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Promoting Sustainable Development in Combating Schistosomiasis through Community-Centric Approaches: The Role of Social Empowerment and Education in Ondo State

D. O. Balogun[1, 2], O. C. Nwinyi[1], P. O. Isibor[1], B. Adewale[3], S. A. Oyegbade[1, 2], E. O Mameh[1, 2] and V. O Aririguzoh[1, 2]

[1] Department of Biological Sciences, College of Science and Technology, Covenant University
[2] Covenant Applied Informatics and Communication Africa Centre of Excellence Canaanland, KM 10, Idi Iroko Road, P.M.B 1023, Ota, Ogun State, Nigeria

[3] Nigerian Institute of Medical Research, Yaba, Lagos State, Nigeria

daniel.balogunpgs@stu.cu.edu.ng, obinna.nwinyi@covenantuniversity.edu.ng, patrick.isibor@covenantuniversity.edu.ng, badewale@hotmail.com, samuel.oyegbadepgs@stu.cu.edu.ng, emmanuel.mamehpgs@stu.cu.edu.ng, victoria-grace.aririguzohpgs@stu.cu.edu.ng

Corresponding email: daniel.balogunpgs@stu.cu.edu.ng

Abstract. Schistosomiasis has been reported to be the most common parasitic disease after malaria capable of affecting over 249 million individuals in lower-income countries. The disease is caused by a blood fluke from the genus *Schistosoma* and can be either chronic or acute in several patients depending on the worm burden. Poor sanitation and lack of potable water are major predisposing factors for the sustained transmission of schistosomiasis in several communities in Africa. In Nigeria, 24 million cases are being reported in all states, with over 100 million individuals at risk of the infection due to the disease being endemic in the region. This disease is made worse when there is a co-infection of urinary tract infections (UTIs) or sexually transmitted diseases (STDs). In Ondo state Nigeria, urinary schistosomiasis is called *Atosiaja,* blood fluke, or snail fever. The disease is endemic in several communities in Ondo states due to little or no access to clean water which increases the contact of villagers to natural flowing rivers and streams that are natural breeding sites for the intermediate hosts. This systematic review was carried out to evaluate the prevalence of schistosomiasis in communities of Ondo state, Nigeria. The review was conducted through a literature search using two scientific databases which focuses on the prevalence and intensity of schistosomiasis infection in communities of Ondo state covering the period 2017 to 2022. This review looks at the relationship between sustainable development initiatives and the prevalence of schistosomiasis in Ondo state. By addressing critical issues such as water quality, community education and integrated vector management as long-term solutions to reduce the burden of schistosomiasis in Ondo state. This holistic approach will contribute overall to improvements in public health and the environment.

Keywords: Prevalence, Schistosomiasis, Communities, Water quality, Community education.

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1. Introduction

Schistosomiasis or Bilharziasis is a water-borne disease caused by schistosomes. Schistosomes are dioecious trematodes, initially called *Bilharzia*; first observed in an Egyptian patient [1]. Trematodes are a class of unsegmented helminths that are digenetic; requiring two hosts for its lifecycle—a definitive host for its sexual reproduction and an intermediate host for the larva stages. Animals, mammals, and humans are the definitive hosts for the parasite while freshwater snails are the intermediate host [2]. Schistosomiasis has been reported to be the most prevalent parasitic disease after malaria [3], capable of infecting over 249 million of the world's population [4]. The disease is caused by a blood fluke from the genus *Schistosoma* and can be either chronic or acute in several patients depending on the worm burden [5]. Schistosomiasis has been reported in about 87% (within the sub-Sahara Africa) of the world population [6]. Poor sanitation and lack of clean water in several communities have been implicated in the prevalence of the disease in sub-Saharan Africa [7]. In the entire African population, the disease is most endemic in Nigeria, thus making the nation the most endemic country in the world [4].

Schistosomiasis is an intestinal infection caused by *S. mekongi, S, japonicum, S, intercalatum* and *S. masoni*, while *S. haematobium* infects the urinary system. *S. haematobium* is endemic in Africa and Asia, while *S. masoni* is more prevalent in Africa, the Caribbean islands, and South America. *S. japonicum* is found in Taiwan, Sulawesi, Japan, China, and the Philippines. Other species of *Schistosoma* include *S. intercalatum,* endemic in Central and West Africa, while *S. mekongi* is prevalent in Cambodia and Thailand [5]. The intermediate hosts for *S. haematobium and S. intercalatum* are freshwater snails of the *Bulinus* species, and the intermediate hosts for *S. masoni* are the *Biompheleria* species. *Oncomelania* is the intermediate host for *S. japonicum*, while *Neotricula aperta* is the intermediate host for *S. mekongi* [5]. In Africa, urinary schistosomiasis is one of the neglected tropical diseases and a parasitic disease that remains predominant in the continent [9]. In Nigeria, 24 million cases have been reported across all states, with over 100 million individuals at risk of the infection due to the attendant endemicity reported in the region. The disease is aggravated by a co-infection of urinary tract infections (UTIs) or sexually transmitted diseases (STDs) [5, 10].

Symptoms of urinary schistosomiasis include dysuria (painful urination), haematuria (presence of blood in urine), proteinuria (presence of protein in the urine), anaemia (inability of the blood to transport oxygen), nutritional deficiencies, impairment of cognitive ability in infected children, impaired concentration, and bladder cancer. The severity of these symptoms depends on the patient’s immunity and the worm burden [11]. In Ondo State Nigeria, urinary schistosomiasis is called *Atosiaja,* blood fluke, or snail fever [12]. The disease is endemic in several communities in Ondo states due to little or no access to clean water which increases the contact of villagers with natural flowing ponds and streams that are breeding sites for the intermediate hosts. Inadequate and inappropriate epidemiological knowledge of the disease among most individuals and lack of political will and commitment to effectively control and eradicate the disease underscore the persistence of the disease in these areas even though health workers in these parts are trained to be fully involved in the mass drug administration of praziquantel [13].

This review is aimed at evaluating the prevalence of schistosomiasis in communities of Ondo state, Nigeria. It seeks to explore the demographic profile of individuals affected, and the laboratory techniques for the detection of *Schistosoma* eggs in stools and urine samples. The study also aims at assessing the activities that increase reinfection in individuals, and the intervention strategy adopted to reduce the burden of the infection in the target population.

