BAYERO UNIVERSITY KANO

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NO. 18

Linking Schistosomiasis and Water Resources Development in Kano State Nigeria: Public Health Impact and Mitigation

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WORK EXPERIENCE

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Prof (Dame) Tinuade Ibijoke Oyeyi earned her Bachelor of Science degree in Biology (Microbiology) in 1978 from University of Lagos, Nigeria. She received her Master of Science degree in Parasitology in 1988 from Bayero University, Kano and her Doctorate degree also in Parasitology in 2000 from Bayero University . She holds a WHO/ UNESO certificate on Membrane studies from University of Ibadan. She started her professional career in 1979 as a Research Officer at Nigerian Institute for Trypanosomiasis Research, Kaduna.

She moved to Bayero University in 1984 where she has since served as a lecturer rising through the ranks to become a Professor of Parasitology. She has taught several courses in Microbiology, Parasitology and General Biology and has supervised 138 undergraduate projects, 20 Masters dissertations and 13 Ph. D thesis. She has to her credit, 4 technical reports and 44 articles published in reputable journals locally and internationally.

She has attended several conferences and workshops both locally and internationally (Washington D C, Boston, Ohio, Oxford- UK, Israel and Ghana). She was the Head of Department of Biological Sciences from 2012 to 2015. She is currently Deputy Director, Quality Assurance, Bayero University, Kano, the chairperson of the Professorial Inaugural Lecture Committee and a Board member of Bayero University Press. Prof Oyeyi has held several responsibilities within and outside the University including membership of several committees and patroness of several youth organizations.

She is an advisor for WHO on the African Programme for Onchocerciasis Control in Nigeria (APOC). She is a recipient of several awards and honors and was honored with Papal Award of Dame of St Gregory the great by Pope Benedict XVI in 2012. She is married with 5 children, blessed with 4 grand children and lives with her family in Kano, Nigeria. A keen researcher, she conducted both her Master's and Doctoral research on schistosomiasis and has supervised 4 PhD theses in the same area – a research interest that forms the substance of this inaugural lecture.

Linking Schistosomiasis and Water Resources Development in Kano State, Nigeria: Health Impact and Mitigation

1.0 INTRODUCTION

Schistosomiasis or Bilharziasis is a disease caused by parasitic worm species of the genus *Schistosoma.* The adult worm lives in the blood of mammals but part of its life cycle requires the use of a freshwater snail for completion; hence the link with freshwater bodies. Chronic, insidious and debilitating, schistosomiasis is responsible for a high degree of morbidity and low productivity in the affected areas and may even cause the death of its victims (Wright, 1972). It occurs globally in 74 countries of the world (See Figure 1).

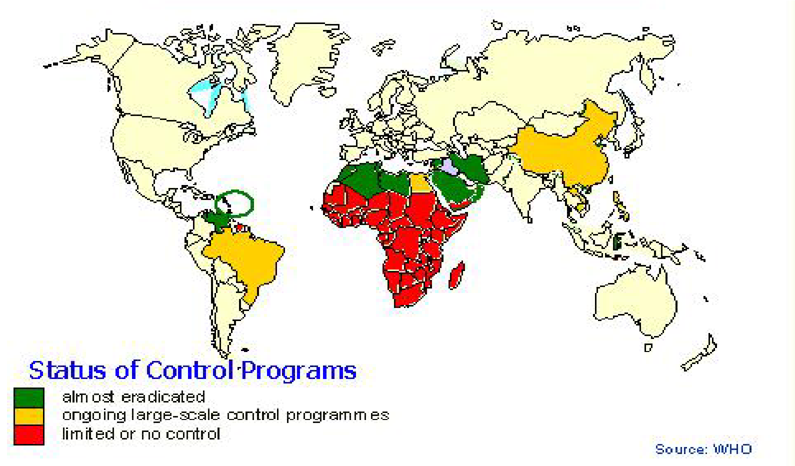


Fig 1: *Global Distribution Schistosomiasis (WHO)*

Water resources development refers to the infrastructure, governance and management measures required to control freshwater to meet human and environmental needs. The development of freshwater resources is particularly important to meet demands of food and energy. In the developing countries, harnessing water bodies for the purposes of irrigation, electricity generation, fisheries as well as other infrastructural development projects (highway construction for example) have often been associated with dramatic increases in the prevalence of schistosomiasis owing among other things to increases in the number of snail habitats and human-water contact (Farid, 1975).

In Nigeria, increased prevalence of schistosomiasis associated with the introduction of irrigation have been reported by Thompson (1967) at Bacita Sugar Plantation, Pugh, Burrows and Tayo (1980) at Malumfashi in Kaduna State and Betterton (1984) for the South Chad Irrigation Project Area in Borno State.

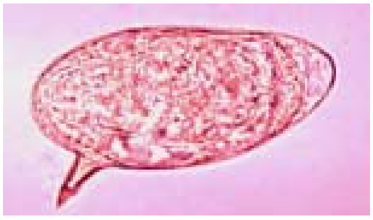
However, in the opinion of Grosse (1993), water resources and agricultural development projects often receive unfair blame for creating health hazards such as schistosomiasis. To generalize, he argued, is usually misleading as studies from northern Cameroon, Burkina Faso, northern Nigeria and northern Ghana did not find any transmission of schistosomiasis from impounding small bodies of water. The association of schistosomiasis with water project is known to vary within different ecological zones in a single country as well as between countries and global regions. While some studies linked dams and irrigation projects to the spread of schistosomiasis, it is also true that other research has not implicated many similar projects.

Given the health impact of uncontrolled schistosomiasis transmission, the World Health Organization (WHO), advises that measures against schistosomiasis be taken as part of any major water resource development project planned for a region endemic for the disease. There is a need to assess and quantify changes in schistosomiasis transmission parameters and infections over the course of water resources development. The general goal of this lecture is to give an update on the existing level of schistosomiasis and examine its relationship with water resources development in Kano State, Nigeria as well as the public health impact and mitigation measures, through a review of past and present studies.

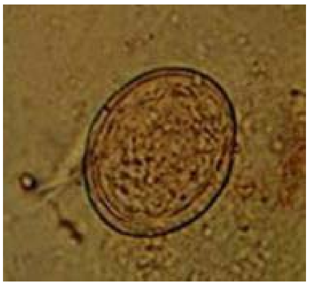
2.0 SCHISTOSOMIASIS: BIOLOGY AND PATHOLOGY

The three most important species of schistosomes or blood flukes that affect humans are *Schistosoma haematobium, S .mansoni and S .japonicum* (see Plate 1).

