soap and water in their houses at the time of visit were 5 times more likely to have schistosomiasis when compared to those who had soap and water (aOR = 4.52, 95% CI: 1.18-17.38, P = 0.028) (Table 4.14).

Table 4.14: Binary and Multivariate Logistic Regression Analyses of Socio-demographic, Behavioral and Environmental factors Associated with Schistosomiasis significant at 5% after chi-square tests

	Freq	Sig	Crude OR	95 CI	Sig	Adjusted OR	95CI
Age group							
5-8	2		1				
9-12	3	0.726	1.38	0.23-8.44			
13-17	**7**	**0.011***	7.57	1.56-28.31	**0.013***	7.42	1.54-35.80
Visit to River							
Yes	12	0.977	5.74	-		-	-
no	0		1				
Swimming							
Yes	11	**0.026***	10.40	1.33-81.60	**0.039***	9.86	1.12-86.5
no	1		1				
Playing							
Yes	11	**0.041***	8.54	1.09-67.04	**0.015***	6.23	2.57-10.65
no	1		1				
Water & Soap available							
Yes	3	**0.036***	4.15	1.10-15.65	0.028*	4.52	1.18-17.38
No	9		1				

* P <0.05 Source: Researcher's field survey, 2022

4.7 Discussion of Findings

4.7.1 Water, Sanitation and Hygiene Conditions of Households

The study found that most of the households surveyed had access to improved water sources for drinking and about half used improved water sources for other household needs. These reslts are similar to findings from Benin and Ghana[1, 2] but a significant proportion of the study population-almost two-fifth- did not have access to improved water for drinking indicating that the study communtiy is still far from attaining the SDG goal of access to safe drinking water for all. However, only one-quarter used improved sanitation facility making open defecation a common practice in the study population. Studies in Benin and Ghana also reported similar results [1, 2]. About half of the survey population had soap and water at home at the time of visit in contrast to a study in Benin where only one-tenth of the population had basic handwashing facilities at home[1]. The effect of poor water and sanitation can have both far reaching and ill-fated effects including increase in preventable diseases, decrease in schooling, and invariably impact the economic growth of the community [3].

4.7.2 Prevalence of Schistosomiasis

The prevalence of schistosomiasis in the population studied was 4.03% with more males than females affected but this difference was not significant. Children aged 13-16 years who had the highest prevalence of schistosomiasis is similar to findings from Mauritania where a prevalence of 4.0% was also recorded among school children aged 5-15 years [4]. Some other studies have found greater prevalence: in the Gambia (10.2%), Sudan (12.9%), and Zimbabwe (15.4%) [5-7] among children aged 7 to 17. Much higher prevalences have also been reported in Kenya (33.2%) among primary school pupils, Maiduguri, Nigeria (62%), among internally displaced persons (IDP) children [8], in Kwara State, Nigeria (45.6%) [9] among

children aged 4-18 and in Ibadan, Nigeria (21.2%) among OVCs in a rehabilitation center [10]. Conversely, another study in Sudan found a substantially lower prevalence of 1.82% among children [11]. The reduced prevalence of schistosomiasis observed in this study area despite the irregular MDA activity in the community may be because there is the provision of improved water supply to the community which may have reduced visits to the river unlike in previous years. Another reason for the prevalence observed may be because the majority (about two-thirds) of the children surveyed were less than 13 years old where schistosomiasis prevalence is reported to be lower.

4.7.3 Geospatial Distribution of Schistosomiasis within the Study Area

Even though over three-quarters of the children surveyed lived within 500m of the river body, proximity to water body was not significantly associated with schistosomiasis in the population studied. This is however, in contrast to a study in China where the spatial distribution of schistosomiasis was significantly associated with nearness to waterbody [13]. The in-significant association between proximity to water bodies and schistosomiasis in the study may possibly be because the main community river- Amuro - generally flows round the community and children in the community may be at equal risk of contracting the disease. 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 indicate where control efforts should be targeted. Nonetheless, individuals living near open water sources are at the highest risk of schistosomiasis infection and should be prioritized when planning control effforts [13].

4.7.4 Molecular Characterization of *S. haematobium*

This study used mitochondrial gene (Cox1) to construct phylogenetic tree that provided an insight into the molecular epidemiology of the *S. haematobium* parasite from the study area. Even though the PCR assay method has been reported to be effective to detect *S. haematobium* DNA in some previous studies [14-16]. Although 9 out of the 12 samples positive after microscopy were amplified, *S. haematobium* DNA was found in only 6 of the samples. This may be partly due to the storage or handling conditions of the urine samples. This result is similar to a study in Spain where long-term frozen urine samples were reported not to be a good source for DNA extraction for use as a template in PCR detection of *schistosoma spp* regardless of the DNA extraction method [17]. It therefore implies that fresh human samples should be used for PCR assay to be effective. Furthermore, *S. haematobium* species in six of the isolates formed clusters with *S. haematobium* reference sequence from northern Senegal in the NCBI database and are different from other haematobium species reported in previous studies. A study in Kebbi State, Nigeria reported sequences phylogenetically closer to sequences from Mali, Tanzania, Ghana, Malawi, Gambia, Cameroun and South Africa [15]. In addition, this current study found three isolates related to hybrid species *(S. haematobium* and *S. bovis)* in the Genebank indicating the possibility of hybridization of the *S. haematobium*, in the area at the time of study. This is similar to findings from Zambia and Mali where hybrids of *S. haematobium* and *S. bovis* were reported in humans and intermediate snail hosts [16- 17]. The hybrid species found in the study area may be associated with the practice of taking cattle to the rivers for grazing and watering which was observed in the community at the time of visit. Hybridization raises the possibility of zoonotic parasite

strain transmission and mostly occurs as animals and humans frequent the same water sources leading to an interplay of the species they carry [18-19]. Hybrids can influence the epidemiology and control of schistosomiasis in terms of virulence, zoonotic potential and resistance to treatment [18].

4.7.5 Risk Factors Associated with Schistosomiasis

4.7.5.1 Socio-demographic Factors Associated with Schistosomiasis

For age, the association found between children aged 13-16 years and a higher risk of schistosomiasis is similar to results from Ethopia where children aged 13-14 years also had a higher risk of the disease when compared to those aged 5-8 years old [20]. Conversely, a study in Sudan reported a higher risk among younger children aged 7-10 years when compared to those aged 10-14 years old [6]. Similarly, a study in Maiduguri, Nigeria, reported that children aged five years and above were found to be more predisposed to schistosomiasis than younger children [9.] The higher prevalence observed among children aged 13-16 years in this study may be due to more frequent water contact activities carried out by this group or rather more freedom in this age group since they are older and likely to be more exploratory. For gender, more boys than girls were infected with schistosomiasis in this study but gender was not found to be significantly associated with schistosomiasis in this study population. A study in Cameroun also reported a similar finding of no significant impact of gender on *S. haematobium* [21]. However, a study in Kwara State, Nigeria reported that more males were at an increased significant risk of schistosomiasis [22]. Many other studies have reported boys being at an increased risk of schistosomiasis than girls [5, 9, 21]. In contrast, a study in Anambra reported that the females had a higher prevalence of the disease when compared to their male counterparts [23]. Males are generally reported to be at an increased risk of schistosomiasis than

females for socio-cultural and behavioral reasons because boys are often more likely to swim, fish and play in freshwater bodies when compared to girls [24].

Parents' occupations and educationsl level were not found to be significantly associated with schistosomiasis in the population studied. These results are similar to reports from Cote d' Ivoire and Nigeria where both parents' occupation and education were also not found to be associated with *S. haematobium* infection [25-26]. These findings are however in contrast to a study in Osun State, Nigeria where parents with higher educational levels had a better understanding of schistosomiasis prevention and could transfer the knowledge to their wards leading to reduced prevalence among the children [27]. Another study in Cote d'Ivoire reported that children whose parents worked as rice farmers were at increased risk of schistosomiasis [28].

4.7.5.2 Behavioural Factors Associated with Schistosomiasis

The relationship between the prevalence of schistosomiasis and contact with contaminated fresh water is well established [21, 24]. As expected, this study showed a significant association between visit to the river, swimming and playing in water bodies and schistosomiasis. Fishing and farming were not associated with schistosomiasis in this study. Studies in the Gambia, Cameroun and Cote d'Ivoire have similarly reported history of swimming, and bathing, and playing in the river as risk factors for schistosomiasis [5, 21, 25]. Another recent study among primary school pupils from seven states in Southern Nigeria reported swimming, washing, and fishing in open water sources as activities significantly associated with schistosomiasis [26].