1.1 *Schistosoma* lifecycle

The lifecycle of most species of *Schistosoma* are the same with few differences in their intermediate and definitive host that alter their patterns of transmission. For example, in *Schistosoma haematobium*, the worms dwell in the veins of the urinary bladder and pelvis region. The male worm is larger than the female worm and has two muscular suckers-the oral and ventral suckers (the latter being larger than the former). Behind the caudal end of the ventral sucker is the gynaecophoric canal. The gynaecophoric canal is an oral groove where the female is held. The female worm fits into the gynaecophoric canal aided by its slender and long body; relatively smaller than the adult male [14]. The female worm can contain up to thirty to three hundred eggs per day in the uterus. These eggs have terminal spines at one pole that produce local tissue reactions and inflammation in the urinary bladder which can later progress to bladder cancer if not treated. Due to poor sanitation and inappropriate waste disposal, the eggs are passed in the urine into water bodies where ciliated miracidia are released. The miracidia are the free-swimming larval stage that infects the intermediate host. The intermediate host snail for *Schistosoma haematobium* in Africa is *Bulinus* species while in India, the intermediate host is *Ferrisia tenuis*.

Upon entrance into the intermediate host, the miracidia lose their cilia and undergo two successions to become a sporocyst. This takes place for a period of four to eight weeks. Many cercariae are produced by asexual reproduction during the second phase of sporocyst development. The cercariae are the infectious form of the trematode that are shed into the water. When shed into the water, they can penetrate the unbroken skins of individuals bathing or wading in the water. This skin penetration is made possible through lytic substances secreted by penetration glands in the cercaria [14]. After the cercariae penetrate the skin of their definitive host, they shed their tails and become *schistosomulae* that enter into venules. A *schistosomulae* is the immature form of the schistosome in the venules of its definitive host. Through the venules, the schistosomulae can migrate to several parts of the body such as the right heart, the systemic circulation, the left heart, and the pulmonary circulation before finally reaching the liver. In the hepatic veins, the schistosomulae grow and are sexually differentiated into male and female adolescents in twenty days. After differentiation, they migrate eventually reaching the urinary bladder or pelvic regions where they mature and begin laying eggs. These eggs can finally be seen in the urine after ten to twelve weeks post-penetration. The adult worms can live up to twenty to thirty years and in some rare cases, they can live up to forty years. For *Schistosoma haematobium*, humans are the only definitive host known so far reported [1].

Figure 1 shows the lifecycle of both *S. haematobium* and *S. mansoni*. *S. haematobium* eggs are shed in urine while *S. mansoni* eggs can be seen in the feces.

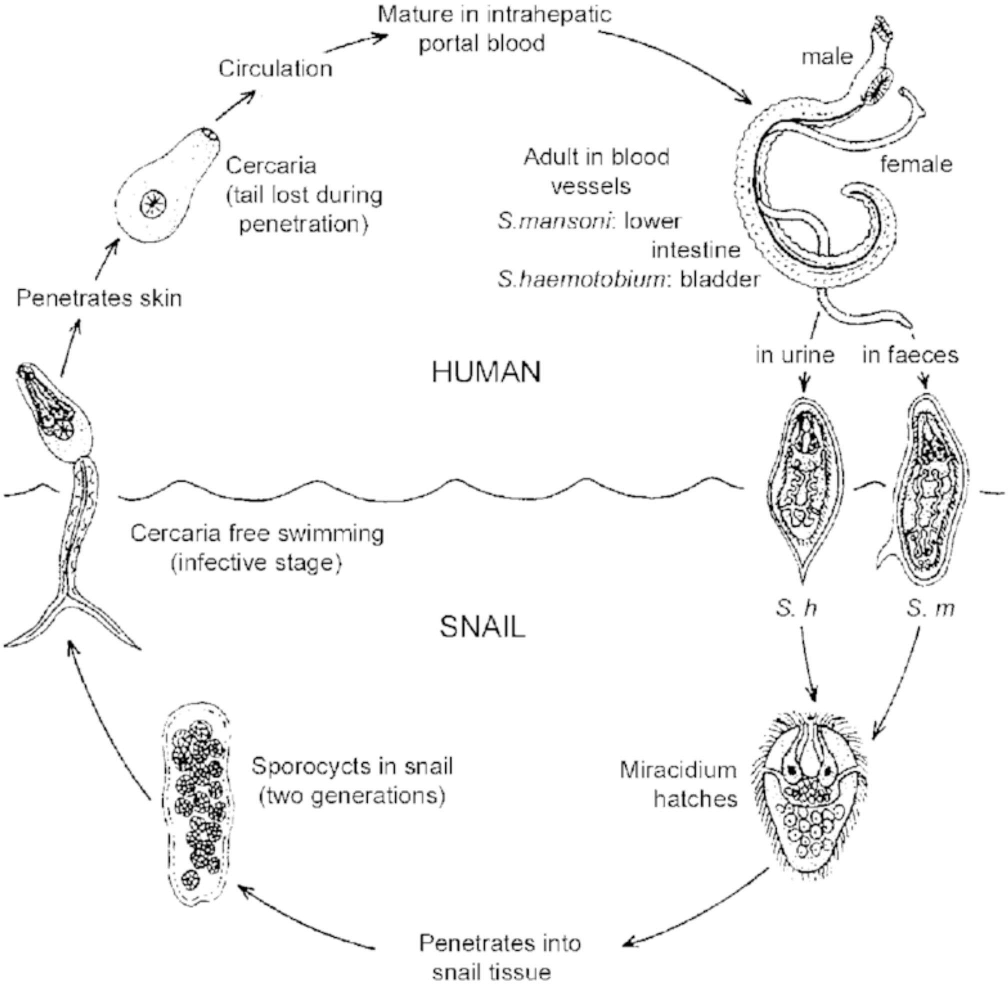

Figure 1: Lifecycle of *S. haematobium* and *S. mansoni* [15]

In the *S. mansoni* lifecycle, the process is the same. However, the intermediate host is the freshwater snail of the genus *Biomphalaria*. In endemic areas, humans are not the only definitive host affected. Monkeys and baboons can also be affected. The major difference between *S. haematobium* and *S. mansoni* is that in the latter, the schistosomulae mature in the liver and move through the venules to the gut wall. This is where the eggs penetrate the lumen and gut wall to be seen shed with the faeces. The eggs of each *Schistosoma* species differentiate them from one another. *S. mansoni* has a spine at the side (lateral spine), *S. haematobium* has a miracidium spine at the end (terminal spine) while *S. japonicum* has a spine only rudimentary and not always visible (Figure 2).

Figure 2: Comparison of *Schistosoma* eggs [16]

In schistosome infections, three different stages are commonly seen in the progression. These stages are influenced by the duration of the infection and the egg burden in the individual. These stages also differ from one another in how rapidly the eggs of the schistosome are excreted in either the stool or urine and their clinical manifestations. The three stages are the acute stage, the established active infection, and the late chronic infection [17].