Egg of S. haematobium



Egg of S. mansoni



Egg of S. japonicum

Plate 1: *Eggs of schistosomes or blood flukes that affect humans*

S. haematobium lives in the vesicular veins surrounding the urinary tract. The mammal host passes out the worm's eggs in urine. The infection is commonly called urinary schistosomiasis and it occurs throughout most of Africa and in parts of western Asia.

The other two species - *S. mansoni* and *S. japonicum* cause intestinal schistosomiasis. *S. mansoni* usually resides in the mesenteric veins around the small intestine. The mammalian host excretes their eggs in faeces. *S. mansoni* occurs throughout sub-Saharan Africa, the Nile Delta in Egypt, in Yemen and in South America and the Caribbean islands. *S. japonicum* exists in Japan, China, the Philippines and a small part of Indonesia. Another closely related specie, *S. mekongi* occurs along the Mekong river in Laos and Cambodia.

Each specie of schistosome can infect only a single specie of snail. The *Bulinus* family of snails is the intermediate host for *S. haematobium*. *S. mansoni* requires *Biomphalaria* snails and *Onocomelania* snails are the essential intermediate hosts for *S. japonicum*. The worm's life cycle begins when the adult female schistosomes deposit eggs in the veins surrounding the bladder or intestine of the mammalian host. The host excretes the eggs via urine or faeces near or in water. Once the eggs reach water, they hatch into *miracidia* which must find and infect the appropriate snail intermediate host. Within the snail, each *miracidium* produces hundreds of *cercariae* which exit the snail and penetrate the skin of an appropriate mammal.

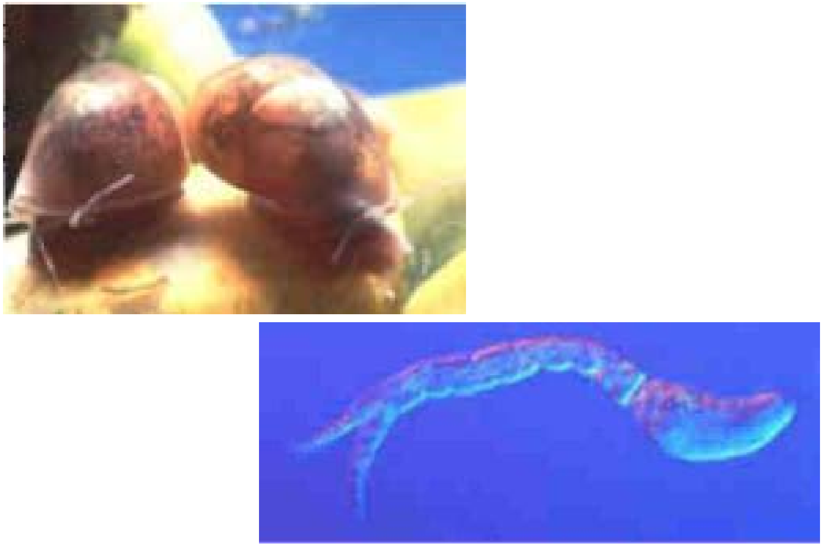


Plate 2: *Bulinus globosus*, the intermediate host snail interference contrast microscopy and *S. haematobium cercaria* (Differential for *S .haematobium* (Source: (**Source:**WHO/TDR/Stammers)

Plate 3: *Schistosome dermatitis, or "swimmers itch" occurs when skin is penetrated by a free-swimming, fork-tailed infective cercaria.* (**Source:** WikiMedia)

Humans get infected through swimming, bathing or wading in contaminated water bodies. After migrating to the right location in the body of the host, the worm matures and mate. The female produces hundreds of eggs each day. The mammal host excretes a fraction of the eggs while most remain in the host tissues, indirectly causing the symptoms associated with schistosomiasis. Figure 2 illustrates the life cycle of the parasite.

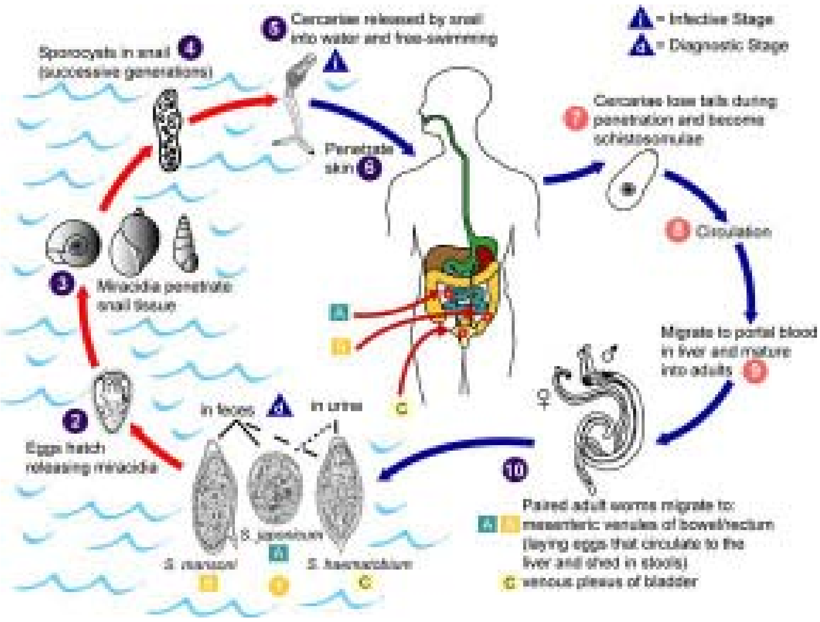


Fig 2: *Life Cycle of Schistosomes*

2.1 Symptoms

The symptoms of schistosomiasis are caused by the body's reaction to the eggs. The classic signs of urinary schistosomiasis include haematuria (blood in the urine (see Plate 4)), dysuria (painful or difficult urination), bladder, ureter and kidney damage and cancer of the bladder is common. In women, urogenital schistosomiasis may present with genital lesions, vaginal bleeding, pain during sexual intercourse and nodules in the vulva. In men, it may cause damage to the seminal vesicle, prostrate, and other organs. This disease may have other long term irreversible consequences including infertility.

Plate 4: *Haematuria (blood in the urine), a symptom of schistosomiasis infection*

Intestinal schistosomiasis can result in abdominal pain (see Plate 5), diarrhoea and blood in the stool. Liver enlargement is common in advanced cases, and is frequently associated with an accumulation of fluid in the peritoneal cavity and hypertension of the abdominal blood vessels. In such cases, there may also be enlargement of the spleen (WHO, 1999).

