ORIGINAL ARTICLE

Factors Affecting the Prevalence of Schistosomiasis in the Volta Region of Ghana

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ABSTRACT The construction of the Akosombo dam in 1964 and the Kpong dam in 1981 on the Volta River created the Volta Lake in Ghana, West Africa. The purpose of this study was to examine the effects of dam construction on schistosomiasis prevalence. Several reports from numerous sources which together spanned a period of time from before the dams were built to recent years were analyzed. Four representative villages were chosen based on their locations with respect to the dams. Also examined were the efforts made by local health authorities to combat the current problem and to what degree their efforts have been successful. A marked rise in schistosomiasis prevalence following dam construction is observed in villages located in close proximity to the Volta Lake. In villages where aggressive action has been taken to correct this problem, a significant decrease in disease prevalence can be seen, demonstrating the importance of implementing proper disease control measures.

INTRODUCTION

When a dam is built on a river in Africa, it is natural to speculate that it will have an impact on the health status of the people in the area. This may manifest itself as an increase in the incidence of water-related diseases in communities located close to the water, such as schistosomiasis (bilharzia), trypanosomiasis (African sleeping disease), onchocerciacis (river blindness) and malaria. After rivers and streams are impounded, the newly created large body of water may promote the breeding of certain vectors of disease, resulting in an increase of these populations. In addition to this, there may be increased disease transmission associated with inadequate sanitary measures in the lakeside settlements.

Schistosoma Haematobium and Schistosomiasis

Urinary schistosomiasis is caused by the blood fluke *Schistosoma haematobium*. The disease is transmitted to humans by its vector, the snail *Bulinus truncatus*, from wading and swimming in infected water. The initially microscopic worms penetrate the skin, and to a lesser extent, mucosal surfaces, and make their way to the bladder venules, where they grow and lay eggs. The adult worm lives in the submucosal venules of the bladder and other pelvic organs, where they inflict most of their damage. The cycle of transmission is completed when the ova, lying adjacent to the mucosal surface of the bladder, rupture into the bladder and are passed to the environment in the urine. These eggs hatch when they are deposited in fresh water. They invade the snail host appropriate for their species, and are transformed into thousands of fork-tailed cercariae. These infectious larvae swim about vigorously for several days after they are released from the snail. During this time, when cercariae come in contact with human skin, they attach, discard their tails, and penetrate into the skin (1).

The clinical manifestations of schistosomiasis include haematuria, anemia, cystitis and, if left untreated, squamous cell cancer of the bladder. The treatment for infection is praziquantel, an anti-schistosomal agent, which stimulates calcium entry into the muscles of the immature and mature forms of the parasite, causing

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non-physiologic contraction and leading to paralysis and death (1).

The Volta Lake

For several decades, the major drawback of Ghana's economy was its dependence on a single crop, cocoa. The main objective of the Volta River Project was to reduce this over-dependence and diversify the economy by changing the commodity structure of agriculture and industrialization. The purpose of the project has been to construct a dam system to produce the power to support the aluminum industry (2).

The construction of the Akosombo dam on the Volta River, and the subsequent formation of the Volta Lake, began in 1961 and was completed in 1964. The Volta Lake now occupies the center of the riverine system of Ghana and drains most of its rivers. It covers approximately 8500 km^2, or 3.6% of the country's surface area. It contains around 148 000 million m^3 of water, and has a shoreline 7000 km (3).

This artificial lake altered the existing physical, biological, and socio-economic environment of the people. Before the area was flooded, there were 80 000 people (1% of the population) living in 700 villages in the area, mainly in mud-brick houses with thatched roofs (2). The majority of these people were subsistence farmers, and only 2% were riverine fishermen. They were subsequently resettled into only 52 villages two years prior to the creation of the lake (3).

Despite the efforts of the Volta River Authority (VRA) to resettle these villages appropriately, the populations were not always resettled at the same distance away from the water as they had previously lived, and thus some farmers were forced to resort to fishing as a living, and vice versa. In addition, fishermen from other villages, attracted by greater catches in the Volta Lake, created new fishing villages along the lakeside (3).