1. 2 The Acute Stage

1. 2.1 Cercarial Dermatitis

When the cercariae penetrate the intact skin, some of the infectious larvae die in the skin while others enter the venous plexus through a small blood vessel or the lymphatic vessel. The larvae are transported through the blood flow to the liver. The skin responds to the dead or dying larvae at the site of penetration by producing innate immune responses that lead to hypersensitivity reactions. These reactions cause a maculopapular pruritic reaction that is also known as cercarial dermatitis. Cercarial dermatitis can be seen in individuals exposed to *Schistosoma* infections for the first time. Examples are migrants entering an endemic area or travellers on a holiday vacation [17].

1. 2.2 Acute Schistosomiasis

When the cercariae has successfully penetrated the skin, it matures into a schistosomula. During this period of maturation, the symptomatic acute stage can develop. Symptomatic acute schistosomiasis, Katayama fever, or Katayama syndrome is seen in individuals previously naïve to the exposure of the infection. Acute schistosomiasis is first detected from 2 weeks to 3 months after exposure to the *Schistosoma* species. Symptoms seen in acute schistosomiasis are due to hypersensitivity reactions and immune complex formations resulting in response to antigens released during egg deposition and schistosomula migration. These symptoms are often with eosinophilia that can be observed with radiography [17].

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1.3 Established Acute Infection

For people living in endemic communities, acute schistosomiasis with symptoms is not seen because the parasite has reached a stage of established active infection in which mature adult worms and progressive egg production are significant in most individuals living in those areas [14]. In this stage, live eggs are excreted in both stools and urine samples. Adult worms also residing in blood vessels do not stimulate any inflammation, hence causing no symptoms. The reason for the established colonization in the body of persons in endemic communities is based on somatic stem cells possessed by the adult worms which help in the regeneration of their surface tegument and the binding of host antigens to this surface teguments which hides the parasite antigen from the host's immune system [6]. Despite established colonization, inflammatory responses can still be targeted to the parasite's eggs since the *Schistosome* eggs secrete antigenic glycoproteins that induce inflammation. However, in the process of inflammation, these eggs trap surrounding tissues to form granulomas. Granumolas consist of inflammatory cells such as lymphocytes, eosinophils, macrophages, and neutrophils that are accumulated in response to the presence of the parasite's eggs. These granulomas if left untreated will progress to bladder cancers in susceptible individuals. Established active schistosomiasis is majorly observed in children living in endemic communities. The infection is reversible after treatment and removal of the adult worms in the children [17].

1.4 Late Chronic Infection

In endemic countries, as individuals become more exposed to infections, the worm burdens decrease after the teenage years as immunity is developed over time for the infection and new infections. Established worms gotten from earlier infections are also reduced with time by natural deaths. This reduction in the adult worms leads to the production of fewer new eggs being deposited in the tissues and excreted in stools and urine. Due to this, granulomas occur with less inflammation as a result of smaller egg production. These granulomas are then replaced by fibrous tissues which are called scarring. This scarring eventually progresses to cancer and severe symptom [17]

2. Study Location

2.1 Epidemiology of the Parasite

Schistosoma spp has six species that infect individuals in different geographic locations. *S. haematobium* has been reported in over 54 countries, namely Nigeria, Egypt, Brazil, Morocco, Oman, Cambodia, Tunisia, China, and Saudi Arabia [1]. *S. mansoni* is endemic in Venezuela, Brazil, the Caribbean islands, and Suriname, while *S. japonicum* was widely seen in Japan but the intervention of control efforts to eliminate it, saw it decline in the late 1970s [17]. Other species of *Schistosoma* have a lower global prevalence, for example. *S. intercalatum* and *S. guineensis* are endemic in regions of West Africa and Central Africa while *S. mekongi* is known to be from the Mekong River in Lao People's Democratic Republic and the southern parts of Cambodia in South East Asia [2]. *S. haematobium, S. guineensis, S. intercalatum,* and *S. mansonii* primarily infect humans as their definitive host but *S. mekongi* and *S. japonicum* are of zoonotic origins. Cattle, water buffaloes, or other bovine species serve as reservoir hosts for *S. japonicum* in transmitting the disease to humans while dogs, pigs, or even cattle are considered reservoirs for *S. mekongi* [17]. Table 1 shows the parasite species, the diseases they cause, and their global distribution in the world.

Table 1: *Schistosoma* Species and the Geographic Distribution of Schistosomiasis

Disease Caused	Species	Geographic Location
Urogenital Schistosomiasis	*Schistosoma haematobium*	Africa, Corsica [France], the Middle East
Intestinal Schistosomiasis	*Schistosoma mekongi*	Lao People's Democratic Republic and several districts of Cambodia
	Schistosoma mansoni	Suriname, Brazil, the Caribbean, Africa, Venezuela, and the Middle East
	Schistosoma japonicum	Indonesia, the Philippines, China
	Schistosoma intercalatum and *S. guineensis*	Rainforest areas of Central Africa

The global distribution of schistosomiasis in the world shows that sub-Saharan Africa had more infections than other continents in 2015. This can be attributed to poor water quality, cultural practices and sanitation in most communities (Figure 3).

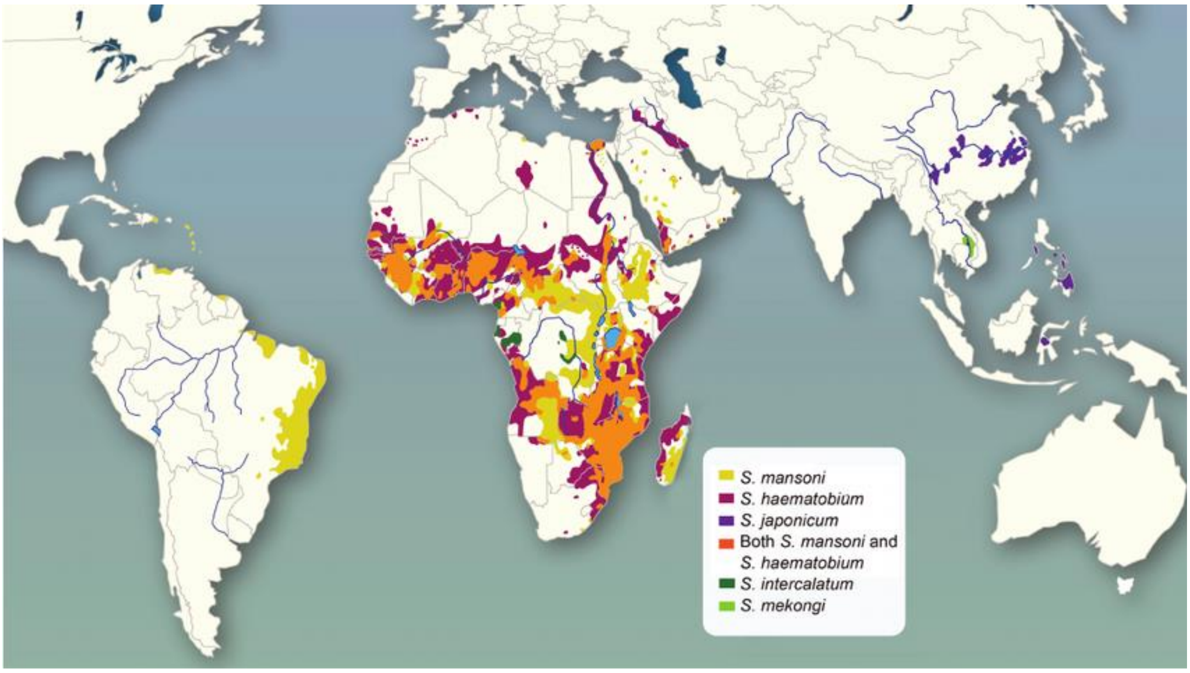

Figure 3: Global Distribution of Schistosomiasis in the World [18]