4.7.5.3 Environmental Factors Associated with Schistosomiasis

Although preventive chemotherapy with praziquantel is the mainstay for schistosomiasis

control in most endemic communities, the World Health Assembly (WHA) has encouraged the addition of WASH programs to endemic communities since there is a strong association between schistosomiasis and poor sanitation [29]. This study did not find a significant association between access to improved water sources and schistosomiasis, similar to a result from Yemen [2]. However, studies in Tunisia and Mauritius, reported that the provision of potable water in addition to preventive chemotherapy was found to help achieve control and total elimination of *S. heamatobium* [30-31]. Studies in Kenya, Côte d'Ivoire, South Africa and Uganda, have reported that the prevalence of schistosomiasis was higher among children who obtained drinking water from unsafe sources [31-34]. Even though, access to clean water is not considered to play a significant role in schistosomiasis prevention in areas where schistosome infections are mostly associated with occupational and recreational contact with water [35]. The prevalence found in this study could be due to the provision of improved water sources for the community which may have drastically reduced visits to the rivers unlike in previous years. Lack of a sanitation facility in most of the households surveyed was not significantly associated with schistosomiasis but several studies have shown a significant impact of the availability of adequate sanitation on the prevalence of schistosomiasis: Lower odds of schistosomiasis was reported in populations with adequate sanitation in Kenya, Côte d' Ivoire and South Africa [31-33]. The insignificant association between lack of improved sanitation and schistosomiasis in the study population may be a result of the gross unavailability of toilets in the community and hence there was no basis for comparison since the majority of the household surveyed had no toilet facility. Moreover, this study found an association between soap use and schistosomiasis with respondents without soap having a 3 times higher likelihood of schistosomiasis. WHO has reported that soap plays a significant

role in schistosomiasis control because soap and endod (a natural soap substitute) are toxic to cercariae, miracidia, and some freshwater snails. This implies that soap use during water contact activities may protect from schistosomiasis transmission [36]. Another review has reported that soap can both destroy cercariae and also prevent cercariae from penetrating the skin and developing into adult worms to produce eggs [37]. A study in Ethiopia reported a significant reduction in the prevalence of schistosomiasis when soap bars were distributed to women for use after water contact activities [38].

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Chapter Five

Conclusion

5.1 Summary of Findings

Most of the households surveyed had access to improved water sources for drinking while about half had access to improved water for other household purposes. Only about one-quarter had a toilet facility. Water and soap for handwashing was available in about half of the households surveyed. Respondents with lower education were found to have lower odds of having soap and water for handwashing at home at the time of carrying out this survey.

The prevalence of schistosomiasis in the study population was 4.03% with the preponderance among children aged 13-16 years. For the spatial distribution of the disease, areas around the community town hall and the major Ipeba-Lagbedu/ Oke Alapata road were observed to be highly endemic. Oguoo, the small settlement on the outskirt of the community had low endemicity. Most of the houses surveyed were within 500m of the river bodies but proximity of child's house to water body was not found to be associated with schistosomiasis.

For the molecular characterization, half of the samples positive for *S. haematobium* eggs from urine microscopy had *S. haematobium* DNA in them and three of the isolates were related to hybrid species of *S. bovis* and *S. haematobium* in the NCBI gene bank. All the *S. haematobium* strains from the study population were related to isolates from Northern Senegal. The major factors associated with schistosomiasis in the community studied were: age, swimming, and playing in fresh water bodies, and unavailability of soap for

handwashing.

5.2 Conclusion

Improved water supply is more or less available for drinking and other household purposes but a significant proportion still lack access to improved water sources. Lack of adequate sanitation facility is a major problem in the study community. Basic handwashing facilities in the community is inadequate as only half of the survey population had soap and water. This finding corroborates the report of the water sanitation and hygiene national outcome routine monitioring data (WASHNORM) for Oyo state where the water, sanitation and hygiene problems in the state have been previously identified. The implications of inadequate WASH in a community is far reaching. Consequently, addressing WASH challenges is important for promoting health, nutrition, education and for improving quality of life in the study community. There is therefore the need to increase the provision of improved water supply, sanitation faciliites and basic hygiene facilities for the community.

S. haematobium infection is still prevalent among school-age children in Otamokun, Ogo-Oluwa LGA Oyo State, Nigeria although in reduced amounts compared to the 2013-2015 FMOH survey. In spite of this, there is still the need to make efforts to bring the prevalence to less than 1% since it is targeted for elimination in the year 2030. Integrated efforts to control schistosomiasis is needful because the disease has not only both health consequences but also social and economic impacts on the affected community.

Although the proximity of houses to the water body was not associated with schistosomiasis

in the population studied, the areas identified with endemicity shows the areas that control efforts should be targeted. Moreover, the 50% agreement between microscopy and the molecular assay results highlights the disparities that can occur when using different diagnostic methods for schistosomiasis detection. Nevertheless, the pivotal role accurate diagnosis plays in implementing strategies for surveillance, control and elimination cannot be overemphasized. Furthermore, The relatedness of three of the isolates from the study area to hybrid species in the gene bank suggests a possible hybridization between cattle and humans in the population studied especially because cattle rearers were observed taking cattle for grazing and watering at the riverside during the data collection process.

5.3 Recommendations

Based on the findings of this work, the following recommendations are made:

Policy Implication:

There is a need for a multisectoral approach since the disease is not only a healthcare system problem; departments such as vector control, epidemiology, health education, medicine, water resources, animal health, education, agriculture, environmental management, and finance are critical and should work together as a team.

Other recommendations are:

i. There is a need for strong advocacy and commitment to the integrated control approach especially the provision of improved sanitation for the community.

ii. There is a need for education of the community on the implications of cattle rearing around water bodies and possible ways of reducing or preventing transmission of schistosomiasis between cattle and humans.

iii. There is a need for further research in the study area especially molecular characterization to identify *S. haematobium* species in the community utilizing fresh samples from children. This is necessary to identify possible hybrids that might stimulate the development of new parasite strains through genetic exchange and recombination between local and introduced genotypes. Control efforts will be better planned if this information is available.

5.4 Contribution to Knowledge

This study is the first to sequence and identify the phylogeny of the *S. haematobium* species in Oyo State, Nigeria. This provides a foundation for further molecular research on urinary schistosomiasis to identify the genetic variety of the disease's causative agent. This will help in understanding the molecular epidemiology of schistosomiasis and inform more effective control efforts for schistosomiasis in the state. The nucleotide sequences from the samples have been deposited in the NCBI database where other researchers can have access to it and determine its genetic relatedness to *S. haematobium* strains from other locations in the world. Furthermore, this study was a household survey and thus provides information on household characteristics that may be associated with schistosomiasis in the study area. This is unlike most of the studies (found in literature) in Nigeria carried out prior to this time which were mostly school-based and community based. This study is the first to show the geospatial distribution of schistosomiasis within households in Otamokun, Ogo-Oluwa LGA, a community reported to have high endemicity during the WHO/FMOH survey where schools were the unit of implementation. Understanding the geospatial distribution of schistosomiasis in the study area will help to understand the transmission dynamics and thus form a basis for designing, implementing and evaluating intervention strategies.

3.4 Suggested Areas for Further Research

- There is a need for further molecular research especially examining all urine samples from endemic communities to identify both early and later infection and not just those positive on urine microscopy since molecular diagnosis has a higher sensitivity and specificity and is able to pick all stages of the infection.
- Preschool age and adult population should also be examined for S. haematobium as they are also at risk.
- The community should also be examined for *S. mansoni* to know whether there's co-infection of both *S. haematobium and S. mansoni* in the community or not.