Plate 5: *Hepatosplenomegaly in chronic schistosomiasis (Patient with enlarged liver; symptom of chronic schistosomiasis)*

2.2 Water Resources Development in Kano State

There are numerous economic and social benefits derived from the damming of rivers. These include irrigation, fishing, sporting, recreation, navigation and hydro-electric power generation. However, damming of rivers and streams gives rise to significant alterations in the natural ecology of the original water bodies. For instance, it creates more conducive environments for the breeding of freshwater snails including intermediate host species and vectors of important human and animal diseases such as malaria, trypanosomiasis, filariasis, schistosomiasis etc. (Owojori et al. 2006). The last century witnessed an unprecedented upsurge in dam construction in Nigeria. Over 245 dams were constructed between 1970 and 1995 (Ofoezie, 2002).

Figure 3 shows the trend of dam construction in Nigeria since 1920. About 148 of these dams registered by the Nigerian Commission on Large Dams (NCOLD) and listed in the Nigerian Register of Dams are formal while most unlisted dams are informal. About 68 of such formal dams are located in Kano State alone. These projects range from fairly large reservoirs such as Tiga (17,000ha. surface area) used

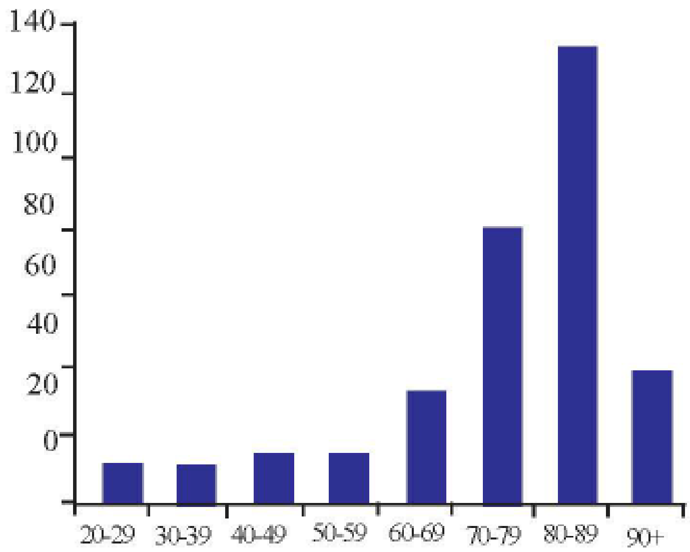


Fig 3: *Trend of dam construction in Nigeria since 1920*
Source: Ofoezie, 2002 (***Note:*** *All dams still uncompleted as at 1995 are included)*

for irrigation, through Kango reservoir (25ha) to very small informal projects used as fish ponds and seasonal rain pool.

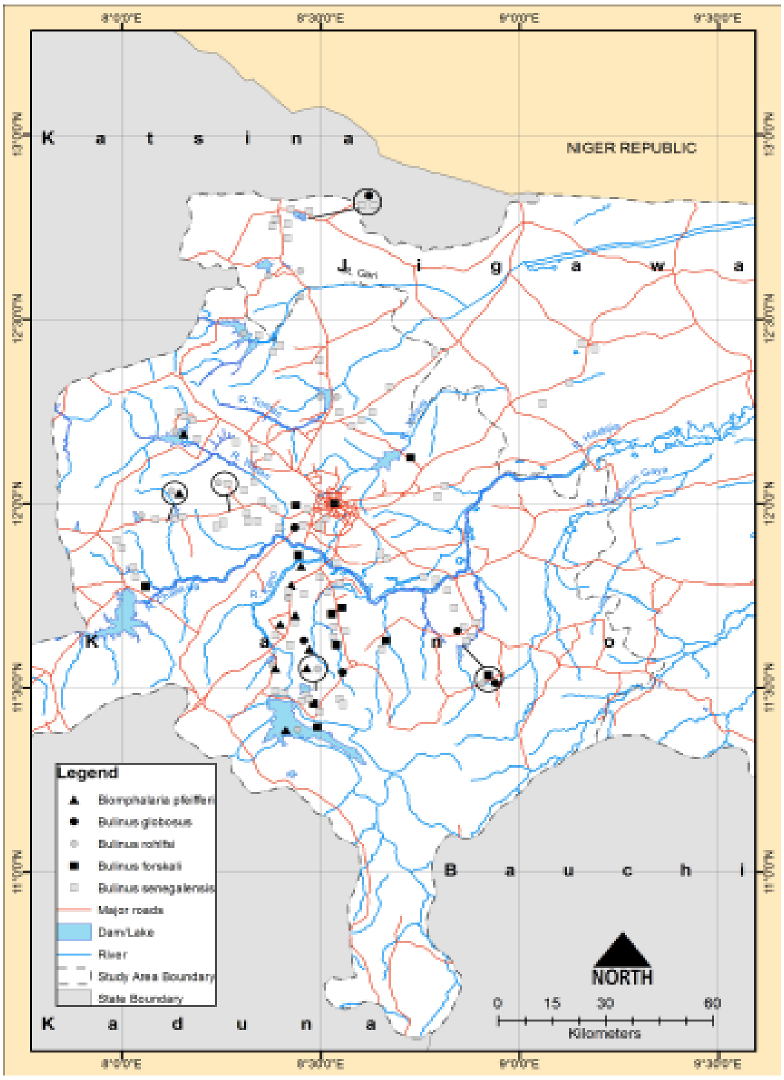
Tiga lake is the biggest and best developed of all the man-made reservoir projects in Kano State. The lake is about 17,000ha in surface area and supplies water for irrigation, fish pond managements and other forms of water use. A concrete open irrigation canal runs from the reservoir through many villages to irrigation fields through a distance of 18km. Along the length of the main canal, secondary canals and tertiary channels, branch out to irrigate private and government farm holdings. Fishermen fish in the main reservoir while farmers wade into irrigation swamps and village children swim and bathe at points along the canal crossing the villages. Older members of the villages also use the canal as their main source of domestic water supply (Imebvore and Ofoezie, 1988).