2. 2 Disease Burden of Schistosomiasis

Schistosomiasis infects over 249 million people globally with even 780 million individuals more at risk due to occupational or cultural lifestyle [19]. Human schistosomiasis is one of the prevalent parasitic infections that causes 279,000 deaths annually and a global burden of 3 million disability-adjusted life years (DALYs) [4]. The fact that it can be spread through immigration and water-based projects such as irrigation means it can also occur in non-endemic countries with devastating effects [20]. The mortality and morbidity associated with *S. japonicum* is higher than most *Schistosoma* species. This is due to the higher number of eggs produced than other species [17].

2.3 Pathophysiology

In Schistosomal infections, the organs affected are determined by the *Schistosoma spp.* The severity of the symptoms in any individual can also be related to the intensity of the infection or worm burden.

2.3.1 Intestinal Schistosomiasis

The schistosomal parasites that cause intestinal schistosomiasis are *S. mansoni* and *S. japonicum.* The adult worms of these parasites thrive in the mesenteric veins to cause infection. The symptoms of intestinal schistosomiasis include mucosal granulomatous inflammation, pseudopolyps, and bleeding. Pseudopolyps are healed tissues developed during the process of inflammation after a repeated cycle of ulceration.

Hepato-splenic schistosomiasis

From the mesenteric veins, *S. japonicum* and *S. mansoni* eggs are swept by the venous blood flow to the portal branches of the liver where they are trapped in the pre-sinusoidal periportal tissues. In the liver, granulomas form around the eggs causing enlargement of the liver and spleen.

2.3.2 Urogenital schistosomiasis

Adult *S. haematobium* is the only schistosome worm to live in the pelvic venous plexus. Due to the terminal spine and the passage of eggs cluster into the lumen of the bladder, there can be seen sloughing off of the epithelial surface, bleeding, and ulceration. This process results in the thickening of the bladder walls by pseudopolyps. The swelling of the kidney or hydronephrosis can also occur when granuloma blocks the openings of the ureter and the passage of urine. Hydronephrosis when progressed can lead to squamous cell carcinoma of the urinary bladder. This occurs after years of exposure, infection, and inflammation of the urinary tract. In men with genital schistosomiasis, analysis of semen samples of individuals in endemic communities shows a high level of leukocytes and inflammatory cytokines. This condition is worse in persons living with HIV/AIDS as the number of inflammatory cells and viral load in the semen is increased which causes bleeding lesions on the cervical mucosa of infected women [17].

2.4 Schistosomal Transmission

Community projects such as irrigation dams constructed in Owena, Ondo state used in agriculture can serve as potential sites for a schistosomal outbreak [21]. This is because in towns such as Owena, Kajola and Baikan, urogenital schistosomiasis is prevalent in these communities due to a lack of pipe-borne water and modern toilet facilities. Movement of infected persons from these communities to an urban area will spread the infection through poor hygiene and improper disposal of waste materials [22]. In communities of Ondo state, the risk factors involved in the development of schistosomiasis were the contact and duration of contact with infected rivers, the age group of individuals living in the communities, occupation and their educational background [23]. To control and limit the spread of infection, emphasis should be placed on educating individuals who are more at risk of the infection (school children, farmers, fishermen and women) on schistosomiasis infection [19]. Treatment of potable water was also suggested by [24] in most water plants either by chlorination or filtration to reduce the spread of schistosomiasis.

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3. Material and Methods

To evaluate the prevalence of schistosomiasis in Ondo state, Nigeria. A literature review was conducted for original articles written in the English Language and focused on schistosomiasis in Ondo state over some time from 2017 to 2023. On November 20, 2023, a literature search was conducted utilizing the online databases Google Scholar and PubMed.

3.1 Inclusion criteria

The articles included in this review strictly reported schistosomiasis in Ondo state, urogenital and intestinal schistosomiasis in Ondo state, laboratory techniques used in identifying schistosomiasis in these communities, demography of individuals in Ondo communities along with longitudinal investigations of treatment effectiveness. English language articles from cross-sectional research such as clinical or community surveys were also included.

3.2 Exclusion criteria

This review removed articles that reported schistosomiasis in other parts of Nigeria, Africa, and other regions of the world. Studies without conclusive investigations of the disease were also disregarded. Review articles were also excluded from this study.

3.3 Data Extraction

The year the study was conducted, the year the article was published, the location of the study area, the length of the study, the age of the participants, and the study design (either observational or interventional) were all captured in the data that was extracted from each article. Additionally, information on sampling techniques carried out, and the clinical condition of the research population were also presented.

3.4 Study Location

Ondo state is a state located in southwestern Nigeria. The state was created on the 3rd of February 1976 and borders Ekiti state to the north, Kogi on its northeast, Edo state in the east, Delta state to the southeast, Ogun state at the southwest, Osun in the northwest and the Atlantic Ocean to the south. Ondo state is nicknamed the "Sunshine State" and is the 19th most populated state in Nigeria. In terms of landmass, the state is 25th in the country. Ondo state has eighteen local governments with the major ones being Okitipupa, Ondo, Owo, Akoko, Idanre, Akure and Ilaje (Figure 4).