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Appendix 1

Study Questionnaire

Quantitative Questionnaire for adults: To be administered to household heads/ adults only

Prevalence, Geospatial Distribution and Factors Associated with Urinary Schistosomiasis in Otamokun, Ogo-Oluwa Local Government Area, Oyo State, Nigeria

SERIAL NO. ---------- NAME OF LGA----------

NAME OF WARD---------- NAME OF COMMUNITY ----------

Section A: Socio-demographic characteristics of Respondents

	Question *	Coding	Skip
1.	No. of people living in household		
2.	How old are you (in years)		
3.	Sex of respondents	Male 1 Female 2	
4.	What ethnic group do you belong	Yoruba 1 Ibo 2 Hausa 3 Others specify--------- 96	
5.	What is your marital status?	Single/ never married 1 Married 2 Widowed 3 Separated/ divorced 4 Others specify ---------- 96	

6.	What is your religious affiliation	Christianity 1 Islam 2 Traditional 3 Other specify --------- 96	
7.	What is the highest level of education you completed?	None 1 Primary 2 Jnr Secondary 3 Snr secondary 4 Tertiary 5 Others specify ---------- 96	
8.	What is your current occupation?	Student 1 Civil servant 2 Fishing 3 Farming 4 Trading 5 Artisan 6 Other specify------ 96	
9.	What is the average monthly income of this household?		
10.	How long have you stayed in this community? (in years)		
11.	Have you ever heard about the disease Schistosomiasis'		
12.	Where did you hear about "SCH"	Yes No Health facility 1 0 Family and friends 1 0 School 1 0 Community meeting 1 0 Mass media 1 0 Can't remember Others specify ----------	
13.	Were you aware of the last MAMS round for SCH?	Yes 1 No 0	
14.	Did you receive drugs at the last MAMS round for SCH	Yes 1 No 0	
15.	Did you take the drugs you received at the last MAMS round for SCH	Yes 1 No 0	

	RESPONDENTS' MIGRATION HISTORY		
16.	Are you originally from this community	Yes 1 No 0	
17.	If Q16 is No, how long have you lived in this community (in years)	Yes 1 No 0	
18	If Q is no, from where did you come here? (Community, state)	Yes 1 No 0	
19	Is SCH endemic in that community?	Yes 1	

		No 0	
20	If Q above is yes, have you ever migrated to another community to live?	Yes 1 No 0	
21	If Q above is Yes, which community did you migrate to? (Community, state)		
22	For how long did you stay in that community (mention name of community) before migrating back to this community?		
23	How long ago did you return to this community? (in years)		
24	If Q above is Yes, is SCH endemic in that community?	Yes 1 No 0	
25	How common is SCH in your community?	Very common b. common c. not too d. common e. not common at all	

SECTION B: WATER, SANITATION AND HYGIENE PRACTICES

26	What is the main source of **drinking water** for members of your household?	Piped into dwelling Piped to yard/plot Piped to neighbor Public tap Borehole **Dug well** Protected well Unprotected well **Water from spring** Protected spring Unprotected spring Rainwater Tanker truck Cart with small tank River/dam/ Lake/pond/stream/canal /Irrigation channel) Bottled water Sachet water others (specify)	**Skip** →
27	What is the main source of water used by your household for **other purposes** such as cooking and hand washing?	**Piped water** Borehole **Dug well** Protected well unprotected well **Water from spring**	

		Protected spring Unprotected spring Rainwater Tanker truck. River/dam/ Lake/pond/stream/canal/ Irrigation channel) Bottled water. Sachet water. Others (specify)	
28	Where is that water source located?	In own dwelling In own yard/plot. Elsewhere.	
29	How long does it take to go there, get water, and come back?	Minutes Don't know	
30	In the past two weeks, was the water from this source not available for at least one full day?	Yes No . . . Don't know	
31	Do you do anything with the water to make it safer to drink?	Yes. No Don't know	
32	What do you usually do to make the water safer to drink? Anything else? RECORD ALL MENTIONED	a. Boil Add bleach/chlorine Strain with a cloth Use water filter (ceramic/sand composite/etc Solar disinfection Let it stand and settle Addition of alum Others Don't know	
33	What kind of toilet facility do members of your household usually use? .	Flush or pour flush toilet Flush to septic tank Flush to pit latrine flush to somewhere else Flush, don't know where Pit latrine VIP latrine Pit latrine with slab. Pit latrine without slab/open pit. No facility/bush/field Others----------	

		-	
34	Do you share this toilet facility with other households?	Yes. No	
35	Including your own household, how many households use this toilet facility?	< 10 . . . ≥10 Don't know	
36	Where is this toilet facility located?	in own dwelling in own yard/plot elsewhere NA	
37	What is the destination of your waste	Public collection Burnt Buried Dumped on a vacant lot Dumped in a river Others specify	
38	How often do you go to the river	1-2 times a week 3 or more times a week Every day Rarely/ not at all Others specify ---------- -	
39	Which of the following activities do you engage in when at the river?	Yes no Swimming/ bathing Playing Fetching water Defecating/urinating Fishing Farming / irrigation Others specify	
40	Do you have a designated place for hand washing in this household?	Yes no	
41	When do you wash your hands? (Do not read out answers, listen and pick all options mentioned) a. Before, during and after preparing food b. Before and after eating c. Before and after caring for someone home who is sick d. Before and after treating a cut or wound After using the toilet After changing diapers or cleaning up a child who has used the toilet	 Yes No Yes No Yes No Yes No Yes No Yes No Yes No Yes No	

	After blowing your nose, coughing, or sneezing After touching an animal, animal feed, or animal waste After handling pet food or pet treats After touching garbage k. After leaving a public place l. After touching objects or surfaces frequently touched by other people . Immediately after returning Home from outside Others specify ------	Yes No Yes No Yes No Yes No Yes No	
42	What do you use to wash your hands?	1. Water only 2. Water with Soap/ detergent 3. Water with ash/ sand 4. Others specify ---	

For Children only

Prevalence, Geospatial Distribution and Factors Associated with Urinary Schistosomiasis in Otamokun, Ogo-Oluwa Local Government Area, Oyo State, Nigeria

Name of Community ----------

Name of Ward ----------

ID No ---------- Name ---------- Household number--------

1	Age of child at last birthday {in years)		**Skip**
2	Gender of child	Male (1) female (2)	
3	Father's Occupation	Student/none 1 Civil servant 2 Fishing 3 Farming 4 Trading 5 Artisan 6 Other specify------ 96	
4	Mother's Occupation	Student/ none 1 Civil servant 2 Fishing 3 Farming 4 Trading 5 Artisan 6 Other specify------ 96	
	MIGRATION HISTORY & HISTORY OF MDA		
5	Was this child born in this community?		

6	If Q5 is yes, how long has the child lived in this community (in years)		
7	If Q5 is no, from where did he/ she come here? (Community, state)		
8	Is SCH endemic in that community?		
9	If Q5 above is yes, has this child ever migrated to another community to live?		
10	If Q9 above is Yes, which community did you migrate to? (community, state)		
11	For how long did the child stay in that community (mention name of community) before migrating back to this community?		
12	How long ago did the child return to this community?		
13	If Q9 above is Yes, is SCH endemic in that community?		
14	How long has this child stayed in this community (in years)		
15	Did this child receive drugs for SCH during the last MAMS round	Yes (1) no (0)	
16	Did this child take the drugs received?	Yes (1) no (0)	
17	Does this child visit the river?	Yes (1) no (0)	
18	How often does this child go to the river?	1-2 times a week 3 or more times a week Every day Rarely/ not at all Others specify ----------	
19	Which of the following activities does the child engage in when at the river?	Yes (1) no (0) h. Swimming/ i. bathing j. Playing k. Fetching water/ washing l. Defecating/urinating m. Fishing n. Farming / irrigation o. Others specify	
20	Has this child experienced/ complained of any of the following in the past 3 months	Yes (1) No (0) Hematuria Abdominal pain Diarrhoea Fever Burning urination Blood in stool Vomiting Itching Aneamia Fatigue	

		Loss of appetite Cough Dysentery Other specify ---------- Don't know	
21	Where do you seek treatment for the child?	I don't do anything Health facility/Clinic Traditional homes Others specify ---------- NA ----------	
	FOR LAB USE ONLY		
	Presence of blood in urine	Yes (1) no (0)	
	Presence of SCH eggs in urine	Yes (1) no (0)	
	Qty of SCH eggs in urine	Nil <10 10-49 >49	