2.3 Past and Present Status of Schistosomiasis in Kano State

2.3.1 Distribution of Potential Snail Intermediate Hosts

Freshwater habitats all over Kano State were investigated between January 1985 and February 1986 by Betterton et al. in the Department of Biological Sciences, Bayero University Kano. Reservoirs were visited both during the rains and during the Harmattan season, while rain pools were examined at the peak of the rains in July and August. Snails were searched for using long-handled scoops and by examination of submerged plants. Snails found were brought alive to the laboratory for identification. Representative samples were later sent to the Experimental Taxonomy Unit, British Museum (Natural History), for confirmation of identification.

Four species of *Bulinus* and one of *Biomphalaria* were found in the study area. Figure 4 illustrates their spatial distribution. Three of the bulinids, *Bulinus senegalensis*, *B. forskali* and *B. rohlfsi* were widespread, occurring in suitable habitats throughout the area searched.



(Adapted from: Betterton 1988)

Fig 4: *Map of area surveyed in Kano State showing the distribution of potential snail intermediate hosts, major river systems and lakes; the latter indexed as follows: (1) Achlafiya; (2) Ibrahim Adamu (Dambo); (3) Mohammadu Ayuba; (4) Gari (5) Tomas; (6) Watari; (7) Jakara (8) Rimin Gado; (9) Kango; (10) Magaga; (11) Karaye; 912) Kafin Chiri; (13) Bagauda; (14) Ruwan Kanaya; (15) Tiga*

By contrast, *B. globosus* was found only south of Kano City (12 N), and the most northerly site for *Biomphalaria pfeifferi* was the Watari Dam (Fig 4, index No. 6).

The freshwater habitats encountered (165) can be divided into six main categories having the following characteristics:

1. Shallow pools:

These are temporary rain-filled depressions, approximately 0.5m deep.

2. Excavations

These include burrow pits formed during road construction and the deep, hand-dug excavations resulting from the abstraction of material for making adobe bricks.

3. Small earth dams

This category comprises shallow impoundments of seasonal streams with a surface area of 1 or 2 hectares.

4. Rivers and marshes

Sites of this type were perennial, their water supply being regulated by dams.

5. Irrigation channels

These were mostly in the Kano River Project but irrigation channels downstream of the Tomas and Jakara Dams were also visited.

6. Reservoirs and lakes

Majority of habitats in this category are man-made and were impounded at various times since 1970. They range in surface area from 10ha at Rimin gado to 17,000ha at Tiga.

Of the 165 sites examined, 118 (71.5%) were found to harbour planorbid snails, and these snails were found in all categories of habitats. Table 1 summarizes the occurrence of the *Bulinus* and *Biomphalaria* species in each category of habitat.

Table 1: *Distribution of Bulinus and Biomphalaria species in Various Categories of Aquatic Habitats Together With Ranges in Electric Conductivity Recorded for Each Specie and Habitat Type*

	snail species							
Habitat Category	Bulinus senegalensis	Bulinus forskali	Bulinus globosus	Bulinus rohlfsi	Biomphalaria pfeifferi	*Number without snails*	*Total number of sites*	*Conductivity range µs*
Shallow pools	46	4	3	1	0	24	72	10-1000
Excavations	31	7	3	3	2	16	56	11-2000
Small earth dams	4	0	0	0	0	1	5	26-46
Rivers and marshes	0	2	1	2	1	1	5	150-470
Irrigation channels	0	1	1	4	4	2	10	55-130
Reservoirs & lakes	1	1	0	12	6	3	17	71-280
Total	82	15	8	21	13	47	165	10-2000
Conductivity range *(µs)*	11-1000	30-100	48-470	60-1200	100-1200			11-1200