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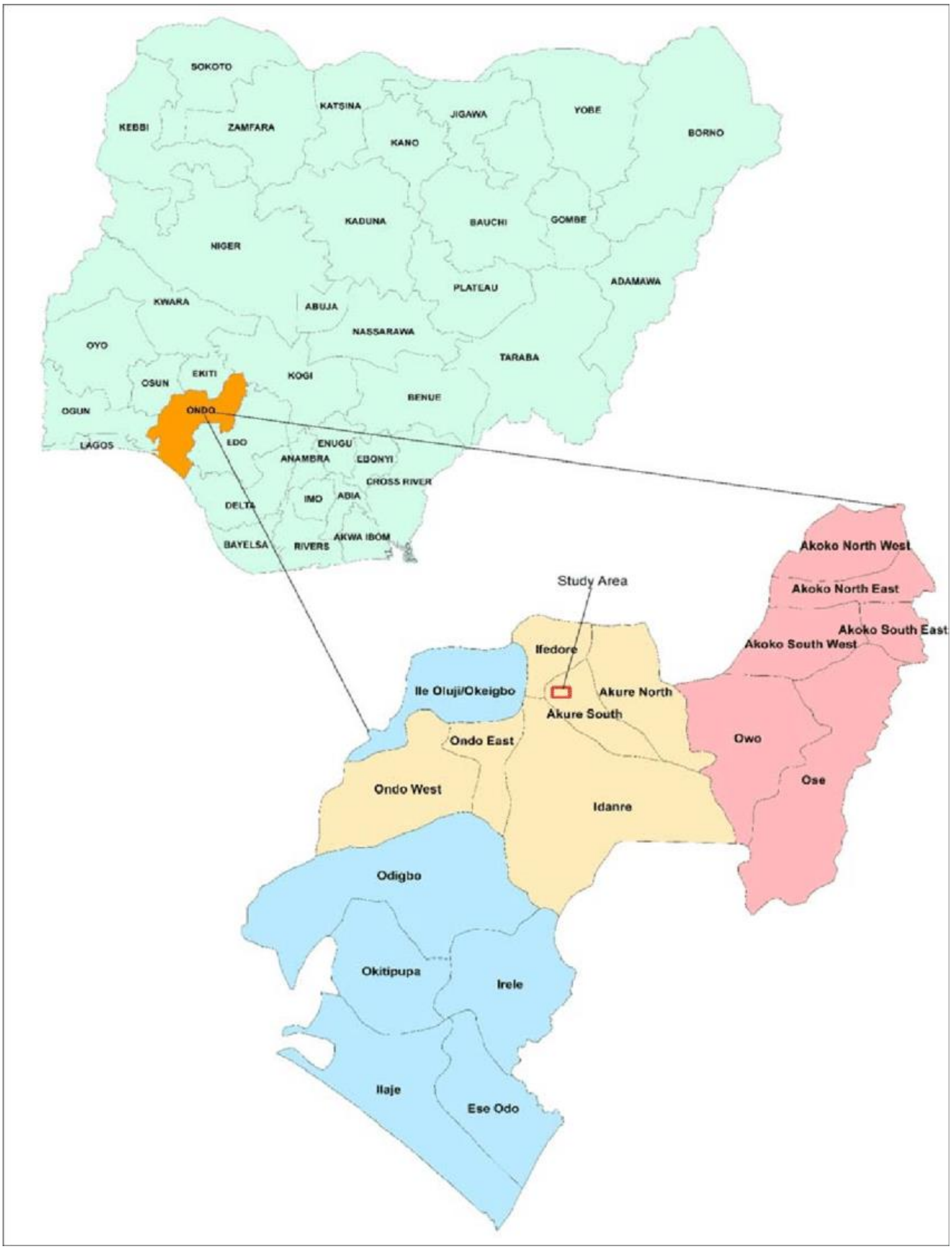

Figure 4: Location of Ondo State on the Nigerian Map and the local government areas [25]

4. Results and Discussion

4.1 Results

The databases of PubMed and Google Scholar were searched for papers of interest. A PRISMA flow chart was used to pool 5762 articles on schistosomiasis (1491 articles were removed due to duplication and 4059 were excluded for not being schistosomiasis related). 212 of those articles matched the requirements for inclusion. In all, 29 studies passed the inclusion criteria for the prevalence of schistosomiasis in Ondo state while 103 articles were removed due to their study location not being from Ondo state (Figure 4)

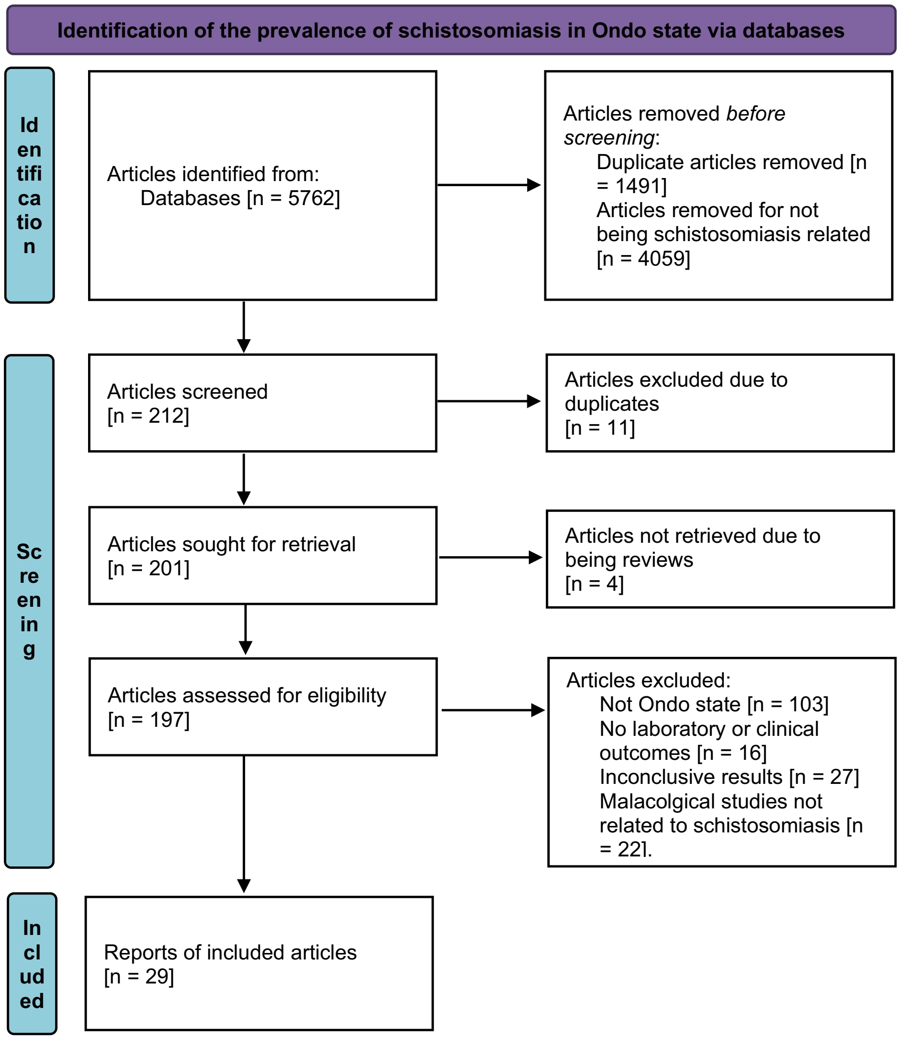

Figure 5: PRISMA flow diagram for the study.

