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Impact Of Infrastructural Developments On_schistosomiasis (Bilharziasis Or Snail Fever) In Northern Nigeria: A Review

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Abstract

Numerous studies conducted across northern Nigeria have demonstrated that infrastructural development projects often result in unintended ecological consequences, particularly the alteration of natural landscapes and ecosystems. These modifications frequently create favorable conditions for the proliferation of freshwater snails, many of which serve as intermediate hosts for snail-borne parasitic diseases, notably schistosomiasis (also known as bilharziasis). Evidence from various research efforts highlights a strong correlation between the construction of large-scale water resource infrastructure—such as dams for irrigation, aquaculture, and hydroelectric power generation—and a marked increase in the prevalence of schistosomiasis in nearby communities. These projects typically involve the creation of artificial water bodies and slow-moving water systems, which provide ideal habitats for the breeding and survival of disease-transmitting snails, such as species within the genera *Bulinus* and *Biomphalaria*. In several instances, studies have reported the emergence of these snail populations in areas where they were previously absent, indicating a disturbing ecological shift driven by human development. The public health implications of such ecological changes are profound. Schistosomiasis, in particular, poses a significant socio-economic burden, affecting school-aged children and rural populations who rely on these water sources for daily activities. Chronic infection can lead to long-term morbidity, reduced productivity, and increased healthcare costs, thereby undermining the socio-economic benefits initially envisioned by the infrastructural projects. In some cases, the negative health outcomes have led to critical reassessment of the net benefits of such developmental initiatives. Given these findings, it is imperative that strategies to mitigate the health and environmental risks associated with infrastructural development be systematically integrated into all phases of project planning and execution. This includes incorporating disease risk assessments, ecological monitoring, environmental impact assessments (EIAs), and the design of snail control and public health education programs. By embedding these preventive and adaptive measures within the development framework, future projects in northern Nigeria can achieve more sustainable outcomes that balance economic growth with ecological integrity and public health safety.

Keywords
Infrastructural Development, Schistosomiasis, Northern Nigeria

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INTRODUCTION

Infrastructural developments are undoubtedly required for the advancement of society. That is why from the colonial era to date, successive governments in Nigeria have embarked on massive construction of roads in order to open up the hinterland and link cities, towns and villages for easy movement of people, goods and services. Good road network is therefore an important index of development. Consequently, massive provision of this infrastructure has been the focus of successive governments. Unfortunately, such developments have led to proliferation of numerous ponds/burrow pits thereby altering the natural landscape (Fig. 1). Many of these ponds have been successfully colonized by freshwater snails which serve as intermediate hosts for various parasites of public health importance (Kela *et al.*, 1990, Istifanus, 1995). These ponds easily become centers of attraction to children for recreation, playing and fishing as seen in Fig.2

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Figure 1: Pond arising from road construction activity which has become a breeding site for freshwater snails

Figure 2 Children playing in water

Furthermore, the development of water resources in order to meet demands for good drinking water, food and energy also has its negative consequence. Records have shown that between 1970 – 1995 (25 years) there has been an unprecedented upsurge in dam construction in Nigeria with over 245 of them being constructed (Ofoeze, 2002). Majority of these dams are in northern Nigeria in addition to numerous unlisted dams/reservoirs and seasonal pools. However, damming of rivers and streams give rise to significant alterations in the natural ecology of the original water bodies, thus, creating more conducive environments for breeding of fresh water snails that are involved in the transmission of parasitic diseases like schistosomiasis.

Several studies in Northern Nigeria have indicated an increased prevalence of schistosomiasis associated with dam construction. These include those of Thompson (1967) at the Bacita Sugar Plantation (Kwara State); Pugh, Burrows and Tayo (1980) at Malumfashi, Katsina State; Betterton (1984) for the South Chad Irrigation Project Area in Borno State and Bettertonet *al.,* (1988) for the Kano River Irrigation Project area (Phase1) in Kano State. Subsequent similar studies in Kano (Abdullahi *et al.,* 2009; Duwa and Oyeyi, 2009; Duwa *et al.,* 2009; Sarkin Fada *et al.,* 2009) have all re-emphasized the increase in prevalence of schistosomiasis in association with dam construction and irrigation works. Other studies by Akogun and Okin (1993) at the Savannah Sugar Plantation staff village in Adamawa State; Ofoeze *et al.,* (1996) at irrigation schemes in Sokoto, Katsina and Kebbi States; Bello *et. al.,* (2003) around the Goronyo Dam Sokoto; Inuwa *et. al.*, (2003) at the Alau Dam Borno State; Adamu *et. al.*, (2004) at Piro village near Gubi Dam Bauchi; Taofik *et al.,* (2017) in the Rima valley Sokoto; in the Dadinkowa Dam Gombe State (Sunday, 2017); in Benue State (Tersoo *et al.,* 2017) and around the Kiri Dam Adamawa State (Kaleson *et al., 2022*); Agi and Okwuosa (2001) in mining ponds in Jos and Okpala *et. al.*, (2017) in mining ponds in Jos South have either observed an increased trend in transmission of snail–borne parasitic infections or occurrence of freshwater snail intermediate hosts of parasites of public health importance in places where they hadn't been earlier observed. These studies are summarized in Table 1.

The Disease Schistosomiasis (Bilharziasis)

The disease schistosomiasis also known as bilharziasis or snail fever is caused by certain flat worms or flukes (Fig. 3) which live inside the blood vessels of their hosts. Therefore, they are referred to as blood flukes. The global estimates of the disease burden show that between 200 – 300 million are infected in 78 countries and 779 million people are at risk of being infected with 200,000 deaths recorded annually. Out of those at risk, 660 million people are found in Africa with the continent currently recording 90% of the global cases (WHO, 2023). In Nigeria, an estimated 29 million people are infected. There are four major blood flukes that affect humans the world over and all of them belong to the genus *Schistosoma*. These are *Schistosoma haematobium,S. mansoni, S. intercalatum* and *S. japonicum.S. haematobium* lives in the vesicular veins surrounding the urinary tract and so the worm's eggs are passed out in urine. Thus, the infection is

commonly called "urinary schistosomiasis". *S. haematobium* commonly occurs throughout Africa and in parts of Western Asia. The other three species (*S. mansoni*, *S. intercalatum* and *S. japonicum)* reside in the mesenteric veins around the small intestine hence they cause "intestinal schistosomiasis". Their eggs are excreted in the faeces of their hosts. While *S. mansoni* occurs throughout sub-saharan Africa, the Nile delta in Egypt, in Yemen, in South America and the Carribean Islands, *S. intercalatum* occurs majorly in Central as well as parts of West Africa. *S. japonicum* is found mainly in Japan, China, Philippines and a small part of Indonesia. A closely related species to *S. japonicum*is*S. mekongi* which occurs along the Mekong River in Laos and Cambodia. The Global, African and National distribution of the schistosome parasites is shown in Fig. 4. In northern Nigeria, *S. haematobium* and *S. mansoni* are the commonly occurring schistosomes and although the infected population has not been rigorously estimated, the number of cases appears to be increasing owing to massive provision of dams and irrigation infrastructure (Ofoeze *et al.*,1996; Bello *et. al.*, 2003; Abdullahi *et al.*, 2009; Duwa and Oyeyi, 2009; Duwa *et al.*, 2009; Sarkin Fada *et al.*, 2009; Tersoo *et al.*, 2017; Kaleson *et al., 2022*). The prevalence of the scourge in the region is shown in Table 2.