In 1981, a second smaller dam was built on the Volta river, 25 km downstream from the existing Akosombo dam. This backed the river as far as Akosombo and formed a headpond that covered an area of 36.5 km^2 and spanned a shoreline of 50 km. As the resulting headpond submerged many of their riverside villages, this project involved the resettlement of an additional 6650 people. The rapids at the villages of Senchi and Kpong, downstream from the Akosombo dam, were thus harnessed for power (4).

Although the lake and headpond created a number of developmental possibilities in fisheries, transport, agriculture, wildlife and tourism, they have also created a number of problems. These relate to social engineering associated with the lake, particularly the relocation of the people, and health concerns, such as schistosomiasis. Urinary schistosomiasis has become the main problem associated with the Volta Lake.

The current project involves a study of the development of trends in schistosomiasis prevalence since the inundation of the Volta basin following the construction of the Akosombo and Kpong dams. It also focuses on the attempts made by local health authorities to control schistosomiasis in the Volta region and to what degree their efforts have been successful.

MATERIALS AND METHODS

An extensive survey of schistosomiasis prevalence and the snail vector, *B. truncatus,* density in selected lakeside resettlement villages was carried out using various epidemiological surveys and previous field research on lake-shore health. These dated from before 1964 (the year of the construction of the Akosombo dam) to the present. The reports that were researched included:

The Preparatory Commission Report (1956), which provided data from epidemiological surveys regarding the health situation in the Volta Lake catchment area before the dam at Akosombo was built. It also contained predictions concerning the development of a schistosomiasis epidemic and suggested possible methods to monitor and deal with this problem once it occurred (5).

The Volta River Authority Lakeside Health Unit Quarterly and Annual reports (1974-1984) provided general information regarding the health situation of the villages bordering the headpond, and cited activities undertaken to alleviate health problems. These also contained data from epidemiological surveys on schistosomiasis prevalence, as well as *B. truncatus* inspections carried out by the Lakeside Health Unit of the VRA (6).

The Akosombo Hospital Quarterly Reports and medical records (1970-1996) give a summarized account of services rendered by the hospital and its Environmental Health Unit during each quarter. As well, records (1990-1996) from the Onipa Nua, the VRA's medical boat, include data from examinations of patients with schistosomiasis made in villages along the catchment area of the Volta Lake, to which the boat travels (7).

Various studies conducted on the health component of the Volta Lake project by World Health Organization (WHO), Akosombo hospital staff and independent researchers were also incorporated in this analysis (8-10).

Trends in the development of schistosomiasis in the resettlement villages since the creation of the Volta Lake and Kpong Headpond were examined. This was done by selecting the villages that were surveyed most

Table 1. Location and population of the selected villages (7).

Village	Population	Distance from Shoreline (m)	Upstream Akosombo Dam	Downstream Akosombo Dam	Downstream Kpong Dam
Kitare	300	200	X		
Lower Kpong	1930	1000		X	
South Senchi	1180	350		X	
Torgome	850	200			X

often, and collecting the results of these investigations from the sources listed above. By assembling the results in chronological order, and considering the prevailing environmental and sanitary conditions during the periods in which the surveys were carried out, it was possible to follow the trends in the developments of schistosomiasis and hypothesize on their etiology.

The villages that were followed were: Kitare, Kpong, South Senchi, and Torgome. These villages were chosen in order to present the chronological progression of schistosomiasis prevalence in a variety of geographical locations including upstream of the Akosombo dam, downstream of the Akosombo dam before the construction of the Kpong dam, upstream of the Kpong dam and finally, downstream of the Kpong dam (7) (Table 1).

While traveling with the medical team of the Onipa Nua medical boat, the current author visited some of these lakeside villages to assess the housing and sanitary conditions.

RESULTS

The inhabitants of the villages bordering the Volta Lake and Kpong Headpond live in mud-brick houses with thatched roofs. The most common occupations are fishing and farming. All of the inhabitants come into contact with the Volta Lake or headpond at least twice a day for various reasons, including fishing, bathing, washing, and collecting water for domestic use. Children also play barefoot along the lake-shore and in the water. A common problem in these lakeside villages is the lack of basic health and sanitary amenities, such as a clean water supply, combined with a low economic level.