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4.1.1 Data Extraction

The year the article was published, the location of the study area, and the authors were recorded and presented in a table, as seen in Table 2.

Table 2: Analysis of the data extraction done for the study

Year of publishing	Study location	Authors
2017	Akure Metropolis, Ondo state	[26]
2017	Owo local government, Ondo state	[27]
2018	Ikare-Akoko, Ondo state	[28]
2018, 2021	Ipogun community, Ondo state	[29], [30], [31], [32]
2018	Ilaje local government, Ondo state	[33]
2019	Idanre local government, Ondo state	[34]
2018, 2019, 2021, 2022	Ifedore local government, Ondo state	[35], [8], [12], [5]
2018, 2021, 2022	Ile-Oluji/Okeigbo local government, Ondo state	[36], [13], [37]
2021	Owena town, Ondo state	[38]
2022	Akure North local government, Akure South local government, Ondo state	[5]
2021, 2022, 2023	Ondo state	[39], [2]
2018, 2023	Ondo East local government [Owena, Kajola and Baiken], Ondo state	[40], [41],
2023	Ayadi community in Irele Ward 3, Irele local government, Ondo state	[42]

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4.2 DISCUSSION

The prevalence of schistosomiasis, laboratory techniques used in the study, activities that increase reinfection among individuals, and the interventions done to reduce the prevalence of schistosomiasis in Ondo state were recorded (Table 3).

Table 3: Communities and local governments in Ondo state affected by schistosomiasis

Prevalence/Intensity of Schistosomiasis	Parts of Ondo State	Demographic profiles of individuals	Laboratory techniques used in the research	Activities that increase reinfection among individuals	Interventions done to reduce the prevalence of schistosomiasis	Authors
	Ondo East local government (Owena, Kajola and Baiken communities)	Male (52.2%) Female (47.8%) Highest demographic age group: 5 to 10 years (41.3%) Highest Educational background of participants: Primary (60.3%)	Haematuria (blood in urine)	Fetching water (12.5%) Bathing (19.3%) Washing (15.8%) Fishing (11.9%) Swimming (39.2%) Others (1.3%)	Parasite-specific control (Focus on snail control) Parasite non-specific control (Awareness to urogenital schistosomiasis)	[41]
0.7% of urinary tract infection seen in the town (in a sample of 300 individuals)	Ikare-Akoko, Ondo state					[28]
Prevalence of urinary schistosomiasis in the community (65%)	Ayadi community, Irele local government, Ondo state	Male (42.1%) Female (57.9%) 5 to 7 years (22.9%) 8 to 19 years (30%) 11 to 14 years	Filtration technique Microhaematuria Chemical strips		Praziquantel to affected individuals	[42]

		(36.4%) 15 years and above (10.7%)				
Prevalence of urinary schistosomiasis among students (48.08%)	Ikota, Ifedore local government, Ondo state	Male (50.7%) Female (49.3%) ≤ 10 years (55.3%)	Microscopy Microhaematuria Chemical reagent strip (Combi-9® urinalysis Medi-test strip manufactured by Analyticon Biotechnologies, Germany)	Others (18%) Washing clothes (6.7%) Fetching water (31.3%) Bathing or swimming (44%)	Examination of urinary schistosomiasis through microhaematuria rather than chemical reagent strips that may vary from study to study	[8]
Schistosomiasis has been reported to be endemic in the communities in the local government due to no access to safe potable water	Ifedore local government (Ipogun and Bolorunduro) and Ile-Oluji/Okeigbo local government, Ondo state.	≤ 10 years (76.9%) 11 to 19 years (48.1%) 20 to 29 years (19.2%) Above 30 years (19.2%)		Swimming (71.2%) Going to fetch water at riverside (1.9%) Others (27.0%)	Health education activities implemented through collaboration with the State Ministries of Health	[13]
Number of males affected (26.2%) Number of females affected (23.2%)	Ipogun community, Ifedore local government, Ondo state	7 to 8 years (29.5%) 9 to 10 years (30.5%)	Microscopy		WHO strategy of treatment once every 2 years in endemic communities	[29]
Prevalence of schistosomiasis in males (71.1%) Prevalence in female (28.9%) (Low when compared to Osun and Ogun state)	Ayede Ogbese in Akure North local government, Ita-Oniyan and Aponmu in Akure South local government, and Ipogun in Ifedore local government, Ondo state		Microscopy Microhaematuria Sedimentation and filtration of eggs			[5]

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4.2.1 The frequency of schistosomiasis cases in Ondo State

In Ondo state, urinary schistosomiasis has been reported to be endemic in the region than intestinal schistosomiasis. In Ifedore local government, Ikota is a community of farmers and traders that had a flowing stream as their source of water in the community. This was because the water borehole system in that area wasn't functioning properly. This led to the prevalence of urinary schistosomiasis in the screened population. The prevalence of *Schistosoma haematobium* in secondary school students of Ikota Comprehensive High School was low compared to other local government areas in 2019 [43]. Despite the low prevalence, urinary schistosomiasis was still endemic in the town. The factors that contributed to this endemicity were lack of access to pipe-borne water which encouraged water-contact activities such as fishing, swimming, washing, and bathing in infected rivers by individuals in the town. Male schoolchildren were the most affected in the study population due to their daily activities that bring them in contact with the infected streams. The low prevalence reported in Ikota town compared to other communities in 2019 should not make us ignore the fact that this infection is still endemic in the community. This was reported by [8] who called for an urgent need to deploy intervention programmes in the form of mass drug administration due to the disease endemicity in the community. Although Awosolu's research centered on chemical reagent strip as a means of diagnosing urinary schistosomiasis, it was obvious that this wasn't the gold method for diagnosis but rather should be combined with microscopic methods to increase the strip's predictive value [8].

Ipogun is another community in Ifedore local government that was selected with Ayede Ogbese (Akure North local government area), Ita-Oniyan, and Aponmu (Akure South local government area) for a study. This selection was conducted based on information from Ondo State Primary Health Care on endemic hotspots. Ita-Oniyan and Aponmu are rural communities where individuals depend solely on farming but Ogbese was the most civilized of the four communities due to trading activities. One of the factors that underscore urinary schistosomiasis prevalence in Ipogun, Ita-Oniyan, and Aponmu was women's engagement in the local production of palm oil which causes regular contact with the *schistosoma-infested* rivers. All four communities rely on rivers and streams as major source of water for domestic and recreational purposes. For example, the River Ogbese is located in Ogbese, while River Awo in Ita-Oniyan and river Aponmu in Ipogun both traverse Aponmu community. The prevalence of urinary schistosomiasis during this period of study was significantly high due to the infection being common in certain age groups. This knowledge informed the treatment decision of mass chemotherapy of praziquantel to school children in the communities. Higher occurrences are also observed in Ita-Oniyan, Ipogun, and Aponmu due to the river linkage in the community. These three communities are traversed by the same river, excluding Ogbese in Akure North local government. A higher prevalence of urinary schistosomiasis was recorded in male individuals of the adolescent age due to their activities such as fishing, swimming, bathing, and sporting in these infested rivers. The high temperature in Ondo state is also a factor to consider for the prevalence of urinary schistosomiasis during the dry season. During dry seasons, the velocity of water is low- a preferable condition for the *Bulinus* snail population. Furthermore, low oxygen conditions recorded during the dry season also promotes the disease. The high prevalence of urinary schistosomiasis in these communities was finally concluded on several factors which were dry seasonality in the community, occupational activities, and linkage of the rivers across three of the communities [5].