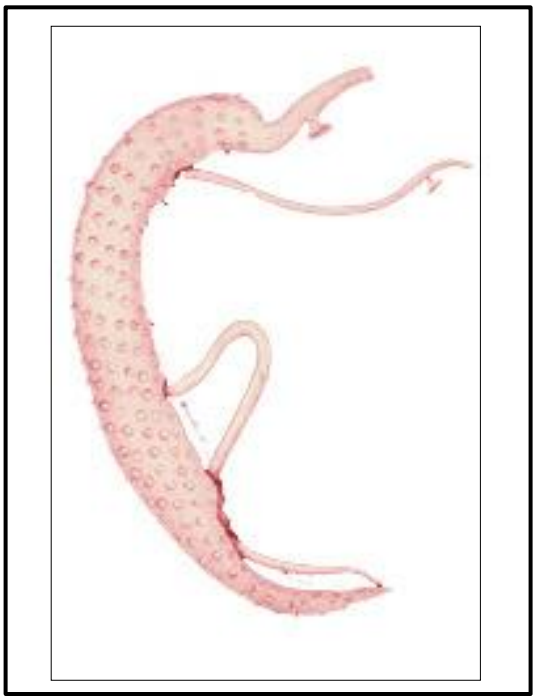

Figure 3: Male and female schistosome in-copular

Table 1: Selected references on increased prevalence of schistosomiasis and/or introduction of shistosome intermediate host snails associated with infrastructural development in northern Nigeria.

S/N	State	Infrastructure	Reference(s)
1	Adamawa	Irrigation: Savana Sugar Plantation Dam: Kiri Dam	Akogun & Okin (1993) Kaleson *et al.*, (2020)
2	Bauchi and Plateau	Ponds and minning ponds	Kela *et. al.*, (1990)
3	Bauchi	Dam: Gubi dam	Adamu *et. al.*, (2004)
4	Bauchi	Ponds: Burrow pits	Istifanus (1995)
5	Benue	Ponds	Tersoo *et. al.*, (2017)
6	Borno	Irrigation; South Chad Irrigation project	Betterton (1984)
7	Borno	Dam; Alau Dam	Inuwa *et. al.*, (2003)
8	Gombe	Dam; Dadinkowa dam and Irrrigation Project Area	Inusa (2017)
9	Kano	Irrigation: Kano River Irrigation Project Area (phase 1)	Betterton *et. al.*, (1988)
10	Kano	Dams: Jakara, Thomas and other Dams	Abdullahi *et. al.*, (2009) Duwa & Oyeyi (2009) Duwa *et. al.*, (2009) Abdullahi *et. al.*, (2011)
11	Katsina	Earth dams	Pugh *et. al.*, (1980)
12	Kwara	Irrigation: Bacita Sugar Plantation	Thompson (1967)
13	Plateau	Ponds: Mining ponds	Agi & Okwosa (2001) Okpala *et. al.*, (2017)
14	Sokoto	Dam: Goronyo dam Rima Valley Irrigation Scheme	Bello *et. al.*, (2003) Taofik *et. al.*, (2017)
15	Sokoto, Katsina and Kebbi	Irrigation	Ofoeze *et. al.*, (1996)
16	Taraba	Ponds and other fresh water bodies	Agereet. *al.*, (2009)

Table 2: Selected references on prevalence of schistosomiasis in the nineteen northern States of Nigeria

States	Locality/Target		Prevalence (%)	Reference(s)
Adamawa	i)	5 LGAs along R. Benue	23.2	Yaro *et al.*, (2020)
	ii)	3 LGAs	5.2	Zamdayu *et al.*, (2023)
	iii)	Communities surrounding Kiri	43.0	Kaleson *et al.*, (2022)
Bauchi	i)	Misau LGA	2.0	Usman (2020)
	ii)	Kirfi LGA	27.5	Bara & Balogun (2021)
	iii)	School Children	35.3	Usman *et al.*, (2016)
Borno	i)	Boko Haram-related children in IDPs	62.0	Saad *et al.*, (2018)
	ii)	Biu LGA	0.5	Usman *et al.*, (2024)
	iii)	Dikwa Community	48.7	Habiba (2015)
Benue	i)	2 LGAs	41.5	Houmsu *et al.*, (2012)
	ii)	Ogbadibo LGA	46.6	Mbata *et al.*, (2009)
	iii)	Katsina-Ala LGA	16.4	Iboyi *et al.*, (2018)
Gombe	i)	Kumo, Akko LGA	10.4	Yohanna *et al.*, (2022)
	ii)	Shongom LGA	27.3	Daniel *et al.*, (2015)
	iii)	All 11 LGAs	12.0	Nebe (2013)
Jigawa	i)	Warwade Community	20.3	Alhaji *et al.*, (2021)
	ii)	Jidawa Community	65.7	Balogun *et al.*, (2022)
	iii)	Zobiya Community	69.0	Balogun *et al.*, (2022)
Kaduna	i)	Giwa & Makarfi LGAs	9.5	Danladi & Henry (2024)
	ii)	Kaduna Metropolis	12.9	Umar (2009)
	iii)	Sabon Gari LGA	25.5	Justina *et al.*, (2024)
Kano	i)	Statewide	8.6	Dawaki *et al.*, (2015)
	ii)	Minjibir LGA	44.2	Duwa *et al.*, (2009)
	iii)	Dawakin Kudu LGA	7.7	Abdullahi *et al.*,(2022)
Katsina	i)	Statewide	8.6	Tolulope *et al.*, (2018)
	ii)	Kurfi LGA	43.8	Abbas *et al.*, (2023)
	iii)	Rimi LGA	54.5	Usman *et al.*, (2016)

Kebbi	i)	Yauri area	42.2	Ukatu *et al.*, (2015)
	ii)	Argungu Emirate	32.1	Shuaibu *et al.*, (2017)
	iii)	Birnin Kebbi	2.8	Iboyi *et al.*, (2022)
Kogi	i)	4 LGAs	18.7	Ejima & Odaiba (2010)
	ii)	Odenyi, Bassa LGA	43.3	Agieni *et al.*, (2020)
Kwara	i)	Rural Communities	45.6	Babamale *et al.*, (2018)
	ii)	Ajase-Ipo	58.7	Bolaji (2015)
		Community	20.1	Amaechi *et al.*, (2024)
	iii)	Jebba, Moro LGA		
Nasarawa	i)	Keffi Town	3.2	Pam *et al.*, (2016)
	ii)	Lafia Metropolis	20.0	Ombugadu *et al.*, (2022)
	iii)	Lafia Metropolis	13.3	Diana *et al.*, (2024)
Niger	i)	Bida	15.8	Barnabas *et al.*,(2011)
	ii)	Minna Metropolis	12.9	Chigozie & Daniyan (2019)
	iii)	Wushishi LGA	40.0	Abdullahi & Saidu (2012)
Plateau	i)	Bassa LGA	15.8	Istifanus *et al.*, (2018)
	ii)	Bukuru, Du & Zawan		
	iii)	Langai	6.0	Thomas *et al.*, (2020)
			6.4	Banwat *et al.*, (2012)
Sokoto	i)	Statewide	2.1-61.8	Jafaru *et al.*, (2023)
	ii)	Statewide	21.3	Solomon *et al.*, (2023)
Taraba	i)	Takum	34.7	Olamiju *et al.*, (2022)
	ii)	Bali	32.5	Ukwubile & Tile (2016)
	iii)	Fikyu Community	32.1	Dawuda *et al.*, (2019)
Yobe	i)	Gashua	37.7	Chiroma (2023)
	ii)	Potiskum	6.0	Bigwan *et al.*, (2012)
	iii)	Nguru LGA	55.0	Dagona (2014)
Zamfara	i)	Shinkafi area	47.2	Surajo *et al.*, (2024)
	ii)	Bakura area	40.0	Mudasiru *et al.*, (2018)
	iii)	Gusau	47.0	Ladan *et al.*, (2012)