Extensive provisions were made by the VRA for the supply of pumps and wells in the lakeside villages, however without proper maintenance, most of these eventually failed. As a result, village inhabitants depend completely on lake water for their domestic use. No proper human waste disposal system currently exists, and the inhabitants freely urinate and defecate at the lake shore, perpetuating the cycle of schistosomiasis transmission (2).

Figures 1 to 4 (6,7,11) show the prevalence of schistosomiasis in the selected resettlement villages over time, both before and after the construction of the Akosombo and Kpong dams. The figures show a trend of increasing disease occurrence in Kitare after the creation of the Volta Lake (Figure 1) and in Kpong and South Senchi after creation of the Headpond (Figures 2 and 3). However, Torgome, a village situated downstream the Kpong dam, and away from the headpond, did not have any increase in the prevalence of schistosomiasis (Figure 4).

In recent years, the VRA has been increasing its efforts to control schistosomiasis. Decreasing prevalence rates of schistosomiasis in Kpong and South Senchi villages can be seen since these measures were initiated (Figures 2 and 3).

The relevance of contact with contaminated lake water is demonstrated in Table 2, as indicated by a WHO survey conducted in 1972 (8). This demonstrates that the villages located closer to the lake generally showed a higher schistosomiasis infection rate than those situated further way. As well, in a survey of children from the village of Mepe, it was shown the prevalence of schistosomiasis in children who had never visited the Volta Lake was only 10.7%, while those children who had visited the Volta Lake at least once had a prevalence of 69.9% (8).

In Table 3, data obtained from a VRA lakeside health unit survey made in 1990 at a school in the resettlement

Table 2. Relationship between schistosomiasis prevalence and distance of the village from the lakeshore (8).

Village	Distance from Lakeshore (km)	Schistosomiasis Prevalence %	Prevalence % in the Nearest Lakeshore Community
Aboam	5.62	6.2	90
Aboraso	6.44	12.2	75
Old Ampem	4.83	14.4	80
Dominase	4.83	26.4	84