SECTION D: CHECKLIST FOR SANITATION, HYGIENE & HANDWASHING PRACTICE IN HOUSEHOLD

	Facility	Observation
	We would like to learn about the places that this household use to wash their hands. Can you please show me where members of your household most often wash their hands?	observed, fixed place observed, mobile not observed, not in Dwelling/yard not observed, no permission to see not observed for other reasons
	Observe presence of water at the place for hand washing. (record observation).	Water is available Water is not available NA
	Observe presence of soap, detergent, or other cleansing agent at the place for Hand washing. (Record observation).	Soap or detergent (bar, liquid, powder, paste) Ash, mud, sand None
	Water source for household	
	We would like to see the places that the household uses as Latrine	**Flush or pour flush toilet** Flush to septic tank Flush to pit latrine flush to somewhere else Flush, don't know where

		Pit latrine VIP latrine Pit latrine with slab. Pit latrine without slab/open pit. No facility/bush/field Others----------

Coordinates of household Longitude: Latitude:

Appendix II

Questionnaire translated to Yoruba

Quantitative Questionnaire: Iwe yi wa fun olori ebi tabi agbalagba inule nikan

WIWOPO ATI AWON OHUN TI OLE DAKUN ITAKANLE ARUN ATOSI AJA LAARIN AWON OLUGBE OTAMAKUN NI IJOBA IBILE OGOOLUWA, NI OYO NI ILU NIGERIA

NUMBA. ---------- ORUKO IJOBA ----------

ORUKO WOODU---------- ORUKO AGBEGEBE

ABALA A: Socio-demographic characteristics of respondents

	IBEERE *	Coding	Skip
	Iye eniyanti o gbeninuile		
	Omo odun melo ni o je?		
	Se obirinni e tabi okunrin?	Okunrin Obinrin	
	Irueya wo ni o tiwa?	Yoruba 1 Ibo 2 Hausa 3 omiran salaye--------- 96	
	Se o tiniyawo tabi oko?	Apon/ mi o loko tabi iyawori Moti loko/iyawo Opo Igbeyawo mi tituka Oomiran,salaye ----------	
	Iruesin wo len se?	Esin Kristiani Esin musulumi	

		Esin Adayeba Beeko, salaye ----------	
	Bawo ni iwe kika re se to?	Mi o kawe Ile eko alako bere Girama ipelekini Girama ipele keji Ile iwe giga Omiran, salaye ----------	
	Ise wo lon se?	Omo ile iwe Osise ijoba Apeja Agbe Onisowo Onise owo Omiran, salaye	
	Elo ni owo ti on wo inu ile yi losu?		
.	O ti to igba wo ti otin gbe ninu iluyi? (ni odun)	Bi odun kan Odun kansiodun meta >Odun meta – odunmarun >Odun marun – odunmewa O tiju odun mewa lo	
	Se o ti gbo nipa aisan 'atosi aja'	Beeni (1) beeko (0)	
11	Ni ibo ni to ti gbo nipa 'atosi aja'"	Beeni (1) beeko (0) Ile iwosan Ore at ara Ile iwe Ipade adugbo Ohunigbe iroyin jade omiransalaye ---------- 96 Mi o lee ranti mo	

	ITAN IRIN AJO OLUDAHUN	Beeni	Beeko
	Se ilu yi ni eti wa		
	If Q13 is No, fun bi odun meelo ni e ti gbe inu ilu (ni odun)		
	If Q13 is yes, latiilu wo ni eti wasi ilu yi?		
	se atosi aja w ani ily ti eti wa yen?		
	If Q13 above is yes, se eti lo si ilu mi logbe ri?		
	If Q17 ba je beeni, ilu wo ni elo gbe? (oruko ilu ati ipinle)		
	O to odun melo tie fi gbe ilu na (daruko agbegeb ki eto ko pada si inu ilu yi ?		
	odun melo seyin ni e pada si inu ilu yi? (ni odun)		
	If Q17 above is Yesse atosi aja wa ninu ilu yi?		
.	bawo ni atosi aja se wopo si ni inu ilu yi?		
.	Se o gba ogun niigba eto ogun alagbeka fun aisan atosi aja ni		

	agbegbeyi to ko ja		
.	Se iwo tabi omo re lo ogun ti e gba nigba eto ogun alagbeka fun aisan atosi aja ni agbegbeyi to ko ja		
.	Se e ni ile igbonse ninu ile yi		
.	Se o man se igbonse tabi to si ibi ti o ba ri		
.	Se o man luwe tabi we niniu odo		
.	Se oma n lo pomi odo		
.	Se o man fo aso tabi abo lodo		
.	Se o e man dako tabi ibomirin lodo		
.	Se iwo tabi ara ile re kankan ni iriri eyi keyi awon nkan nwonyi ni arin osu mefa seyin? Iko Ara yiyun Ori fifo Ara gbigbona Eje ninu ito Eje ninu igbonse Igbe gbuuru Nkan miran (saalaye)		
20	Nibo leti gba itoju fun aisan yi? Mi o gba itoju ni ibi kan kan Ile iwosa Ile iwosan ibile nkan miran (saalaye) ko bamu		
21	Se gbogbo igba ni o maa wo bata ti o bafe jade ninu ile? Gbogbo igba 1 Opolopo igba 0 Mo ngbiyanju Lekookan Rara		
22	Ki ni awon ohun ti o man se lati daabo bo ara re ati ile re lowo arun atosi aja? Mi ki se nkan nkan Yiyago fun wiwe, luwe ati si sere lodo Mimu omi to mo Sise moi ti afin we Imoto to dara Lilo ile igbonse Yiyago fun fifi ese lasan rin Lilo ogun nigba eto alagbeka fun atosi aja Omira saalaye	beeni	beeko

ABALA E: OMI, IMITOTO ATI ITOJU

23	Ni ibo ni eti ma n pon omi mimu ninu ile yi	Omi ero	**Skip**

		Omi eroti o wo inu ilewa. Omi eroti o wo inu ogbawa Omi ero to wo ile aladugbo wa. . Omi ero agebegewa omi ero ti igbalode (borehole) ero agebegewa. omi ero ti igbalode KONGA Kongati a dabobo tabi toni ideri Konga tiko ni abo tabi ideri. OMI ORISUN Omi orison ti a dabobo Omi orison ti a ko dabobo Omi ojo . Omi ti won ja lati inu oko ajagbe Omi ti apon lati inu keke ti won fi nponmi Omi Odo/ Omi Adagun Tiagba Jo/ omi ti won fin se ibominrin Omi inu igo Omi inu ora. Omiran saalaye	
24.	Nibo leti npo omi ti en lo fun ikan miran bi asofifo ati idaana nile yin?	Omi ero Omi eroti o wo inu ilewa. Omi eroti o wo inu ogbawa Omi ero to wo ile aladugbo wa. Omi ero agebegewa omi ero ti igbalode eroagebegewa. omi ero ti igbalode KONGA Konga ti a dabobo tabi toni ideri Konga tiko ni abo tabi ideri. OMI ORISUN Omi orison ti a dabobo Omi orison ti a ko dabobo Omi ojo .	

		Omi ti won ja lati inu oko ajagbe Omi ti apon lati inu keke ti won fi nponmi Omi Odo/ Omi Adagun Tiagba Jo/ omi ti won fin se ibominrin Omi inu igo Omi inu ora. Omiran saalaye	
25	Nibo ni omi naa wa?	Ninu ile yi. Ninu ogba wa Ibomiran	
26	O to Iseju melo lati lopon mi ati lati pada sile?	Iseju melo Mi omo	
27	Nibi ose mej iseyin, nje a ri ojo ti e ko ri omi pan lati ibe?	Beeni Beeko Mi omo.	
28	Nje e maan se oun koun lati se atunse omiyi fun mimu?	Beeni Beeko Mi omo.	
29	Kini e maa nse lati se atunse omiyi fun mimu? Se nkan miran wa? (Ko gbogbo ohunti won baso)	 sise fifi bilisi/chlorine sii .. a maa nfi aso se a maa nlo ase igbalode a maa nlo iyepe to kunna a maa nlo orun lati yo kokoro a maa nfun laye lati duro ko sinle alomu omiran saalaye mi omo . . .	
30	Iru ile igbonse wo ni e nlo ni ile yin? .	Ile igbonse igbalode 1. ka te omi lati ijoko igbonse lo siinu koto 2. ka da igbonse sinu salanga 3. ka da igbon se si ibomi 4. ka da igbonse sibi ti akomo **Salanga** 5. salanga alakanse toni opa fun ategun 6. salanga to ni ideri	