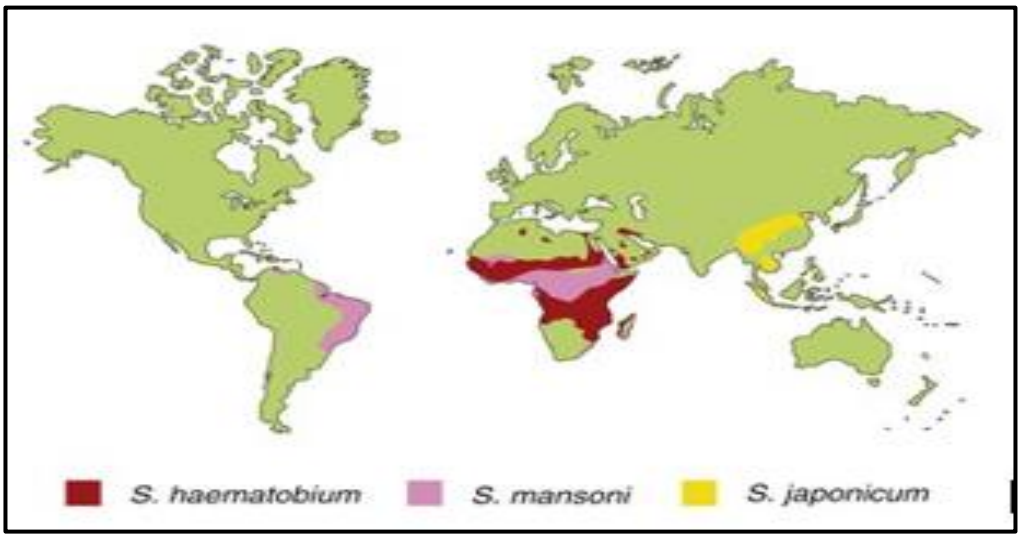

Figure 4a: Global distribution of human schistosome parasites

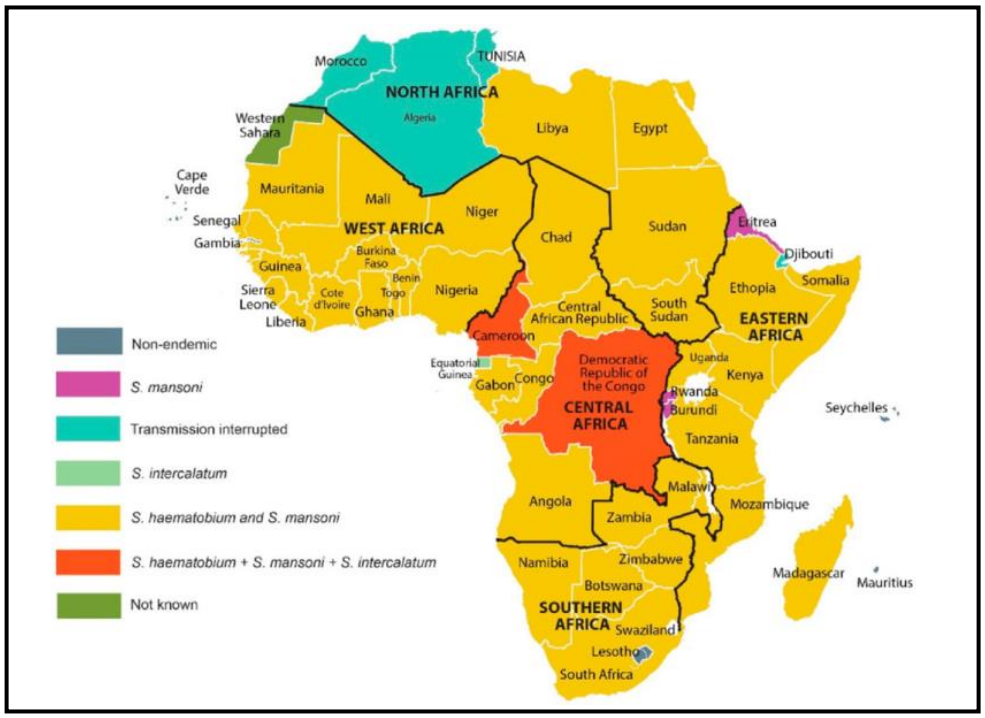

Figure 4b: African distribution of human schistosome parasites

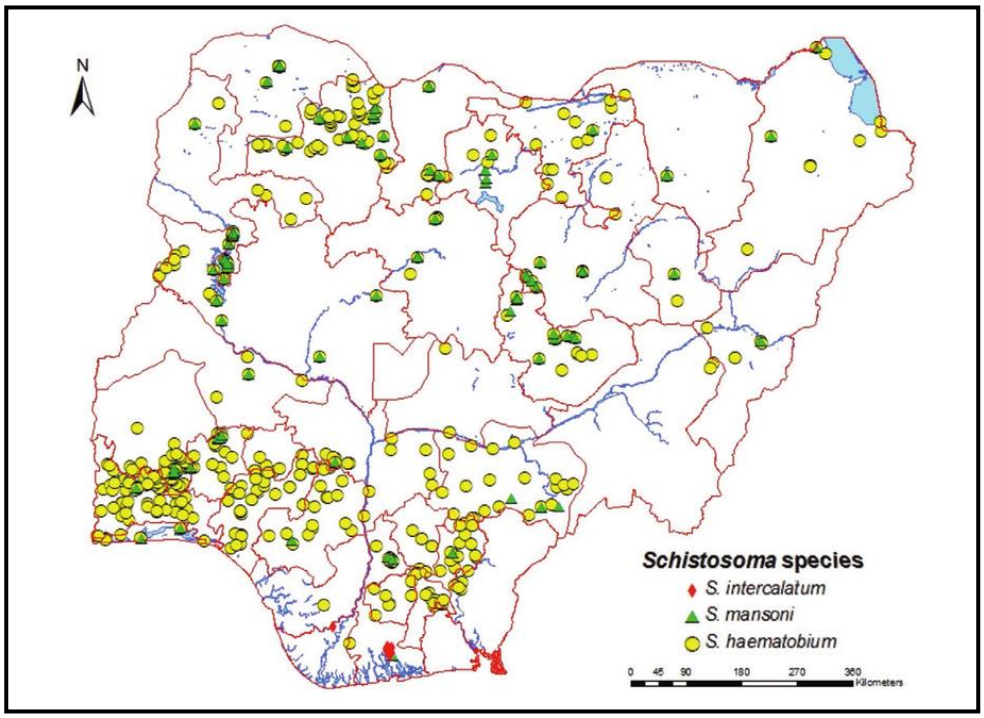

Figure 4c: Distribution of human schistosome parasites in Nigeria

Each schistosome species infects only a single genus of snail. Thus, *S. haematobium* is only found in *Bulinus* species snails, *S. mansoni* is harbored by *Biomphalaria* species,*S. intercalatum* has *Bulinus africanus* and *B. forskalii*as intermediate hosts while *S. japonicum* develops in *Oncomelania* species while the only known intermediate host of *S. mekongi* is *Neotricula aperta*. In northern Nigeria, the common schistosome intermediate host snails are *B. globosus, B. truncatus, B. senegalensis* and *Biomphalaria pfeifferi* (Fig. 5).