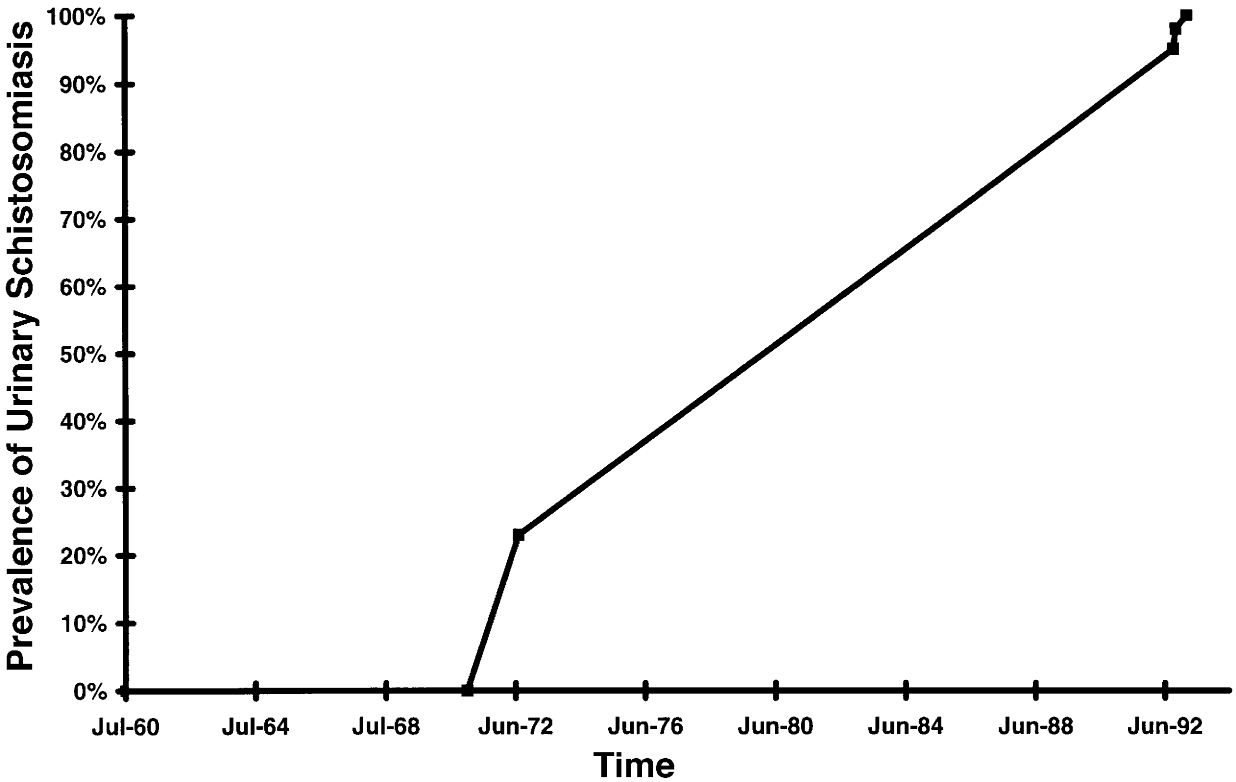

Figure 1. Prevalence of urinary schistosomiasis in children under 15 years of age living in Kitare.

village of Torgome indicates that the age distribution of schistosomiasis infection is highest among children younger than 15 years (7). This seems to be a trend in all the villages that border the lake and the headpond (12).

DISCUSSION

Epidemiological surveys made in 1960, before the Volta Lake was formed, showed that endemicity of schistosomiasis was low along the Volta River (12). In the Volta Basin, the area to be inundated, the prevalence rate among school children was 5% (13), compared with the country's overall rate of 18% (10). The low prevalence of schistosomiasis in this area was related to the scarcity of the snail vector, *B. truncatus*, which was attributed to the unfavorable ecological conditions (9).

Table 3. Age group prevalence of urinary schistosomiasis in a school in Torgome (7).

Age Group Years	% Infected
0-4	10
5-9	30
10-14	70
15-19	55
> 20	45

Seasonal flooding and scouring of the river bed by the silt-laden water prevented the establishment of aquatic weeds, which harbor the snail hosts. The fast rate of flow of the river also prevented the establishment of *B. truncatus*, as they require still waters to breed (14).

The completion of the Akosombo dam and the subsequent formation of the Volta Lake led to an explosion of aquatic weeds to which the snail vectors of schistosomiasis attach and feed. In addition, organic materials in the lake increased as a result of the submerged vegetation, providing a source of nutrients for the snails. This led to an increase in the population of *B. truncatus* in the lake (9).

The creation of the lake was also immediately accompanied by an increase in fish population (10). News of greater catches on the new lake attracted a number of fishermen, especially from the area of the Volta Delta, which was highly endemic for schistosomiasis. These fishermen established a large number of fishing villages and camps around the lake (2).

Transmission of schistosomiasis seems to occur in the lake and headpond. The significance of human-water contact in the transmission of the disease is illustrated by Table 2, which demonstrates an increased prevalence in villages closer to the lakeshore. As well, there is a