***(Source:** Betterton 1988)*

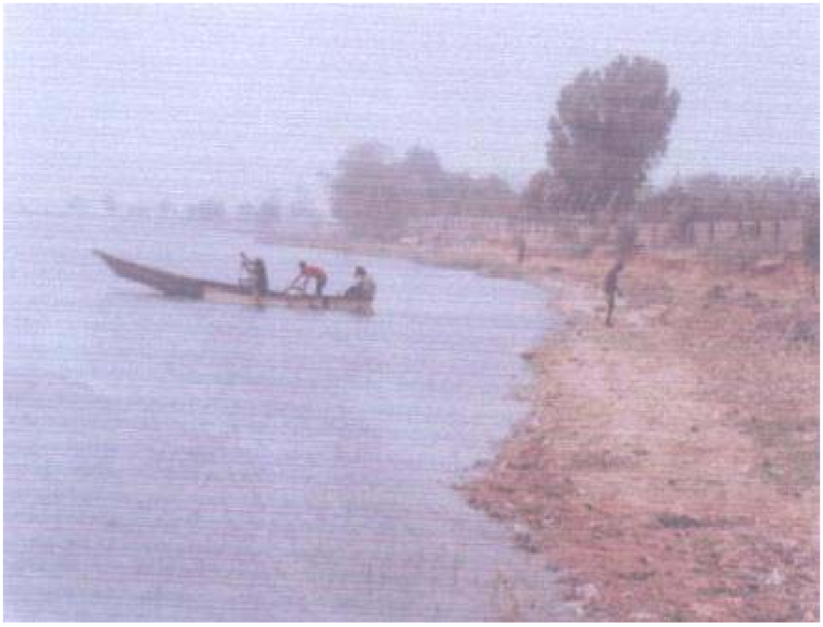


Plate 6: *Fishermen at Wasai Dam*

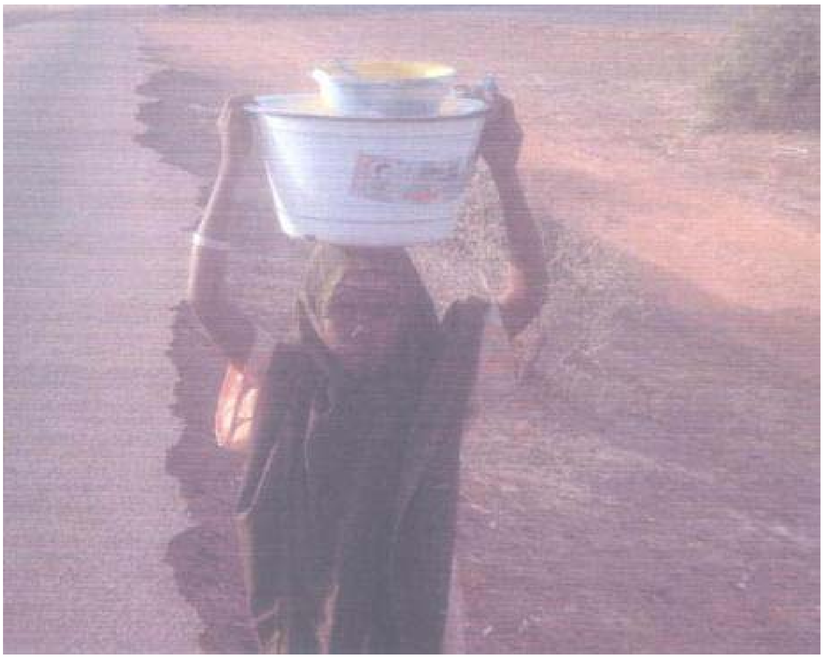


Plate 7: *Girl Hawker at Wasai Dam*

2.3.2 Human Infections in Kano Water Project Sites

With respect to schistosomiasis endemicity, Cowper (1973) zoned the country into three as hyper-endemic, moderately endemic and low/no endemicity zones. Table 2 shows the distribution of Nigeria's 36 states and the Federal Capital Territory into these zones and the number of dams in each zone/state. Kano State has the highest number (68) of formal dams and falls within the hyper-endemic zone. The Table also shows the mean and range of prevalence of schistosomiasis in the various states before and after 1973 when the upsurge in dam construction started in Nigeria. The prevalence of infection is seen to increase significantly ($p < 0.001$) from 0.8% before 1973 to 37.6% after.

Table 2: *Prevalence of Schistosomiasis infection in the various states and endemicity zones of Nigeria before and after 1973*

State	No. of dams	Infection Status	
Hyperendemic zone		***Before 1973***	***After 1973***
Adamawa	3	37.1(700) 9.7–59.1; 1-2	98.0(1834);3
Bauchi	10	NAR**	15.1(3249) 10.8–17.5; 4–5
Kaduna	50	32.0(45741;6	NAR
Kano	68	0.8(NA); 7	37.6(1278) 26.6–46.7; 8–9
Katsina	21	46.8(728); 10	20.3(5710) 2.7–59.3; 11–13
Lagos	0	5.7(46588) 0.06–92.0; 6. 14–18	21.8(871) 14.2–24.0; 19–20
Ogun	4	33.3(204) 12.0 -53.8; 9. 14–18	30.3(3500) 7.7–81.0; 21–22
Oyo	21	6.1(12693) 3.1–91.0; 17, 23–30	29.9(2337) 17.4–59.9; 31–33
Sokoto	13	NA(NA) 23.0–50.0; 17	28.8 (250) 6.0–51.0; 34
Zamfara	2	NA(NA) 12.0–50.0; 17	22.4 (98) 21.3–23.5; 34
Total	192	8.5(65487) 0.06–92.0	31.2(19027) 2.7–98.0
Moderately endemic zone			
Borno	4	10.5(660) 4.3 30.5; 17, 35	6.2(12207) 36
Cross River	2	NAR	NAR
Delta	0	NAR	NAR
Edo	4	NAR	NAR
Ekiti	2	NAR	NAR
Imo	1	30.0(300) 6	NAR
Niger	23	29.8(1656) 37	4.2(53502) 3.5–38.0; 38–39
Ondo	6	NAR	NAR
Osun	8	NAR	71.1(641) 4.3–76.2; 40–41
Total	50	24.9(2616) 4.3–30.5	5.2(66350) 3.5–76.2
Low/No endemicity zone			
Abia	0	NAR	14.8(1664) 5.5–22.7; 42
Akwa-Ibom	1	NAR	NAR
Anambra	0	NAR	25.5(333); 43
Bayelsa	0	NAR	NAR
Benue	2	NA(NA)18–47;17	15.4(2300) 1.3–30.6; 44
Ebonyi	3	NAR	NAR
Enugu	0	0(529) 45	59.3(1136) 57.0 79.0; 46 47
Gombe	9	NAR	NAR
Jigawa	20	NAR	NAR
Kebbi	4	NA(NA)90.0; 17	24.0(125) 8.2–33.3; 34
Kogi	2	27.6(854) 6.3–83.0; 48	NAR
Kwara	6	46.0(164) 49	45.4(425) 50
Nassarawa	2	NAR	NAR
Plateau	25	NAR	47.8(2888) 22.9–62.4; 51
Taraba	0	NAR	NAR
Rivers	0	NAR	NAR
Yobe	2	13.1(290) 10.1–15.4; 49	NAR
FCT	5	NAR	NAR
Total	81	19.0(1837) 6.3–90.0	33.4(8870) 1.3–79.0
Overall	323	9.4(699140) 0.06–92.0	13.1(94247) 1.3–98.0

*Information presented as a(b)c-d;e

a = Mean prevalence based on pooled date from all relevant publications
b = Total number of persons examined
c-d = Range of mean prevalence given by all releant publications
e = Reference(s) as listed below:

1. Robertson (1929); 2. Purser (1959); 3. Akogun and Akogun (996); 4. Istifanus *et al* (1989); 5. Akogun (1989); 6. Oldenburg (1942); 7. McCoulloch (1927); 8. Betterton *et al* (1989a); 9. Ndifon (1991); 10. Collard (1962); 11. Bell and Howells (1973); 12. Pugh and Gilles (1978); 13. Pugh *et al* (1980); 14. Fisk (1939); 15. Okpala (1957); 16. Okpala 91961); 17. Blair (1956); 18. Gilles *et al* (1965a); 19. Osegbe and Amaku (1984); 20. Ejezie and Ade-Serano (1981); 21. Ofoezie *et al* (1991); 22. Mafiana and Beyioku (1998); 23. Cowper (1959); 24. Cowper and Woodward (1960); 25. Cowper and Woodward (1961); 26. Gilles *et al* (1965b); 27. Edington *et al* (1970); 28. Gilles (1964); 29. Stegal (1968); 30. Akinkugbe (1962); 31. Thomas *et al* (1972); 38. Adekulo-John (1979); 39. Mafe (1997); 40. Adewunmi *et al* (1990); 41. Adewunmi *et al* (1991); 42. Udonsi (1990); 43. Amazigo *et al* (1997); 44. Amali (1989); 45. Okpala (1971); 46. Ozunba *et al* (1989); 47. Nwaorgu and Anigbo (1992); Ellis *et al* (1968); Thompson (1967); 50. Edungbola *et al* (1988); 51. Aku fongwe *et al* (1996).
**NAR - No Avalaible Record

(Source: *Ofoezie,2002)*

Several other studies have been carried out over the years to investigate the level of infection in the human populations living in close vicinity of water projects. One of such studies investigated two areas close to man-made lakes. These were the Tomas Dam area (Fig 4 index No.5) which was surveyed between February and June 1985, and the region close to the Rimin gado Dam (Fig 4; index no. 8) which was studied between November 1985 and February 1986. Stool and urine samples from 813 school children and adults from Tomas and Rimin gado Dam areas of Kano State, showed *Schistosoma haematobium* to be present at both localities with prevalences of 26.6 and 36.8%, respectively (Table 3) . No cases of *S. mansoni* were found (Betterton et al. 1988).