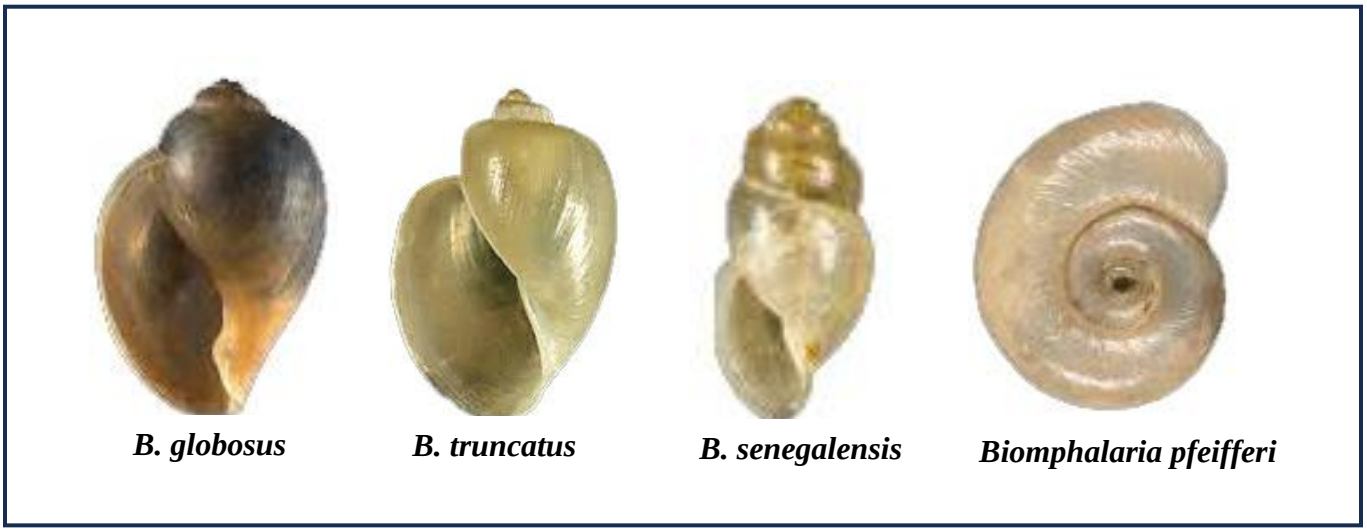

Fig. 5: Freshwater snail intermediate hosts of schistosomes in northern Nigeria

Public Health Impact of Schistosomiasis

The health impacts of schistosomiasis are considerable and the disease disables more than it kills. The symptoms are generally caused by the body's reaction to the eggs. The classic signs of urinary schistosomiasis (urogenital schistosomiasis) include haematuria (blood in urine (Fig. 6), dysuria (painful or difficult urination), bladder, ureter and kidney damage as well as cancer of the bladder.

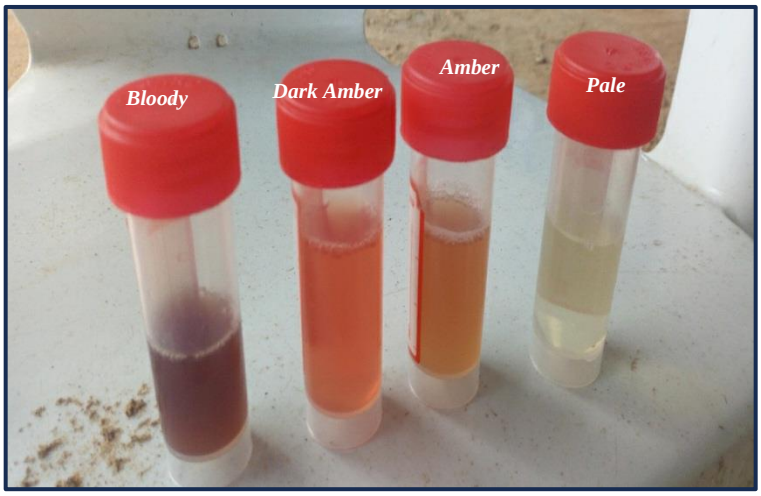

Figure 6: Different degrees of haematuria

In males, it may in addition to the foregoing effects damage the seminal vesicle, prostate gland and other organs like the testes causing other long term irreversible consequences including infertility. In women on the other hand, urogenital schistosomiasis may present with vaginal bleeding, pain during sexual intercourse and nodules in the vulva. The impact on health of intestinal schistosomiasis involves abdominal pain, diarrhoea and blood in stool. Liver enlargement (Hepatomegaly) 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. In such cases, there may also be enlargement of the spleen known as splenomegaly. Often, these conditions are found together and is called hepatosplenomegaly (Fig. 7).

Figure 7: A child with hepatosplenomegaly

Mitigation Measures Against Schistosomiasis

It is generally agreed that a combination of the following measures can contain the disease:

(i) Morbidity Control
(ii) Infection Control
(iii) Transmission Control
iv) Health risk assessment

Morbidity Control

Morbidity control based on chemotherapy is the strategy of choice. The drug of choice is Praziquantel (Fig. 8). This drug is very effective and well tolerated by patients. Treatment follows a rigorous assessment of the prevalence of infection. Prevalence of up to 50% or more is given a single annual treatment while a prevalence of 10% is given a triennial treatment. Praziquantel is administered in relation to height of patients. The treatment regime is shown in Table 3:

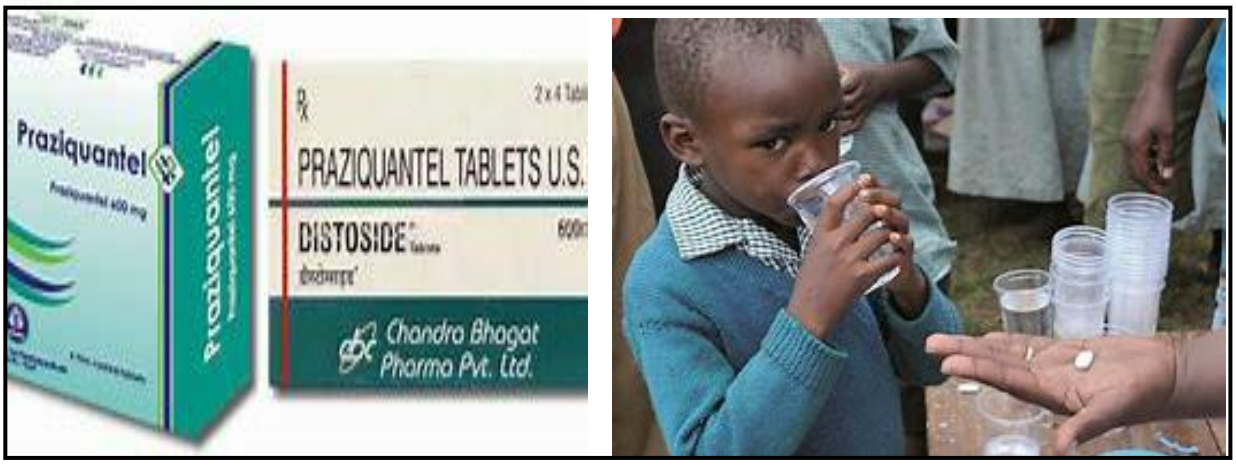

Figure 8: Praziquantel treatment of schistosomiasis

Table 3. Praziquantel treatment regime

Height (cm)	Doage (tablet/s)
94 – 110	1
110 – 125	1.5
125 – 138	2
138 – 150	2.5
150 – 160	3
160 – 178	4

It is however noteworthy that it is extremely common in children in hyper-endemic circumstances to regain 40% - 100% of their pre-treatment egg counts within a year due to re-infection (Polderman, 1981). Therefore, treatment may be repeated. In order to have an effective control in view of rampant cases of re-infection, a multifaceted approach to control is advised.

Infection Control

It is a very common finding that majority of the rural populace infected are completely oblivious on how the infection is acquired. Therefore, health education come in handy through means like radio jingles, cinemas, poster presentations as the case may be so as to enlighten those at risk of the infection on various ways of becoming infected and the required precautionary measures.

Infection control can also be through vaccination. Although at the moment no vaccine is available as a prophylactic measure, 4 candidate vaccines have undergone various stages of clinical trials in human as well as animal models. These are shown in Table 4.

Table 4. Schistosome candidate vaccines under trial

Candidate vaccine	Species Targeted	Clinical Phase	Efficacy in human/animal model
Recombinant Sh 28GST/Alhydrogel^{R} (Bilharvax	*S. haematobium*	1, 2, 3 completed	50% reduction in tissue eggs and up to 77% reduction in excreted eggs. No effect on worm burden in immunized monkeys. No protection in immunized humans
Recombinant Sm 14/GLA- SE	*S. mansoni*	1, 2a completed; 2b initiated	67% and 93% worm reduction in immunized mice and rabbits respectively

Recombinant Sm TSP-2/Alhygrogel^{R}	*S. mansoni*	1a completed; 1b initiated	Immunized mice had 57% and 64% reduction in worm and liver burden respectively
Recombinant Sm-P8D/GLA-SE	*S. mansoni*	1 initiated	93% reduction in adult female worms in baboons. 90% reduction in tissue egg.

Source: Adapted from Adebayo Molehin (2020).

Transmission Control

The aim of transmission control is to break the lifecycle of the parasite at the weakest point which is the intra-molluscan stages through destruction of the snail intermediate host. This is based on a thorough knowledge of snail ecology and bionomics. The technical know-how must be available before this is contemplated. The application of molluscicide is as shown in Fig. 9

Figure 9: Application of molluscicide for snail control

Choice of the control agent is also critical. Bayluscide or Niclosamide is the molluscicide of choice. This is a synthetic molluscicide which is very effective but it has drawback of being expensive and not always available especially to rural areas that need it most. There is also the fear of misuse which can lead either to resistance or accumulation in the environment bringing about concerns on the health status of the environment. Consequently, emphasis has shifted to molluscicides of organic origin which may be

cheaper, or readily available to most rural communities. Of the many plants screened for molluscicidal activity in Nigeria (Adewunmi & Sofowora, 1980; Ndifon & Ukoli, 1984; Istifanus, 1988; Kela & Bowen, 1995) the berries of *Phytolacca dodecandra* commonly known as Endod plant used for local soap making in Ethiopia is the most researched giving promising results of similar magnitude to Niclosamide (Fig. 10).

Figure 10: *Phytolacca dodeccuntra* plant with berries

Following satisfactory testing in accordance with "The Organization for Economic Cooperation and Development" (OECD) guidelines for premarket chemicals, it was concluded that schistosomiasis mitigation through the use of Endod for snail control is justifiable (Lambert *et al.*, 1990). However, the challenge of local availability especially in Africa is still there. Although the plant grows in the wild in Ethiopia, there are challenges regarding cultivating it in most parts of the continent except in Zimbabwe where it had been successfully grown. We tried it in Bauchi from seeds obtained from Zimbabwe but it failed. So, if the required foreign exchange is available, then it can be sourced from either Ethiopia or Zimbabwe.

Another transmission control endeavor is environmental management and modification. This involves either reclamation of borrow pits and other derelict lands, preventing growth or removal of aquatic vegetation from irrigation

canals and drainages to discourage snails from colonizing them, lining of canals with cement (Fig. 11) or plastic materials which has the same effect with removal of vegetation, regularly fluctuating water levels as well as periodic drying of irrigation canals which are both inimical to the snails.

Figure 11: Concreting of irrigation canal for snail control

A biological control method of the snails is also possible. This include snail predators like *Gambusia affinis* fish (Fig. 12) which is introduced to prey on the snails. Snail competitors like the snail *Helisoma duryi* (Fig. 13) has also been advocated. This has the effect of outcompeting the snail hosts until they are decimated. Biological control methods of snail intermediate hosts of trematode parasites have been extensively reviewed by Istifanus (2023).

Figure 12: *Gambusia affinis* Fish

Figure 13: *Helisoma duryi* snail

A final transmission control strategy often neglected is improved water supply and sanitation. Disease transmission is only through contact with cercariae infested water. Therefore, provision of safe water supply (Fig. 14) and sanitary facilities will reduce the risk of infection because it is out of necessity that water polluted by freshwater snails are visited and used. So, when alternative good water sources are available to communities, visits and regular contacts with those polluted waters will be drastically reduced. This has been shown to be the case by Sanu *et al.*, (2022) in their study in communities surrounding Kiri reservoir in Adamawa State, Nigeria where provision of bore holes to Boyire community drastically reduced the prevalence of schistosomiasis compared to Bondo community that relied solely on water from Kiri dam for domestic water supply. Provision of toileting facilities where faeces can be safely deposited as opposed to open defecation is also crucial in controlling transmission of helminth parasites since the eggs which may be contained in the faeces are kept away from polluting water sources that are used by humans and animals.

Figure 14: Hand operated borehole for safe drinking water

Health Risk Assessment

Feasibility studies for road construction and water resources developmental projects should include the health risk assessment of these projects. By so doing, any inherent negative effect will be identified. Consequently, adequate budgeting and financing for appropriate intervention measures will be put in place. When that is done, all potential negative consequences are eliminated and the full benefit of such a project will be realized.

Conclusion

Various studies across Northern Nigeria have demonstrated the negative consequence on public health of infrastructural developmental projects. Thus, it had been shown how these projects had contributed to the increased transmission of schistosomiasis and other snail–borne diseases. Furthermore, it has been shown that communities that lacked portable water sources and so relied solely on polluted water from such project sites generally showed a higher prevalence of infection than those that have alternative water sources. Therefore, strategies to mitigate negative effects should be made integral parts of the planning, implementation and operation of future infrastructural development projects in the region.