		7. salanga ti a si sile 8. ko si ileigbonse rara/ inuigbo/ ori papa-isere 9. omiransaalaye	
31	Se eyin ati awon elo miran jon lo ile igbonse yi?	beeni. beeko	
32	Idile melo lapa po pelu idile yin lo nlo ile igbonseyi?	< 10 . . . ≥10 Mi omo	
33	Nibo ni ile igbonse naa wa?	Inu ile yin Inu agbala yin Ibomiran. Ko bamu	
34	Nibo ni e maa nda idoti yin si?	Nibo ni e maa ndaidoti nu si? a. Won ma wagbeniilewa b. A maa njonina c. a maa nbo mole d. E maa nda sori ileti won ko lo e. E maa ndasinu odo to nsan f. Omiran s aalaye	
35	Bawo le se man lo so do si?		
	Ewo ninu awon nkan won yini o maa nse ninu odo?	Liluwe wiwe sisere Piponmi Yiyagbe/tito Pi peja Didako/ fifiomi won irungbin Nkan miran salaye	
36	Se e nibi ti e yasoto fun fifo owo niile yin	Beeni (1) beeko (0)	
37	Nigba wo ni o man foo owo re? (ma se ka idahunsita, fetisiidahun ki osi mu eyikeyi to won badaruko)	a. Kinto dana, tin ban dana ati tin ba dana tan b. Kin o jeun ati leyin ounje c. Kin to toju alaisan abi tin ba toju alaisan tan d. Kin toju abi ti mo ba toju egbo tan e. Leyin tin ba lo ileigbonse tan f. Leyin timo ba paro iledi omode abi toju omo to se	Beeni beeko

		igbonse g. Leyin ti mo ba fon imu, wuko tabi sin h. Leyin ti mo ba fowo kan eranko i. Egbin eranko abi ohun itoju eranko j. Leyin ti mo bafo wo kan egbin k. Timo bakuro laarin opoeyan l. Leyin timo bafo wokan ibiti opo eyan man sabafo wokan m. Ni kete timo ba tiwole lati ita n. Omiransalaye	
38	Kinni o fi nfowo?	Omi nikan Omi ati ose Omi ati eeru /yepe Nkanmiran -	

ABALA F: IWE AYEWO FUN IMO TOTO, ITOJU ATI OWO FIO NINU ILE

	Facility	Observation
39	A femo nipa e bi ti idile yin tifoowo. Nje e le fi ebitiawonebi yin ti ma fowo lore kore?	Mo riibitowalojukan. Moriibiifowoalagbeka Mi ori, ko sininuile/ ogba won mi ori, won o je jekin wo ibe mi o ri fun idimiran
40	Wo boya omi wa ni ibiti won ti n fowo.	Omi wa Omi ko si Ko bamu
	Wo boya ose tabi oniruru ikan mi bi ose wa fun owo fi fo (ko ohun to bari sile)	Ose(owo,olomi,powda, ate jade) eru, amo,iyepe ko si nkan nkan
41	Ibi ti idile tin ponmi	
42	Mo fewo ibi ti idile yin lo fun igbonse/ ito Iru ile igbonse	Ile igbonse igbalode 1. ka te omi lati ijoko igbonse lo siinu koto

		2. ka da igbonse sinu salanga 3. ka da igbon se si ibomi 4. ka da igbonse sibi ti akomo **Salanga** 5. salanga alakanse toni opa fun ategun 6. salanga to ni ideri 7. salanga ti a si sile 8. ko si ileigbonse rara/ inuigbo/ ori papa-isere omiransaalaye

Coordinates of household Longitude: Latitude:

Appendix III

Consent Form

This informed consent form is for parents/guardian of school-aged children participating in the research titled "Prevalence, Geospatial Distribution and Factors Associated with Urinary Schistosomiasis in Otamokun, Ogo-Oluwa Local Government Area, Oyo State, Nigeria."

Principal Investigator: Mofadeke Jaiyeola

Affiliation: Department of Public Health, Lead City University, Ibadan

This Informed Consent Form has two parts:

- Information Sheet (to share information about the study with you)
- Certificate of Consent (for signatures if you agree that you and your child may participate)

Part I: Information Sheet

I am Ms. T.M Jaiyeola, and a PhD student at Lead City University in Ibadan, Oyo State. I am conducting this research, which might help your community to effectively eradicate

Schistosomiasis (SCH) that is prevalent in your community. In this research, we are going to talk to you and your children. The research requires us engaging you and your children in a conversation, both girls and boys, and asking you a number of questions. Whenever researchers study children, we talk to the parents and ask them for their permission. After you have heard more about the study, and if you agree, then the next thing I will do is ask your daughter/son for their agreement as well. Both of you have to agree independently before I can begin.

Purpose

The study proposes to understand factors associated with SCH in this community and could lead to reduction of morbidity, disability and mortality due to SCH in Nigeria. In addition, the study will identify challenges experienced in SCH control and suggest ways for timely and efficient communication to improve SCH control.

Type of Research Intervention

A questionnaire, a focus group discussion, key informant interview, and in-depth interview will be carried out in this course of this research.

Selection of Participants

1. Study participants must be school age children and their relevant parents or local guardians in ogo-Oluwa LGA.

2. School-aged and non-school aged children age ranges has to be between 5 to 15 years old.

3. Community members, health care workers, NTD officials

Voluntary Participation

You do not have to agree that you nor your daughter/son can talk to us. You can choose to say no and any services that you and your family receive at this centre will not change. We

know that the decision can be difficult when it involves your children. And it can be especially hard when the research includes your child's health. You can ask as many questions as you like and we take the time to answer them. You don't have to decide today. You can think about it and tell me what you decide later

Procedure

1. The following applies only to focus group discussions:

   You 6-8 other parents will be invited to a discussion that will be guided by me.

   The group discussion will start with me, or the focus group guide (or a designated research assistant), making sure that the participants are comfortable. We will also answer questions about the research that they might have. Then we will ask questions about knowledge, attitude and practice towards SCH and factors associated with the disease within this community. The discussion will take place in the health facility/ town hall or a centralized chosen location where they will be comfortable, and no one else but the people who take part in the discussion and the designated research assistant or I will be present during this discussion. The entire discussion will be tape-recorded, but no-one will be identified by name on the tape. The tape will be kept safe at the safe deposit of the Department of Public Health, Lead City University, Ibadan, Oyo State. The information recorded is confidential, and no one else except the Principal Investigator and the Research Assistant will be allowed to listen to the tapes. The tapes will be destroyed after 6 months of recording.

2. The following applies only to questionnaire surveys:

   You and your daughter/son will fill out a questionnaire, which will be provided by [**name of research assistant**] and collected by [**name of research assistant**].

   OR The questionnaire can be read aloud and he/she can give me the answer which she/he

wants me to write.

Duration

We are asking you/ your child to participate in an interview which will take about 30-45 minutes of her/his time. We can do this outside of school/work hours. Any other thing done will be in accordance with the study guideline and we will be very time conscious in all we do. Altogether, we are asking for about 30 minutes of your time.

Risks and Discomforts

"We are asking you/ your son/daughter to share with us some of their opinions on Schistosomiasis and within the community, and how the community get to handle these diseases and its treatment. There is a risk that your son/daughter may share some personal or confidential information by chance, or that he/she may feel uncomfortable talking about some of the topics. However, we do not wish for this to happen. You must know that he/she does not have to answer any question or take part in the discussion/interview/survey if he/she feels the question(s) are too personal or if talking about them makes him/her uncomfortable. You/your daughter/son may choose to tell you about the interview and the questionnaire but she/he does not have to do this.

Benefits

There will be no immediate and direct benefit to you/your child, but you/your child's participation is likely to help us find out more about the handling and the treatment of tese SCH in the community, and we hope that this will help the policy makers and important stakeholders know how to better handle SCH until they are totally eliminated in the community.

Reimbursements

You/ your child will not be provided with any payment to take part in the research but you will get a little incentive for your time.

Confidentiality

We will not be sharing information about you/ your child outside of the research team. The information that we collect from this research project will be kept confidential. Only the researchers will know what his/her number is and we will lock that information up with a lock and key.