Ipogun and Ilara-Mokin communities of Ifedore local government were selected as 2 of 12 sites in seven states screened for the prevalence of urogenital schistosomiasis among primary school children by [2]. The other states selected were Osun, Ebonyi, Enugu Anambra, Benue, and Plateau. Among the seven states pooled, all western states showed beyond-average of schistosomiasis. The research rated Ipogun and Ilara-Mokin as hyper-endemic zones with >50% prevalence. However, positives can be drawn from the study in curbing the disease. This study emphasized that infected children have a leading role to play in the spread of the parasite and that a significant increase in treatment coverage has yielded positive results in the fight against the disease [2].

Five secondary schools were sampled for urinary schistosomiasis In the Ifedore local government area. They include Anglican Grammar School Igbara Oke, The Apostolic High School Ilara Mokin, Ayo Grammar School Ipogun, Anglican Grammar School Ijare, and Community High School Isarun. Their major water sources were rivers, streams, and springs which are used for recreational, occupational, and domestic purposes. The prevalence in this area is 13.8%. According to the World Health Organization (WHO), 13.8% is considered low. However, infection is widespread in the local government area. The prevalent rate was attributed to the fact that students drink and bathe from infected Apomu and Ipogun Rivers [29]. The pattern of water contact, accessibility, and nearness to schools were also factors that contributed to the prevalence of urinary schistosomiasis among the school children. In the Ifedore local government, the problem was attributable to lack of portable drinking water, hence provision of portable water in the community is imperative [35]

Akure Local Government area in Ondo state was assessed for the patterns of urinary schistosomiasis infection [9]. Ogbese, Igoba, Iju, Ita Ogbolu, and Oba Ile communities were selected for the study. Urinary schistosomiasis was observed to be endemic in this area due to the clustering of residential areas. Olusi observed that clustered households situated near infected rivers contributed to the spread patterns of the infection. Hotspots of urinary schistosomiasis were seen in Ita Ogbolu and Ogbese. The factors for this were the Ogbese River serving as a bathing and washing source for traders especially among the Hausas in those parts. Oba Ile had fewer hotspots for the infection due to its proximity to Akure, the state capital, from which the community derives social amenities and well-being. One of these social amenities is a good source of portable drinking water. Their location in the state capital explains the observed fewer hot spots. The endemicity in all these five communities in the Akure local government area necessitates the need for an integrated control of the disease, such as mass chemotherapy for the school children, clean water for the public, and restriction from the infected water bodies, and sensitization of the general public on the basic epidemiology of schistosomiasis [9].

Oke-Igbo community in Ile-Oluji/Okeigbo local government area was assessed for the prevalence of urinary schistosomiasis and the efficacy of praziquantel among school children. Oke Igbo community has over 10 schools and the major source of livelihood in the community is farming. Oke Igbo has 6 springs namely Omi-Iye, Majeroku, Omi Iya-Isobo, Ojege-Amuye, Egbatedo, Odo-Arepa, Odo-Awo Odo-Oni, Odo-Alaidan. Odo-Oloori and Ogiran that serve domestic and recreational purposes. The schools selected in Oke-Igbo community were St. Joseph, St. Luke, and St. Mark where schistosomiasis remains one of the major diseases among school children. Schistosomiasis has been endemic in Oke-Igbo community until the lower prevalence observed in recent years due to the intervention from the government in providing chemotherapeutic treatment and educational awareness of the populace on the risk factors. In the Oke-Igbo community, predisposing factors for their infection and reinfection are due to low literacy, domestic activities, and consumption of the host snails for animal protein. Despite the administration of praziquantel, low cure rates were

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reported in Oke-Igbo community. This requires prioritization of the administration based on inequalities that exist in the population and proper surveillance of the disease. Children under 4 years old were not included in the study of the prevalence of schistosomiasis among school children [36]. In the Oke-Igbo community, application of eco-friendly molluscicide can be adopted by the community members [36].

In Ondo East local government area, Owena, Baiken, and Kajola communities were randomly selected for patterns of urogenital schistosomiasis in Ondo East local government area, Ondo State. The schools screened include Owena Community Grammar School, Owena; St. Peter's Roman Catholic Mission Primary School, Baiken and Ebenezer Anglican Primary School, Kajola. Baiken is the most remote of the three communities. The sources of water for individuals in these communities include streams and rivers. Their contact with infected water bodies encourages the higher prevalence of schistosomiasis through reinfection in the community. The study proved that urogenital schistosomiasis is endemic to Baiken, Owena, and Kajola communities of Ondo East local government area [41].

In Ilaje local government area, a riverine part of Ondo state, 5 villages were selected based on the prevalence of urinary schistosomiasis. The 5 villages include Ugbo-nla, Ori-Oke, Maran, Ode-Mahin, and Abe-alala. There was a high prevalence of urinary schistosomiasis in the study area due to lack of adequate waste disposal, poverty in some communities, and ignorance. Parental occupation was also a factor to consider as children of fishermen were mostly infected. This shows a correlation between occupation and schistosomiasis. The prevalence of the disease in the Ilaje local government area should prompt health workers and local government leaders to start awareness programmes and mass drug administration in these parts to alleviate the impact of the disease on individuals [14].

Urinary schistosomiasis is endemic in several communities and local government areas in Ondo state. This corroborates previous reports that have recommended immediate intervention of the disease. The occupation of most individuals in the community plays a significant role in the infection dynamics of the disease. Sadly, persons in most communities and several local governments of Ondo state are fishermen and traders with only a few towns showing diversity of profession due to proximity to the state capital. Portable drinking water is therefore a necessity in most communities. This hasn't been addressed enough by the state and local government as reports from several articles emphasized the need for a borehole or pipe-borne water. This major step could significantly reduce the risk of infection and reinfection in the community. Despite mass drug administration of praziquantel in most parts of Ondo state the disease persists- a challenge that can be caused by drug resistance of the parasite. This is a major concern to health workers.