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References

Abbas, U., Eberemu, N. C., Orpin, J.B and Kaware, M.S (2023). Human water contact behavior and *Schistosoma* haematobium infection among Almajiri school children in Kurfi LGA of Katsina State, Nigeria. *Nigerian Journal of Parasitology* 44(1): doi: 10.4314/nijpar. v4414.

Abdullahi, M.K., Bassey, S.E. and Oyeyi, T.I. (2009). A comprehensive Mapping of Urinary schistosomiasis using Geographic Information System (GIS) in Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences* 2(1): 41-46.

Abdullahi, M.K., Bassey, S.E. and Oyeyi, T.I. (2011). The epidemiology of *Schistosomahaematobium* infections in the 44 Local Government Areas of Kano state. *Nigerian Journal of Parasitology.* 32(1): 19-24.

Abdullahi, M. and Saidu, T.B. (2012). Prevalence of urinary schistosomiasis among school aged children in Wushishi LGA of Niger State, Nigeria. *Bayero Journal of Pure and Applied* Sciences 4 (2): 53-55.

Abdullahi, A. M., Lurwan, M., Tinuoye, O. O. and Muhammad, A. (2020). Prevalence of schistosomiasis among Primary Pupils in Dawakin-Kudu LGA, Kano State, Nigeria. *ARC Journal of Urology* 5 (1): 15-20.

Adamu, U.S., Panda, S. M. and Okafor, A. (2004). Studies on human water

contact pattern and other schistosomiasis predisposing factors in Gubi Dam. *The Science Forum: Journal of Pure and Applied Sciences* 7(2): 197-202.

Adewunmi, C/O. and Sofowora, E.A. (1980). Preliminary screening of some plant extracts for molluscicidal activity. *Planta Medica, Journal of Medicinal Plant Research* 39: 57-65.

Agere, J.H., Istifanus, W.A. and Kela, S.L. (2009). Transmission dynamics of human urinary schistosomiasis in some parts of Taraba State, Nigeria. *Nigeria Journal of Allied Science and Technology* 3(1): 55-68.

Agi, P.I. and Okwuosa, V.N. (2001). Aspects of water quality of freshwater systems harbouring snail vectors of schistosome parasites in Jos, Nigeria. *Journal of Aquatic Sciences* 16(1): 13-17.

Agiene, A. G., Otalu, O. J., Omobije, P. A., Obande, G. A., Omatola, C. A. and Alo, O. O. (2020). Prevalence of urinary schistosomiasis among Primary School Children in Odenyi, Bassa LGA, Kogi State, Nigeria. *FUW Trends in Science and Technology Journal* 5 (2): 451-453.

Akogun, O. B. and Okin, B. N. (1993). The ecology of fresh water snails in an agro-industrial estate in Yola, Nigeria. *Nigerian Journal of Parasitology* 14: 75-80.

Amaechi, E. C., Nwachukwu, P. C., Ezekiel, O. O., Nwadike, C. C., Bonfere, F. E. and Adewale, S. S. (2024). Prevalence of intestinal schistosomiasis infection and associated risk factors among school aged children in Jebba, Moro LGA, Kwara State, North Central Nigeria. *Journal of Applied Sciences and Environmental Management* 28 (8): 2443-2448.

Babamale, O.A., Kolawole, O.H., Abdulganiyu, K., Abdulkareem, O.A., and Ugbomoiko, U.S. (2018). Urogenital schistosomiasis among school children and the associated risk factors in selected communities of Kwara State, Nigeria. *Journal of Tropical Medicine* 2018 (1): doi: 10.1155/2018/6913918.

Banwat, M. E., Ogbonna, C., Daboer, J. C., Chingle, M. P., Envuladu, E.A., Audu, S., Lar, L. A. (2012). Prevalence of urinary schistosomiasis in school aged children in Langai, Plateau State: Pre- and Post-intervention. *Nigerian Journal of Medicine* 21 (2): 146-149.

Barnabas, B.B., Mann, A., Nma, E.M., Obi, P.U., Ezeako, I.A. (2011). Prevalence of schistosomiasis and other intestinal helminth parasites among school children in Bida, Niger State, Nigeria. *European Journal of Scientific Research* 48: 621-626.

Bello, Y. M., Adams, T., Abubakar, U. and Mohammed, A.A. (2003). Urinary schistosomiasis in some villages around the Goronyo dam, Sokoto state, Nigeria.*NigerianJournal of Parasitology* 24: 109-114.

Betterton, C. (1984). Ecological Studies on the snail hosts of schistosomiasis in the south Chad Irrigation Area, Borno State, Northern Nigeria, *Journal of Arid Environments* 7: 43-57.

Betterton, C., Ndifon, G.T., Bassey, S.E., Tan, R. R. N. and Oyeyi, T. I. (1988). Schistosomiasis in Kano State, Nigeria I: Human infection near dam sites and the distribution and habitat preferences of potential snail intermediate hosts. *Journal of Tropical Medicine and Parasitology* 82(6): 561-570.

Bigwan, E.I., Tinja, B. and Damen, J.G. (2012). Prevalence of schistosomiasis among secondary school boarding students in Potiskum metropolis, Yobe State, North-Eastern Nigeria. *Bayero Journal of Pure & Applied Sciences* 5(1): 155-158.

Bolaji, O. (2015). Prevalence and intensity of *Schistosoma haematobium* among school children in Ajase-Ipo, Kwara State, Nigeria. *Asian Journal of Biomedical and Pharmaceutical Sciences* 5(43): 6-11.

Chigozie, E.U. and Daniyan, S.Y. (2019). Epidemiological survey of urinary schistosomiasis among children in selected schools: A preliminary study in Minna, Nigeria. *African Journal of Medicine and* Surgery 7(16): 1-4.

Chiroma, A. (2023). Studies on the prevalence of urinary schistosomiasis in Gashua town of Yobe State, Nigeria. *International Journal of Innovative Agriculture and BiologyResearch* 11(4): 10-16.

Dagona, A.G. (2014). Prevalence of *Schistosoma* haematobium among selected tsangaya school children in Nguru LGA, Yobe State, Nigeria. *International Journal of Engineering and Technical Research* 2(9): 363-367.

Daniel, L.A., Alo, E.O. and Yusuf, A.I. (2015). Epidemiology of urinary schistosomiasis in Shongom LGA, Gombe State, Nigeria. *International Journal of Innovative Research and Development.* 4(11): 1-7.

Danladi, A.M. and Henry, G.B. (2024). Prevalence of urinary schistosomiasis among school children in Giwa and Makarfi LGAs, Kaduna State, Nigeria. *Science World Journal* 19(1): 224-228.

Dawaki, S., Al-Mekhlafi, H.M., Ithoi, I., Ibrahim, J., Abdulsalam, A.M., Hany, S., Nabil, A.N. and Wahib, M. A. (2015). The menace of schistosomiasis in Nigeria: Knowledge, Attitude & Practices regarding rural communities in Kano State. *PLOS ONE* 10(11): e0143667 doi: 10.1371/journal.pone.0143667.