Table 3: *Aspects of the Prevalence and Intensity of Infection With Schistosoma haematobium Among Human Populations in the Tomas Dam and Rimin Gado Dam Areas*

Aspects of prevalence and intensity of infection with Schistosoma heamatobium among human populations in the Tomas dam and Rimin Gado Dam areas

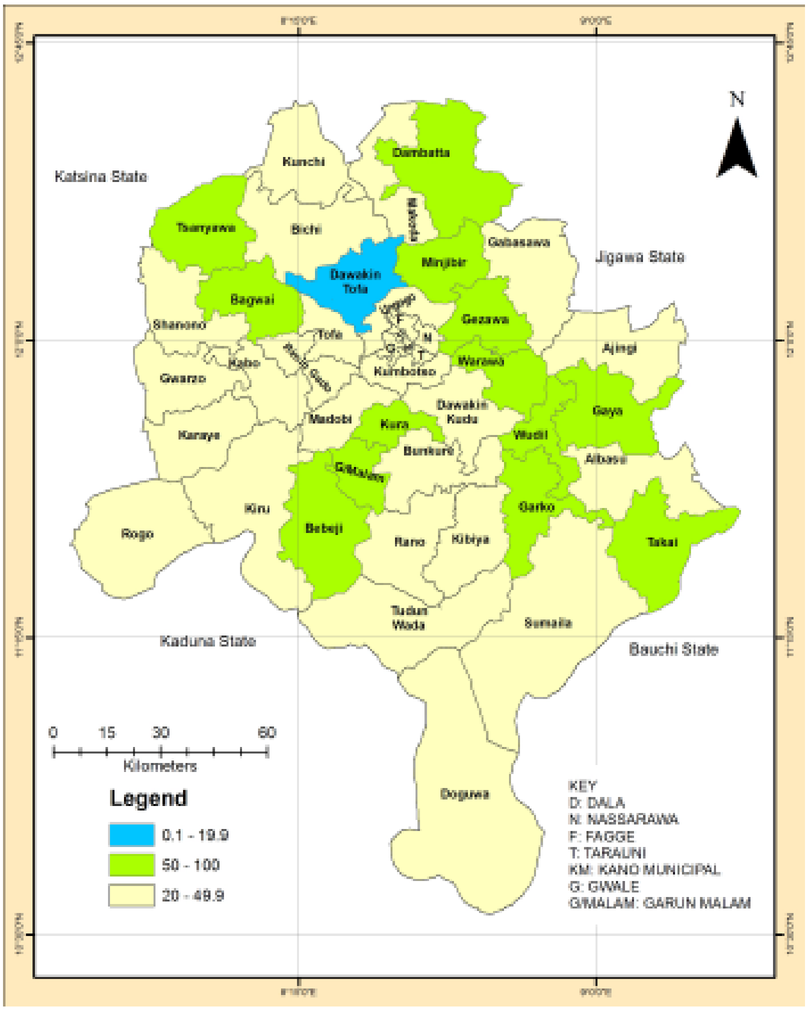
	Tomas Dam area	*Rimin Gado Dam area*	*Remarks*
Number of urines examined	353	463	
Number with *S. haematobium* (%)	94 (26.6)	179 (36.8)	x^2 = 13.0245 *P*=0.0006
Infected males (%)	87 (30.8)	178 (42.6)	
Infected females (%)	7 (9.8)	1(2.4)	
Number of 8-19-year old males	203	402	
Number with *S. haematobium* (%)	72 (35.5)	171 (42.5)	NS
Relationship between infection and location (8-19-year olds)	x^2 = 15.4759 *P*=0.0019 d off=3	x^2 = 35.3386 *P*=0.0007 d off=12	
Peak prevalence age group (prevalence	14-16 years (54.5)	14-16 years (57.6)	
Number infected without haematuria (%)	19 (5.4)	20 (4.3)	
Number uninfected with haematuria (%)	14 (3.9)	10 (2.1)	
Geometric mean no. ova per 10ml urine (95% confidence limits)			
Overall	6.17 (3.86–9.87)	8.43 (5.99–11.87)	NS
8-19-year old males	8.13 (4.75–13.92)	8.57 (6.05–12.13)	NS

***(Source:** Betterton 1988)*

In 2001, another study was conducted in Danjarima village, comprising Zaura, Watari and Sabon-Fegi sub-villages in Kumbotso LGA of Kano State (Sarkinfada, et al, 2009). A large body of water, River Watari flows across the length of Watari and part of Zaura and the river is used for irrigation and domestic purposes by the inhabitants. The study revealed *S. haematobium* prevalence rates of 54.4%, 51.45 and 6.4% in Zaura, Watari and Sabon-Fegi subjects respectively with an overall prevalence rate of 41.6%. The study suggested a linear relationship between urinary schistosomiasis and individual water-related activities and the higher prevalence rates recorded in Zaura and Watari can be attributed to the presence of the Watari River flowing through the two localities.