Sharing of Research Findings

At the end of the study, we will be sharing what we have learnt with the participants and with the community. We will do this by meeting first with the participants and then with the larger community. Nothing that your child will tell us today will be shared with anybody outside the research team, and nothing will be attributed to him/her by name. A written report will also be given to the participants which they can share with their families. We will also publish the results of the study in order for other interested people may learn from our research.

Right to refuse or withdraw

You may choose not to have your child participate in this study and your child does not have to take part in this research if she/he does not wish to do so. Choosing to participate or not will not affect anything about your own child or you yourself, you and your child will not have any issues in the community or anywhere because of your decision. Your child may stop participating in the discussion/interview at any time that you or she/he wish without either of you losing any of your rights here.

Who to Contact

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact the principal investigator:
Ms T.M Jaiyeola,
Department of Public Health,

Lead City University, Ibadan.

08066580105
fadekejay@gmail.com
This proposal has been reviewed and approved by the ethical approval board of the Oyo State Ministry of Health, which is a committee whose task it is to make sure that research participants are protected from harm. If you wish to find about more about the study, contact NIMR IRB, contact:

Dr. Gbolahan Abass
Ethics Committee Chairman,
Oyo state ministry of health,

PART II: Certificate of Consent

Certificate of Consent

I have been asked to give consent for my daughter/son to participate in this research study which will involve her completing one interview and one questionnaire

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily for my child to participate as a participant in this study.

Name of Parent or Guardian _____

Signature of Parent/ Guardian_____

Date _____ dd/mm/yyyy

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the parent of the potential participant, and to the best of my ability made sure that the person understands that the following will be done:

1. The parent/child will be interviewed for their opinion about SCH.
2. The interview will be recorded for research purpose.

Print Name of Researcher/person taking the consent_____

Appendix IV

Assent form

This informed assent form is for school age children participating in the research titled "Prevalence, Geospatial Distribution and Factors Associated with Urinary Schistosomiasis in Otamokun, Ogo-Oluwa Local Government Area, Oyo State, Nigeria."

This Informed Assent Form has two parts:

- Information Sheet (gives you information about the study)
- Certificate of Assent (this is where you sign if you agree to participate)

Part 1. Information Sheet

My name is [Research Assistant's Name], my job here is to ask some questions about your

knowledge on urinary Schistosomiasis, and factors contributing to Schistosomiasis in your area. This research will help us to know how well we can treat diseases in your community.

I am going to give you some information and invite you to be part of a research study. You can choose whether you want to participate. We have discussed the research details with your parent(s)/guardian and they are aware that we will asking you for your agreement. If you are going to participate in the research, your parent(s)/guardian also have to agree. But if you do not wish to take part in the research, you do not have to, even if your parents have agreed. You may discuss anything in this form with your parents or friends or anyone else you feel comfortable talking to.

Purpose: Why are you doing this research?

We want to find better ways to plan, design and implement Schistosomiasis control programs, and to identify barriers and facilitators to increasing the effectiveness of the programs in Nigeria. This will assist us to develop practical interventions and implementation plans for increasing Schistosomiasis control in Nigeria.

Choice of participants: Why are you asking me?

We are asking questions from children and their parents who are the targets and recipients of MDA programs to combat Schistosomiasis in this area.

Participation is voluntary: Do I have to do this?

You don't have to be in this research if you don't want to be. It's up to you. If you decide not to be in the research, it is okay and nothing changes, everything stays the same as before. Even if you say "yes" now, you can change your mind later and it is still okay.

I have checked with the child and they understand that participation is voluntary __(Initial)

Procedures: What is going to happen to me?

Nothing is going to happen to you, we are just going to ask questions from you as a child and we are not administering any drugs to you. The questions to be asked are going to provide information on SCH as well as how the MDA programs are executed to fight against SCH.

I have checked with the child and they understand the procedures _____ (Initial)

Risks: Is this bad or dangerous for me?

The questioning is absolutely safe for you, it doesn't pose any threat to your health other than the fact that you may feel a little fatigue or tiredness from answering questions, aside that, you are not exposed to any form of danger answering these questions. Your urine sample will be checked for the presence of SCH eggs there.

Benefits: Is there anything good that happens to me?

Nothing really good nor bad might happen to you. The questioning may not bring any immediate benefit. But this research might help us to find a better way to plan, and implement policies that will ensure effectiveness in SCH control.

Reimbursements: Do I get anything for being in the research?

No reimbursement but a little incentive will be given to your parents for their time in participating in the research.

Confidentiality: Is everybody going to know about this?

We will not tell other people that you are in this research and we won't share information about you with anyone who does not work in the research study. Information about you that will be collected from the research will be put away and no-one but the researchers will be able to see it. Any information about you will have a code on it instead of your name. Only the researchers will know what your code is.

Sharing the Findings: Will you tell me the results?

When research is completed, if you are interested in knowing the outcome of the research, you will be duly notified officially by the Principal Investigator. Afterwards, we will be telling more people, scientists and others, about the research and what we found. We will do this by writing and sharing reports and by going to meetings with people who are interested in the work we do.

Right to Refuse or Withdraw: Can I choose not to be in the research? Can I change my mind?

You do not have to be in this research. No one will be mad or disappointed with you if you say no. It is your choice. You can think about it and tell us later if you want. You can say "yes" now and change your mind later and it will still be okay.

Who to Contact: Who can I talk to or ask questions from?

You can ask me questions now or later. You can ask your parent questions. I have written a number and address of the Principal Investigator where you can forward any complaint or questions.

If you choose to be part of this research I will also give you a copy of this paper to keep for yourself. You can ask your parents to look after it if you want.

You can ask me any more questions about any part of the research study, if you wish to. Do you have any questions?

PART 2: Certificate of Assent

I understand the research is about mass drug administration programs to mitigate neglected tropical diseases in my area. I understand that I will be questioned about the MDA programs in my area and my responses will be recorded which will be used for the purpose of the research only. I understand that I can withdraw from this research anytime if I want to do that,

my participation is voluntary.

I have read this information (or had the information read to me) I have had my questions answered and know that I can ask questions later if I have them.

I agree to take part in the research.

OR

I do not wish to take part in the research and I have not signed the assent below.

_____ (initial by child/minor)

Only if child assents:

Child's name _____

Child's signature: _____ Date: _____ day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the child understands that the following will be done:

1. He/She will be questioned.

2. The responses will be recorded.

I confirm that the child was given an opportunity to ask questions about the study, and all the questions asked by him/her have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Name of Researcher/person taking the assent_____

Signature of Researcher /person taking the assent _____

Date _____ Day/month/year

Copy provided to the participant _____ (initialed by researcher/assistant)