Dawuda, B.M., Bala, A.Y., Agbo, J.O., Iorgema, U.C., Agere, I.H. and Elijah, B.B. (2019). Prevalence and intensity of urinary schistosomiasis in selected villages of Fikiyu community, Ussa LGA, Taraba State, Nigeria. *FUW Trends in Science and Technology Journal* 37: 209-212.

Diana, A.D., Kwasen, I.Z., Goewen, P., Musa, N.N., Solomon, P.O., Adaaku, P.S. and Cephas, I.O. (2024). Incidence of urinary schistosomiasis and the contributory risk factors among Primary School Children in Lafia metropolis, Nasarawa State, Nigeria. *World Journal of Advanced Research and Reviews.* 21(2): 487-495.

Duwa, M.R., Oyeyi, T.I. and Bassey, S.E. (2009). Prevalence and intensity of urinary schistosomiasis among Primary School pupils in Minjibir LGA of Kano State. *Bayero Journal of Pure and Applied Sciences* 2(1): 75-78.

Duwa, M.R., and Oyeyi, T. I. (2009). Role of Jakara dam in the transmission of schistosomiasis. *Bayero Journal of Pure and Applied Sciences* 2(1): 58-62.

Duwa, M.R., Oyeyi, J.I. and Bassey, S.E. (2009). Prevalence and intensity of urinary schistosomiasis among primary school pupils in Minjibir Local Government Area of Kano State. *Bayero Journal of Pure and Applied Science* 2(1): 75-78.

Ejima, I.A.A. and Odaibo, A.B. (2010). Urinary schistosomiasis in the Niger-Benue basin of Kogi State, Nigeria. *International Journal of Tropical Medicine* 5(2): 73-80.

Habiba, B. (2015). Incidence of urinary schistosomiasis among out of school pupils and almajiris in Dikwa, North-East Nigeria. *Global Journal of Medical Research* 15(2);

Houmsu, R.S., Amuta, E.U. and Sarr, T.T. (2012). Profile of an epidemiological study of urinary schistosomiasis in 2 LGAs of Benue State, Nigeria. *International Journal of Medicine and Biomedical Research* 1(1): 39-48.

Iboyi, M.O., Onekutu, A. and Amuta, E.U. (2018). Prevalence and risk factors of urinary schistosomiasis among school children in Katsins-Ala LGA of Benue State, Nigeria. *European Journal of Pharmaceutical and Medical Research* 5(11): 499-506.

Iboyi,, N.O., Ogala, H., Ojie, S.M., Ebiye, A., Adah, M.E., Chidizie, E. and Danjuma, B. (2022). Prevalence of urinary schistosomiasis among patients suspected of urinary tract infection in Birnin Kebbi, Kebbi State, Nigeria. *Science Journal of Clinical Medicine* 11(4): 85-88.

Inuwa, A., Istifanus, W.A. and Kela, S.L. (2003). The diversity, distribution and health implications of the snail fauna of Alau Dam, Borno State,Nigeria. *The Nigerian Academic Forum* 5(2): 126-131.

Istifanus, W.A. (1995). Ecological and Allozyme Studies on Freshwater snails in Bauchi Nigeria with Special Emphasis on Schistosome Intermediate Hosts.*Ph.D Thesis, Abubakar Tafawa Balewa University, Bauchi 185pp.*

Istifanus, W.A., Anyanwu, F.C., Panda, S.M., Kela, S. L. and Samaila, A.B. (2018). Intestinal schistosomiasis among some

inhabitants of Bassa LGA of Plateau State, Central Nigeria. *Science Forum (Journal of Pure & Applied Sciences)* 15: 40-45.

Jafaru, S., Isyaku, N.T., Ukatu, V.E. and bagudu, A.I. (2023). Systematic Review on epidemiological studies of schistosomiasis in Sokoto State, Nigeria. *Journal of Biomedical* Investigation 11(3): 116-131.

Justina, S.O., Muhammad, S.A. Ahmed, B.S., Aminu, I.M., Adetutu, F.A., Gideon, I.J and Emmanuel, O.B. (2024). Molecular detection of *Schistosoma haematobium* among school children in Sabon-gari LGA, Kaduna State, Nigeria. *African Journal of Biotechnology* 23(11); 318-326.

Kaleson, M. S., Istifanus, W. A., Suleiman, M. M. and Panda, S. M. (2022). Urogenital schistosomiasis among communities surrounding Kiri reservoir, Adamawa State, Nigeria. *African Journal of Health, Safety and Environment* 3(1): 1 – 10.

Kela, S.L., Istifanus, W.A. and Okwuosa, V.N. (1990). Note on the ecology and distribution of fresh water snails in the Bauchi and Plateau states, Nigeria. *Revue d'Elevage Medicine of veterinary pays tropicaux* 43(2): 177-178.

Ladan, M.U., Abubakar, U., Abdullahi, K., Bunza, M.D.a, Ladan, M.J.,and Adamu, T. (2012). Studies on urinary schistosomiasis in selected villages around Gusau Dam site, Zamfara State, Nigeria. *Nigerian Journal of Basic and Applied Sciences* 20(3): 189-191.

Ladan, M.U., Bunza, M.D.A., Karaye, L.U., Mainasara, M.M., Nasir, M., Yelwa, S.M. and Salihu, A. (2019). Prevalence of urinary schistosomiasis I two selected communities of Shinkafi LGA, Zamfara State, Nigeria. *Savanna Journal of Basic and Applied Sciences* 1(1): 64-69.

Lambert, J.D.H., Temmink, J.H.M., Marquis, J., Parkhaust, R.M., Lugt, C.B., Schoonen, A.J.M., Holtze, K., Warner, J.E., Dixon, G., Wolde-Yohannes, L. and Sarigny, D. de. (1990). Endod: safety evaluation of a plant molluscicide. 3rd International Workshop on Recent Development and Future Directions in Endod Research, 15-9 October, 1990, Addis Ababa, Ethiopia.

Lawiye, J.L., Philips, V., Godly, C., Midala, A.L., Watirahel, P. and Enamola, W. (2020). Prevalence and risk factors of *Schistosoma* haematobium infection among primary school children in Yola North LGA, Adamawa State, Nigeria. *African Journal of Biomedical Research* 23(1): 7-9.

|Mbata, T.I., Orji, M.U. and Oguoma, V.M. (2009). High prevalence of urinary schistosomiasis in a Nigerian community of Benue State, Nigeria. *African Journal of Biomedical Research* 12(2): 101-105.

Mudasiru, L., Suleiman, A.B., Dibal, D.M., Abdulhamid, Y. and Abba, A.M. (2018). Prevalence of urinary schistosomiasis

among school aged children in Bakura LGA of Zamfara State, Nigeria. *UMYU Journal of Microbiology Research* 3(2): 7-12.

Nebe, O.J. (2013). Report of schistosomiasis and soil transmitted helminths epidemiological mapping and baseline survey in 11 LGAs of Gombe State.

Ofoeze, I. E. (2002). Human Health and Sustainable Water resources development in Nigeria: Schistosomiasis in artificial lakes. *Natural Resource Forum* 26: 150-160.