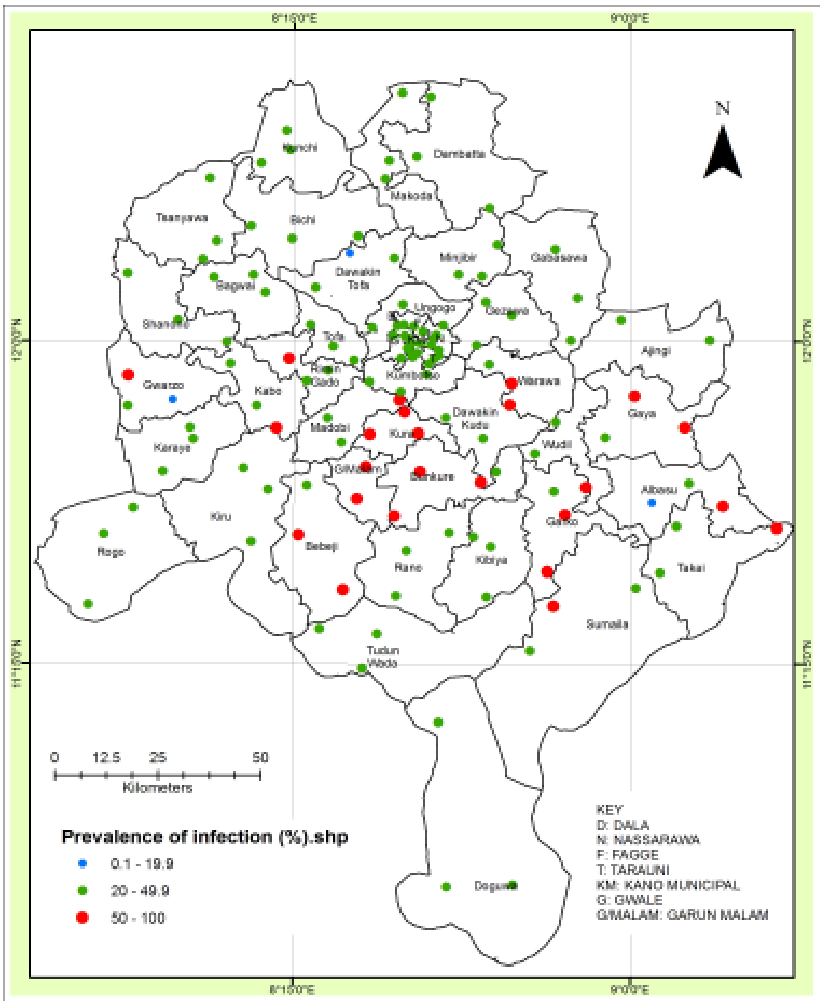
A study on the prevalence and intensity of urinary schistosomiasis among primary school children in Minjibir LGA was conducted between January 2005 and December 2006 (Duwa, Oyeyi and Bassey, 2009). Out of 493 pupils drawn from Wasai and Dingim towns that were examined, 218 (44.22%) were infected.

A state-wide survey on urinary schistosomiasis involving 6600 subjects from 132 towns and villages in the 44 Local Government Areas of Kano State was carried out between July 2005 and August 2007 using GIS to integrate the parasitological and site location data. Figure 5 is a colour coded map of Kano State, showing the prevalence level of *S. haematobium* in the 44 LGAs and Figure 6 shows the spatial distribution of infection in the 132 towns and villages surveyed. Infection was recorded in every LGA with the highest prevalence rate (64.0%) occurring in Kura LGA and the lowest (18.0%) in Dawakin Tofa LGA. The overall prevalence of *S. haematobium* in Kano State was found to be 42.7% (Abdullahi et al. 2009).



*(**Adapted from:** Abdullahi, 2008)*

Figure 5: *Colour coded map of Kano State, showing the prevalence level of S. haematobium in the 44 LGAs*



(***Adapted from:*** *Abdullahi, 2008)*

Figure 6: *The spatial distribution of infection in the 132 towns and villages in Kano State (**Source:** Abdullahi, 2008)*

3.0 PUBLIC HEALTH IMPACT

The health impacts of schistosomiasis are considerable and the disease disables more than it kills. In children, it can cause anaemia, stunting and reduced ability to learn, although the effect is usually reversible with treatment. Chronic schistosomiasis may affect people's ability to work and in some cases can result in death. The number of deaths due to the disease is difficult to estimate due to hidden pathologies such as liver and kidney failure and bladder cancer. WHO estimates that there are about 200,000 deaths globally due to schistosomiasis each year (WHO, 1999).

An overwhelming desire to increase the agricultural output of Nigeria has resulted in an astronomical increase in water development projects within the past three decades and a half. For example, in Kano State, the Kano River and the Hadejia Valley Irrigation Projects as well as numerous small-scale irrigation schemes have been executed by both the Federal and State governments. Thus, a situation has arisen in which large areas of land that in the past lacked water for most of the year now enjoy an abundance of perennial surface water. One of the ecological consequences of this development has been the spread of disease vectors, for example freshwater snails such as those involved in the transmission of schistosomiasis and fascioliasis.

Following the establishment of large scale irrigation schemes, the overall prevalence of schistosomiasis in Kano State increased from 36.8% in 1986 (Betterton et al. 1988) to 42.7% in 2007 (Abdullahi et al. 2009) with the most commonly encountered form of the disease being the urinary form. In Africa, urinary schistosomiasis is associated with low weight for height in both children and adult. The disease can inhibit growth in children but growth rate improves after successful treatment

(WHO 1993). In a study to assess the impact of treatment on growth and nutritional status of school children in Minjibir LGA (Plates 8-11), anthropometric indices of weight, height and mid-upper arm circumference of each child in the trial and control groups were measured prior to, and nine months after the administration of single dose Praziquantel.

The treatment resulted in higher anthropometric measurements and accelerated growth among the treated children compared to the control group that received a placebo (vit. c). There were no reported side effects and the cost of treatment per child for a single dose of Prazequantel and Albendazole was N53.61K. Figures 7, 8 and 9 illustrate the observed differences in anthropometric indices of the trial and control groups from the two localities (Wasai and Dingim) surveyed. Further studies are needed to determine the effect of schistosomiasis on children's school attendance and performance and on the work capacity and productivity of both children and adult.

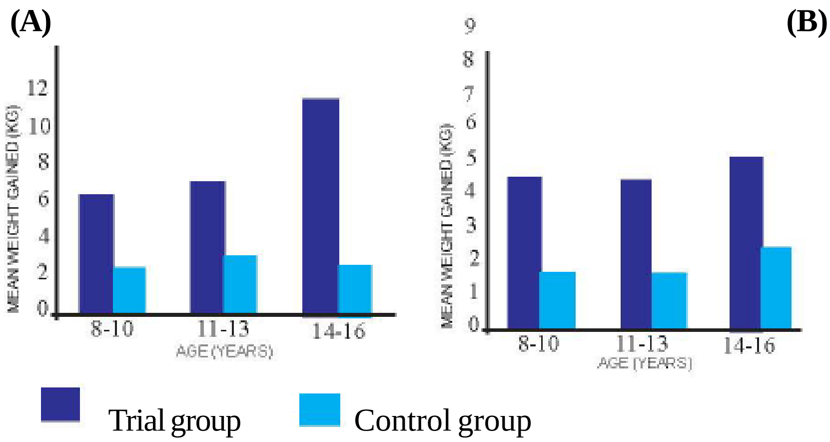


Fig. 7: *Mean weigh gained of trial and control groups in (A) Dingim and (B) Wasai, nine months after treatment in different age groups*