Parent/Guardian has signed an informed consent ___Yes ___No

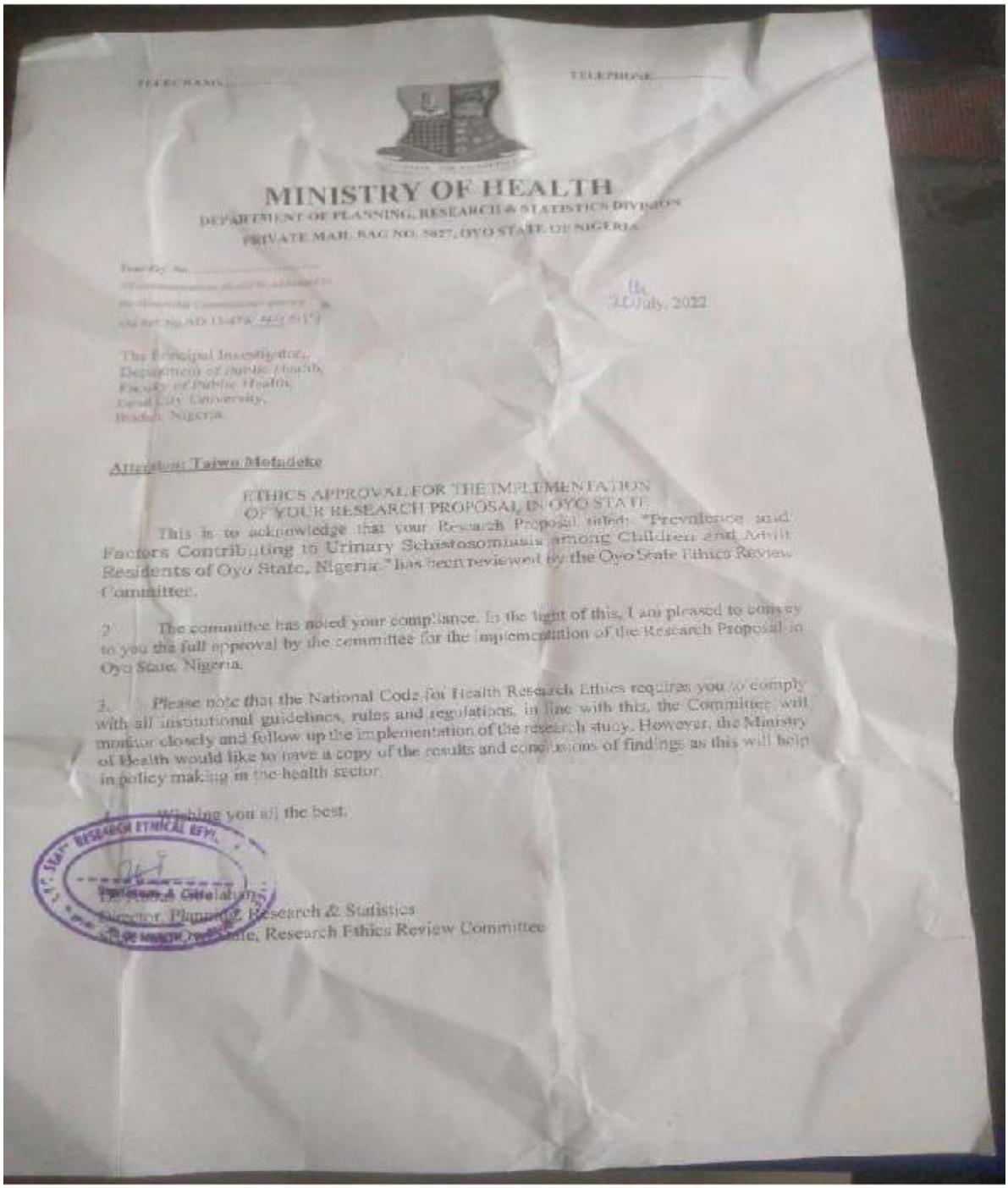
_____ (initialed by researcher/assistant)

Appendix V

Table showing the family structure of Otamokun

	Setting name
	Ogundiya
	Ogunsola
	Ogunwole
	Asipa
	Lagunju
	Popoola
	Bamgboye
	Kolajo
	Jagun
.	Eniola
.	Ofa
.	Agbopa
.	Ikolaba
.	Oguntona
.	Omo Ade
.	Ga Fulani
.	Oguoo

Appendix VI



TELEGRAMS: TELEPHONE:

MINISTRY OF HEALTH
DEPARTMENT OF PLANNING, RESEARCH & STATISTICS DIVISION
PRIVATE MAIL BAG NO. 5027, OYO STATE OF NIGERIA

Your Ref. No.
Our Ref. No. AD 13/479/ /T

th
20 July, 2022

The Principal Investigator,
Department of Public Health,
Faculty of Public Health,
Lead City University,
Ibadan, Nigeria.

Attention: Taiwo Mofadeke

ETHICS APPROVAL FOR THE IMPLEMENTATION
OF YOUR RESEARCH PROPOSAL IN OYO STATE

This is to acknowledge that your Research Proposal titled: "Prevalence and Factors Contributing to Urinary Schistosomiasis among Children and Adult Residents of Oyo State, Nigeria." has been reviewed by the Oyo State Ethics Review Committee.

2. The committee has noted your compliance. In the light of this, I am pleased to convey to you the full approval by the committee for the implementation of the Research Proposal in Oyo State, Nigeria.

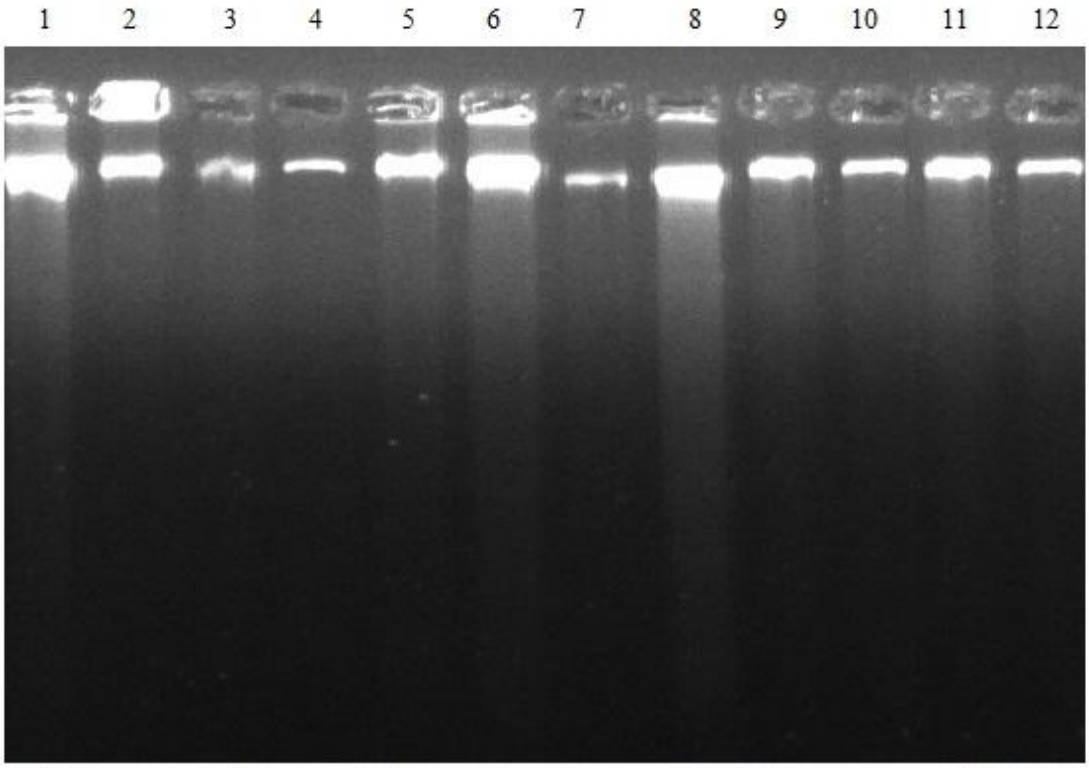
3. Please note that the National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations, in line with this, the Committee will monitor closely and follow up the implementation of the research study. However, the Ministry of Health would like to have a copy of the results and conclusions of findings as this will help in policy making in the health sector.