Ofoeze, I.E., Bolton, P., Imevboire, A.M.A. and Christensen, N.O. (1996). Schistosomiasis and other helminth infections in irrigation schemes in Sokoto, Katsina and Kebbi States of Nigeria. *Nigerian Journal of Parasitology* 17:31-37.

Olamiju, F., Obiageli, J.N., Hammed, M., Ayodele, M., Perpetua, A., Rita, O.U., Ebenezer, A., Olatunwa, O., Chidinma, O., Ijeoma, A. and Okezie, M. (2022). Schistosomiasis outbreak during COVID-19 pandemic in Takum, N.E. Nigeria. *PLOS ONE* 17(1): doi: 10.1371/journal.pone 0262524.

Okpala, H.O., Ajayi, J.A., James-Rugu, N.N. and Emelike, O.F. (2010). Survey of snail intermediate hosts of trematodes in Jos South Local Government Area, Plateau State, Nigeria. *International Journal of Natural and Applied Science* 6(2): 151-154.

Ombugadu, A., Abe E.M., Adekoya, R.A. and Aimankhu, O.P. (2022). Prevalence and factors associated with urinary schistosomiasis among school aged children in Lafia metropolis, Nasarawa State, Nigeria. *Journal of Tropical Medicine and Infectious Diseases.* 1(1): 103-108.

Pam, D.D., Pam, V.A. and Nuhu, E.I. (2016). Prevalence of *Schistosoma* mansoni infection among Primary School pupils in Keffi town, Keffi LGA, Nasarawa State, Nigeria. *Nigerian Journal of Parasitology* 37(2): 212-217.

Pugh, R. N. H., Burrows, J.W. and Tayo, M.A. (1980). Malumfashi Endemic Diseases research project xvi: Increasing schistosomiasis transmission. *Annals of Tropical Medicine and Parasitology* 74: 561-570.

Saad, M.Y., Adam, I, R., Abubakar, G.F., Hassan, A.F., Ibrahim, U., Bello, A.I., Halima, A.I., Abubakar, S.B., Talatu, A.B. and Wasiu, A.O. (2018). Urinaru schistosomiasis in Boko Haram-related internally displaced Nigerian children. *Saudi Journal of Kidney Disease Transplant* 29(6): 1395-1402.

Sarkin Fada, F., Oyebanji, A. A., Abubakar, I. S. and Iliyasu, Z. (2009). Urinary schistosomiasis in the Danjarima community in Kano, Nigeria. *The Journal of Infection in Developing countries* 3(6): 452-457.

Shuaibu, U., Saadatu, H.S., Shuaibu, A.H., Vasanthakumari, N., Kumar, S., Syafinaz, A.N. and Osman, M. (2017).

Prevalence and molecular characterization of *Schistosoma haematobium* among primary school cjildren in Kebbi State, Nigeria. *Annals of Parasitology* 68(2): 133-139.

Singh, K., Dalhatu, M. and Jitendra, S. (2016). Status of schistosomiasis in Sokoto, Nigeria. *Parasite Epidemiology and Control* 23(3): 239-244.

Solomon, M.G., Aminu, G., Princewill, T., Solomon, D.G., Daniel, D. A. and Isaac, I. (2023). Prevalence and intensity of urinary schistosomiasis among primary school children in Silame, Sokoto, Nigeria. *Microbes and Infectious Diseases* 4(2): 695-703.

SundayI, D. (2017). A Study on the Ecology and Symbionts of the Snail Fauna in Dadin Kowa Reservior and Irrigation Project Area in Gombe State. *M.Sc. Thesis, Abubakar Tafawa Balewa University, Bauchi 77pp.*

Surajo, Y., Timothy, A., Tolulope, E.A., Nalado,Y. A., Jafar, H. and Ezra, J.J. (2024). Risk factors associated with urinary schistosomiasis and its spatial distribution among male children in selected communities in Shinkafi, Zamfara State, Nigeria. *Dutse Journal of Pure & Applied Sciences* 10(36): 29-37.

Taofik, S., Bunza, M.D.A., Majeed, Q., Abubakar, M.B. and Ladan, M.U. (2017). Studies on snail vectors of Helminth Disease Agents along Rima Valley, Wamakko Local Government Area, Sokoto state, Nigeria. *SM Tropical Medicine Journal* 2(1): 1011-1015.

Tersoo, A. R., Terngu, I.S. and Akogwu, A.E. (2017). Survey and identification of macroinvertebrates found in some ponds in Makurdi. *International Journal of Ecotoxicology and Ecobiology* 2(1): 26-32.

Thomas, H.Z., Akinseye, J.F. and Sunday, A.B. (2020). Prevalence of schistosomiasis among secondary school students in Bukuru, Du, and Zawan in Jos-South LGC, Plateau State. *Annals of Microbiology and Infectious Diseases* 3(3): 12-17.

Thompson, K. D. B. (1967). Rural health in northern Nigeria: some recent developments and problems. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 61:277-303.

Tolulope, E.D., Stephen, D.A. and Kingsley, M.E. (2018). The current epidemiological status of urogenital schistosomiasis among school pupils in Katsina State, Nigeria. *PLOS Neglected Tropical Diseases* 12(1): e0006636 doi: 10.1371/journal. Pntd.0006636.

Ukatu, V.E., Yahaya,S., Yaye, A.S., Shabandan, B.S. and Arrah, O.A. (2015). Urinary schistosomiasis in Yauri riverine area Kebbi State, Nigeria. *Nigerian Journal of Parasitology* 36(2): 77-80.

Ukwubile, C.A. and Tile,T. (2016). Prevalence rate of urinary schistosomiasis in Bali town, Bali LGA, Taraba State, Nigeria.

ARC Journal of Public Health and Community Medicine 1(1): 18-21.

Umar, A.Y. (2009). Prevalence of urinary schistosomiasis in Kaduna metropolis, Kaduna State, Nigeria. *Research Journal of Science* 16: 65-71.

Usman, A.I., Abdulhamid, A. and Adamu, T. (2016). Schistosomiasis among school children living in endemic communities around Kwanar Areh Dam, Rimi LGA, Katsina State, Nigeria. *International Journal of Science and Research* 7(12): 758-764.

Usman, A.M., Malann, Y.D. and Babeker, E.A. (2016). Prevalence of *Schistosoma hamatobium* among school children in Bauchi State, Nigeria. *International Journal of Innovation & Scientific Research* 26(2): 453-458.

Usman, A. M. (2020). Epidemiological studies of schistosomiasis in Bauchi central senatorial zone. *Current Trends in Biotechnology & Pharmacy* 14(5): 226-232.

Usman, A.M., Khadija, M.D. and Baban-Tanko, F.S. (2024). Prevalence and risk factors associated with urinary schistosomiasis among school children in Biu LGA, Borno State, Nigeria, *Science World Journal* 18(4): 602-606.

Yaro, M.B., Naphtali, R.S. and Alo, E.B. (2020). Prevalence and intensity of urinary schistosomiasis among residents along river Benue, Adamawa State, Nigeria. *Nigerian Journal of Pure & Applied Sciences* 33(1): 3577-3584.

Zamdayu, N.M., Qadeer, M.A., Cgessed, G. and Markus, I.F. (2023). Prevalence of urinary schistosomiasis among children from three selected LGAs in Adamawa State, Nigeria. *Dutse Journal of Pure & Applied Sciences* 9(3): 168-178.