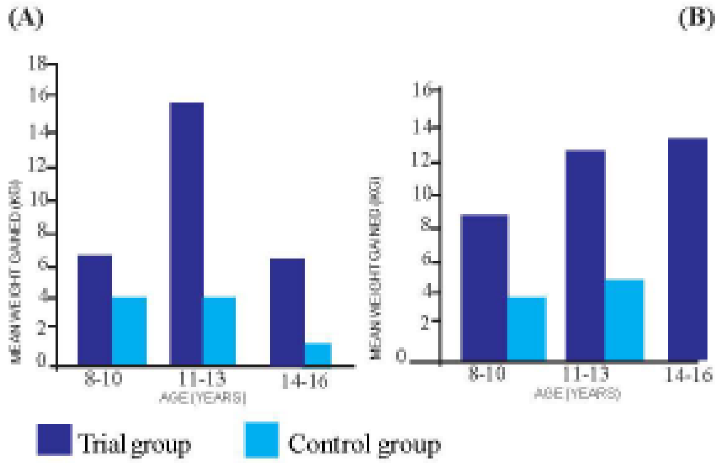


Fig 7: *Mean increase in height of the trial and control groups 9 months after treatment in the different age groups in (A) Wasai and (B) in Dingim.*

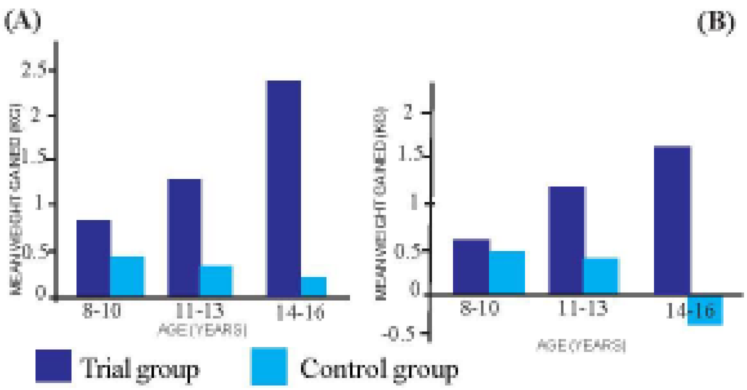


Fig 8: *Mean increase in Mid-upper arm circumference in the trial and control group in (A) Dingim and (B) Wasai*

Plate 8: *Pupils being enlightened on schistosomiasis*

Plate 9: *Pupils lining up to receive treatment*

Plate 10: *Children receiving Praziquantel and Albendazole tablets*

Plate 11: *Children receiving Praziquantel and Albendazole tablets*

4.0 MITIGATION MEASURES

Most experts agree that applying proper combination of sanitary engineering, water control management, snail control, infection surveillance and treatment drugs can avert irrigation effects on schistosomiasis. Even without water control measures, chemotherapy with or without treating water to kill snails may adequately control schistosomiasis transmission. Large scale morbidity control programme together with socio-economic development and environmental changes have brought about interruption in transmission or elimination of the disease in nine countries: (Iran, Japan, Lebanon, Malaysia, Martinique, Montserrat, Thailand, Tunisia and Turkey). Considerable reduction of people infected and disease morbidity have been achieved in Brazil, China, Egypt, Morocco, the Philippines, Venezuela, the Caribbean as well as Cambodia and Laos (WHO, 1993). Measures that may be employed for mitigating the effect of water project development on schistosomiasis transmission include the following:

4.1 Strategy of Control

In areas where prevalence of infection are high, morbidity control primarily by use of population based chemotherapy remains the strategy of choice. However, strategies for transmission control can also be considered in all areas where there are available resources and an operational health care system. These include snail control, health education, improved sanitation, environmental management and modification, supply of drinking water and the planning of adequate health care facilities (WHO, 1999).

Environmental management and modification to control schistosomiasis in water resources development projects include:

- Preventing or removal of aquatic vegetation
- Lining canal with cement or plastic

Plate 12 : *Construction of concrete irrigation ditches will prevent breeding of Oncomelania snails (**Source:** WHO/TDR/ Crump)*

- Regularly fluctuating water levels
- Periodic drying of irrigation canals (WHO, 1985)

4.2 Targeting School Children

The distribution of prevalence and intensity of infection supports WHO's concern that control programmes should give priority to school-aged children who are the fastest growing vulnerable group in developing countries. In a state-wide study conducted in Kano State (Abdullahi et al. 2009), the prevalence of urinary schistosomiasis peaked among the 11-13 years age group. The harmful effect of schistosomiasis on growth, development and health status of this vulnerable group is greater than was previously imagined (WHO, 1993). The Kano State Ministry of Health, in line with this strategy, carried out a school-based mass chemotherapy with Praziquantel in 2015 and 2016 in the 13 most endemic LGAs in Kano. Hopefully, this will effectively reduce morbidity to a bearable level in that group.

4.3 Health Education

Health education remains a high priority in control programmes. In a state-wide study that assessed people's knowledge of schistosomiasis in Kano, only 51.3% of those surveyed were aware of the disease (Abdullahi et al. 2009). A health education approach should be developed emphasizing personal hygiene and the people's role in schistosomiasis transmission.

4.4 Water Supply and Sanitation

Schistosomiasis can only be by water contact especially for domestic, recreational and occupational purposes. Therefore, providing safe water supply and sanitary facilities including drinking water, washing facilities, cattle watering facilities and bathing will not only reduce the risk of infection with schistosomiasis but also with other parasitic and bacterial infections.

4.5 Health Risk Assessment

WHO Expert Committee on the Control of Schistosomiasis noted that health risk assessment was not consistently included in the terms of reference of pre-feasibility and feasibility studies for water resources projects. Budgeting and financing to implement appropriate intervention measures need to be coordinated with the Ministry of Health and development agencies.

5.0 CONCLUSION

Various studies in Kano State have demonstrated the wide spread presence of the snail intermediate host of schistosomiasis especially those for the urinary form at water project sites as well as high level of water contact activities at such sites. Furthermore, it has been observed that communities located close to these water project sites generally showed a higher prevalence of schistosomiasis than those situated farther away and the state in general has recorded an increase in the disease prevalence from 37% in 1986 to 42% presently. There is no doubt that the development and management of water resources in Kano State has contributed to the increased transmission of schistosomiasis in the State, therefore strategies to mitigate negative effects should be made integral parts of the planning, implementation and operation of future water projects.

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