4. Wishing you all the best.

STATE RESEARCH ETHICAL REVIEW

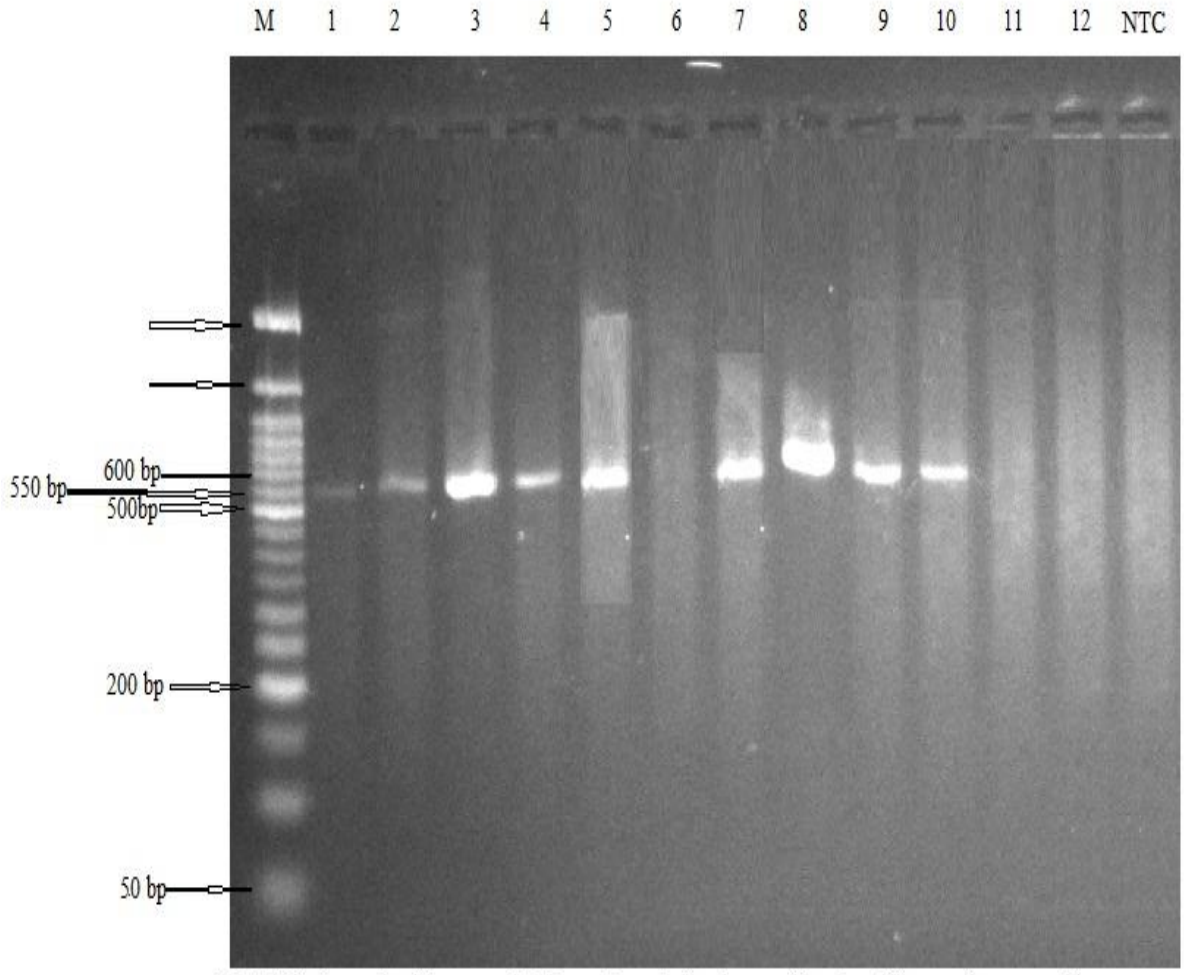
Director, Planning, Research & Statistics
Oyo State, Research Ethics Review Committee

Appendix VII



1% Safe view stained Agarose Gel electrophoresis image of the high moleculare weight DNA extracted from the Urine samples.

Plate1: Agarose Gel Electrophoresis image of the DNA extracted from the Urine Samples
Source: Researcher's Lab Result, 2022



1.5% Safe view stained Agarose Gel Electrophoresis showing amplification of the cytochrome c oxidase subunit I (COX1) of S. haematobium at 543bp. Lane M is a 50bp DNA ladder; Lane 1-12 are samples while lane NTC is a negative control. All lanes showed positive amplification except for lane 6; 11 and 12.

Plate 2: Agarose Gel Electrophoresis of the cytochrome c oxidase subunit (COX1) of the *S. haematobium* Source: Researcher's Lab Result, 2022

Plate 3: A Resident Washing in the Amuro River

Plate 4: Children Playing in the Amuro River

Plate 5: Researcher and a Research Assistant during the Urine Collection Process

Plate 6: Urine Samples in the Laboratory

Plate 7: With the Lab Scientists for Urine Microscopy

Biodata

A. Personal data:

Full Name: Taiwo Mofadeke JAIYEOLA
Address: fadekejay@gmail.com
Mobile: +2348066580105
No. 19, CBN Quarters, Opposite Ahosh Hotel Iyaganku, Ibadan.

Date and Place of Birth: 26th June 1987, Ibadan Oyo State Nigeria.
Nationality: Nigerian
Next of Kin: Mr. Adekunle Ajayi, +2347066557733

B. Educational Background:

School Attended	Date	Qualifications
• New Life Nursery Primary School Ibadan, Oyo State	(1996)	School Leaving Certificate
• Bishop Phillips Academy School, Ikara, Kaduna State	(1996-2002)	SSCE
• Federal University of Agriculture, Abeokuta, Nigeria	(2003-2009)	B.Sc. Biochemistry
• University of Ibadan, Ibadan	(2012-2015)	Masters in Public Halth

C. Work Experience

- Lecturer
  Lead City University October 2016-till date
  (Environmental Health Science Department)

- Volunteer
  Association for Reproductive and Family Health January- October 2016 (Evaluations and Operations Research Unit)

- Research Associate November 2012-July 2015
- Research Assistant November 2010-2011
  Institute of Child Health, College of Medicine University College Hospital

D. Awards and Fellowships (if any) None

E. Professional Membership:

- Member, National Association for Environmental Health Scientists' Association (NAEHSN), Oyo State Chapter
- Organization for Women in Science in Developing Countries (OWSD)

2022- till date

F. Publications (if any):

Adeniyi T.T., Ajayi G.O., Akinsanya M.A. and **Jaiyeola** T. M. 2010. Biochemical Changes Induced in Rats by Aqueous and Ethanolic Extracts of Zygotritonia crocea corms. Scientific Research and Essay Vol. 5 (1), pp. 071-076. online http://www.academicjournals.org/SRE

Jaiyeola M T, Adeyemo AA (2018) Quality of life of deaf and hard of hearing students in Ibadan metropolis, Nigeria. PLoS ONE 13(1): e0190130. https://doi.org/10.1371/journal.pone.0190130

Jaiyeola, T. M., Udoh, E. E., & Adebambo, A. (2022). Knowledge, Attitude, and Practice towards Lymphatic Filariasis among Inhabitants of an Endemic Town in Oyo State, Nigeria. Journal of Epidemiological Society of Nigeria, 5(1), 23–35. https://doi.org/10.5281/zenodo.7046800

Olanrewaju J.A, Tairu T.T, Sokan-Adega A.A, Kehinde S.A, Tella E.B, **Jaiyeola** T.M. Physico-Chemical and Thermodynamic Adsorption Studies of a Few Soils from Delta and Oyo State, Nigeria. *Asian Soil Research JournalAsian vol. 7, no. 4, pp. 1-11, 2023* DOI: 10.9734/ASRJ/2023/v7i4136

Jaiyeola T.M, Sokan-Adeaga A.A, Kehinde S.A, Tella E.O. Knowledge, Attitude and Preventive Practices towards Onchocerciasis among Residents in Ogun Waterside Local Government, Ijebu South-West, Nigeria: A Cross-Sectional Study. *Journal of Public Health Research. 2025*

G. Major Conferences Attended with Dates

- 2nd International Faculty of Basic Medical & Applied Sciences Conference FASCON 2018 Lead City University, Ibadan Nigeria: Transformational Research Innovations/Approaches for National Health and Technological Advancement 29th October - 1st November 2018
- Workshop on Ethical Conduct in Higher Institution by Liporich Consult, Ibadan Nigeria. 27th October-10th November 2018.
- Conference on Health Advances and Innovation Research (CHAIR) held at NIMR, Yaba Lagos between 8-10th November 2021
- Workshop on research impact metrics by PenKnights Media, Ibadan, Nigeria, in collaboration with Miles Development Industry Corporation, Texas, USA, on 25 August

2022

- 3rd Annual Scientific Conference in collaboration with African Institute of Public Health Professionals (AIHPHP) by Faculty of Basic Medical Sciences, Adeleke University Ede on May 17-19, 2023.

H. References

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adebolajo@gmail.com

Dr. Olugbenga Akinola
Department of Pharmacology,
University of Ibadan, Ibadan Nigeria
+2348038160637
gbenga_akinola@ymail.com

_____ _____

Signature **Date**

The University Compliance Certification

This is to certify that the thesis titled 'Prevalence, Geospatial Distribution and Factors Associated with Urinary Schistosomiasis in Otamokun, Ogo-Oluwa Local Government Area, Oyo State, Nigeria by **Taiwo Mofadeke, JAIYEOLA** with Matric no LCU/PG/002000 in the department of **Public Health**, Faculty of Basic Medical and Health Sciences, Lead City University, is in full compliance with the approved university format and style.

_____ _____

Signature **Date**