Overall, intestinal schistosomiasis was not as reported as urinary schistosomiasis in several parts of Ondo state. The reason for this could be as a result that researchers might feel that if they could address the issue of urinary schistosomiasis, they could also limit intestinal problems occurring from the parasite as praziquantel could be used to eliminate enough worm burden from the individuals. Another factor to consider is the lack of funding to carry out research in parts of Ondo state. Therefore, fully funded standard research on intestinal and urinary schistosomiasis in the communities of Ondo state should be conducted where recommended.

In Nigeria, control programmes initiated by the Federal Ministry of Health, State Ministry of Health, and other voluntary organizations have attempted the use of mass drug administration to treat patients and people at risk of infection in remote areas. Despite this intervention by the government and non-governmental organizations, schistosomiasis remains a challenge. Other

challenges faced in the country include religious crises, and general security challenge that have made these hotspots inaccessible to researchers and medical experts [2].
Persistence of these disease in the community is attributable to school children and adolescents in rural areas of Nigeria who frequently bath in infected streams and rivers, especially during hot seasons. Other factors include lack of portable water, fishing, swimming, and washing in the rivers, and poverty. To tackle this issue, the implementation of mass drug therapy, molluscicides and an effective control strategy initiative as seen in Egypt, Japan and Tunisia should be considered [45]. This approach will prevent reinfection of the disease, reduce the frequency of infection after treatment, and reduce drug resistance by the parasite [45].

4.2.2 Laboratory techniques used in the study

The laboratory technique used in most studies was haematuria [41,42,23,8] either self-reported by the patients or detected using a reagent strip. This was preferred by most researchers due to its ease and convenience. However, this indirect method of diagnosing schistosome infection is not reliable despite its ease due to the fact that other diseases (urinary tract infections, bladder cancer and kidney stones) can also result into haematuria [46]. The gold standard for the diagnosis of schistosomiasis is microscopy of urine sample concentrated by filtration, sedimentation or centrifugation over a filter paper [23,29,42,43]. This method is reliable and specific enough to diagnose the infection in Ondo state. The reason for this is because different species of the parasite can be viewed in terms of their morphology and spine formation. This knowledge will better aid in species identification, parasite burden quantification and treatment regimen for the affected individuals. Antibody detection and polymerase chain reaction (PCR) are other ways for diagnosis of schistosomiasis [46]. However, this method was not used in any research carried out in Ondo state due to its cost and limited application.

4.2.3 Activities that increases reinfection among individuals in Ondo State

The major activities that increased reinfection among individuals such as schoolchildren and young adults was contact with infected rivers in their communities (fetching water, bathing, washing, swimming) [5,13,41–43]. Occupational activities of individuals (fishing and farming) also meant they came in contact with these infected rivers as a source of livelihood [41]. These mean that planning public health objectives that will deal with water-related issues in Ondo State communities is necessary. Farmers and fishermen are forced to interact with these water bodies, demonstrating how dependent they are on it for their daily subsistence. This demonstrates the connection between environmental socioeconomic variables and the spread of disease. The fact that these behaviors are continuous throughout several years (2019–2023) indicates that the identified risk factors are still present in the community, according to numerous studies done in Ondo state. These have the effect of requiring long-term interventions, such community education and continual disease monitoring in accordance with public health plans.

4.2.4 Interventions done to reduce the prevalence of schistosomiasis in Ondo state

The intervention carried out in Ondo state include parasite specific control by focusing on the host and parasite non-specific control through awareness of individuals to urogenital schistosomiasis in the community [41], administration of praziquantel to infected individuals (schoolchildren, young adults and those at risk through occupational risk) [42], examination of urinary schistosomiasis through microhamaturia by health practitioners rather than chemical reagent strips which may vary due to lack of specificity [8], health education activities implemented through collaboration with the state ministry of health in Ondo state

[13] and implementing WHO strategy of treating schoolchildren and those at risk once every 2years in endemic communities [29].

Combining non-specific and parasite-specific management aims to provide a complete strategy for controlling schistosomiasis. This is due to the author's recognition of the significance of treating affected individuals and raising community awareness to stop the sickness from spreading. Giving prazinquantel to particular community groups is a targeted therapy strategy that focuses on the most susceptible in an effort to lower the overall burden of the disease. However, in an endemic population, this strategy alone is not optimal due to resistance to prazinquantel in recent years. The fact that medical professionals prioritize using microhaematuria above chemical reagent strips when analyzing urine schistosomiasis indicates that they are making a deliberate attempt to increase the infection's diagnostic accuracy.

The significance of partnerships in public health matters is shown by Ondo state cooperation with the ministry of health to raise community awareness about health concerns. Promoting a long-term, sustainable preventative effort in the community and altering individual behavior depend heavily on health education and health awareness within the community [47]. Worldwide consensus has been reached on the necessity of adopting the WHO approach every two years. In the state of Ondo, this strategy guarantees a recurring intervention that aids in the prevention and management of schistosomiasis. The fact that Ondo State adopted it demonstrates the state's attention for sustainable development, since long-term advancement of these objectives will be greatly aided by monitoring, adjusting measures, and evaluating results.

5. Conclusion and Recommendation

5.1 Conclusion

In conclusion, schistosomiasis has been reported to be the most common parasitic disease after malaria in lower-income countries. *Schistosoma spp* has six species that infect individuals in different geographic locations. In several communities and local government areas in Ondo state, urinary schistosomiasis is known to be endemic in the state. This has to do with the occupation of most individuals in the community which has a way of influencing their infection of the disease. The case study of Ondo state demonstrates the potential for collaboration between environmental sustainability and public health, community education, and integrated vector control with regard to water quality. In order to combat schistosomiasis, it will be important going ahead to promote cooperation between scientists, politicians, and the local population. This will support the adoption of sustainable development. The interaction between human health and the environment will be strengthened by this solution, which will not only help the state of Ondo but also consider the welfare of future generations.

5. 2 Recommendations

In Ondo state, the testing and treatment of people infected with schistosomiasis infection and the provision of a good drinking source should be paramount to government bodies and organizations in the communities as it is possible to use sanitation and water treatment to control schistosomiasis.

Recommendations to consider from this study will be better methods to evaluate schistosomiasis in endemic communities using available data obtained from longitudinal studies. Control efforts of this disease have been a major problem in sub-Saharan Africa due to limited resources. Therefore, successful control implementations from countries outside Africa can also be considered. With the limitations surrounding praziquantel in therapy, the direction should be on long-term cost-effective control measures to address schistosomiasis in line with better healthcare settings in lower-income countries. Like every neglected tropical disease, schistosomiasis is a disease attributed to poverty so emphasis should be made by government bodies both locally and internationally to support and alleviate the burden seen in endemic communities to finally eradicate the disease from the world.

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