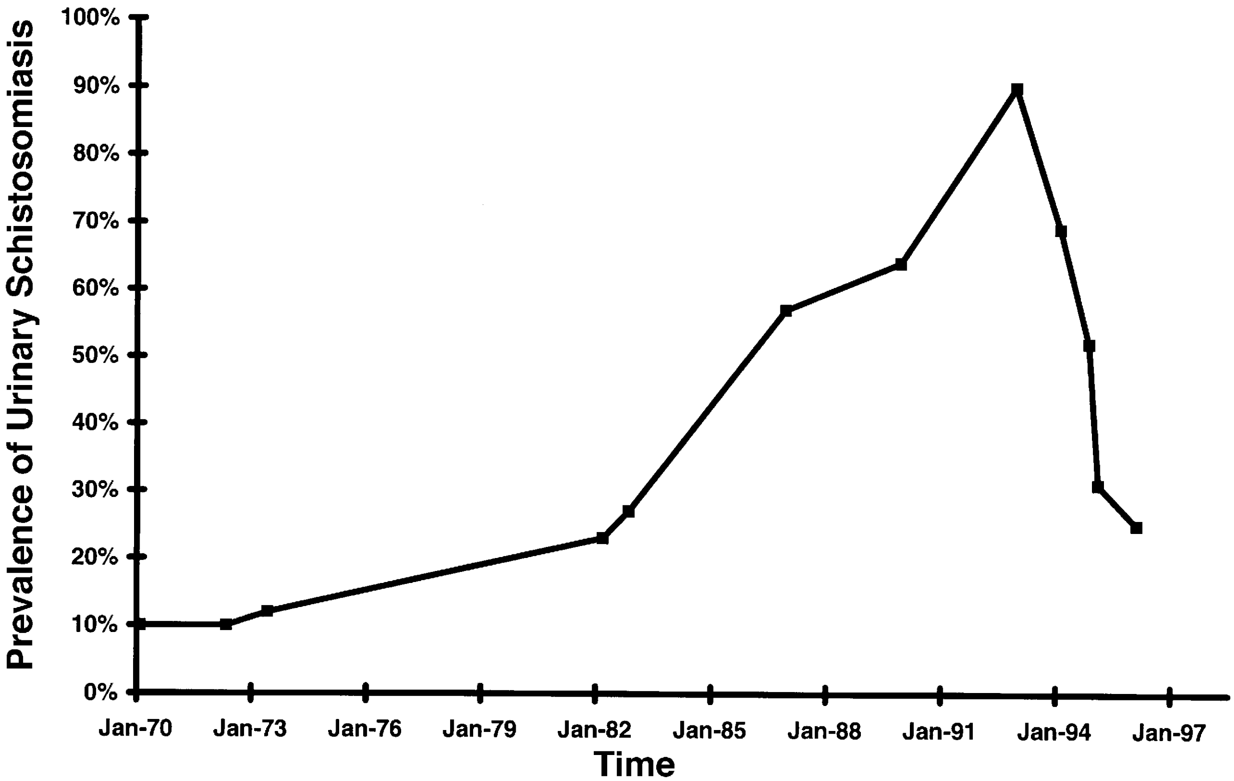

Figure 2. Prevalence of urinary schistosomiasis in children under the age of 15 living in Kpong.

marked difference in prevalence of the disease between children in the same village who have visited the Volta Lake at least once (69.9%) and those who have never visited the lake (10.7%) (6). It was also noted that there was a trend in the incidence of the disease with respect to age and occupation. All surveys showed that children under the age of 15 years seemed to be the group with the highest infection rate (7) (Table 3) and one investigation demonstrated that among adults, fishermen showed the highest incidence of urinary schistosomiasis (11).

The explanation for this is that fishermen, who dock their fishing canoes on the shallow shoreline of the contaminated lake, and who frequently dive into the lake to set their fish traps, come into contact with the infested water more often than other adults (2). They also constitute the group of people who most often travel to other schistosomiasis-endemic areas to fish and trade, where they become infected. They then return to their own villages where they spread the disease (3). Thus, the migratory habits of the fishermen ensure the spread of the disease from endemic areas to other areas. The children, who help their fathers in fishing activities, and who often play and swim in the lake water, form the group that comes into contact with the contaminated water most often.

Survey of Individual Villages

By 1970, only six years after the completion of the Akosombo dam, high prevalence rates of the disease were being recorded among school children in some of the lakeside villages. For example, in Kitare, a resettlement village situated only 1 km away from the lake, there was a rapid rise in rate of infection (6,7,11) (Figure 1).

Following the construction of the Akosombo dam, the expected rise in schistosomiasis occurred in Kitare because of migration of fishermen to the village from more endemic areas of the Volta Delta and the increase in snail density. Over the years, the situation worsened, perpetuated by the local inhabitants' unsanitary practices of urinating in the lake, the children's swimming and playing in the lake, and the use of the contaminated water for washing, bathing, and drinking.

Medical facilities are beyond the reach of this rural community, and only the very limited medical services rendered by the VRA's medical boat, which visits infrequently, are available. Very little has been done to control the transmission of the disease in this community, and the infection rate remains high.

Downstream from the dam, along the Volta river, schistosomiasis occurrence was still relatively low. Following the construction of the Kpong dam, however,

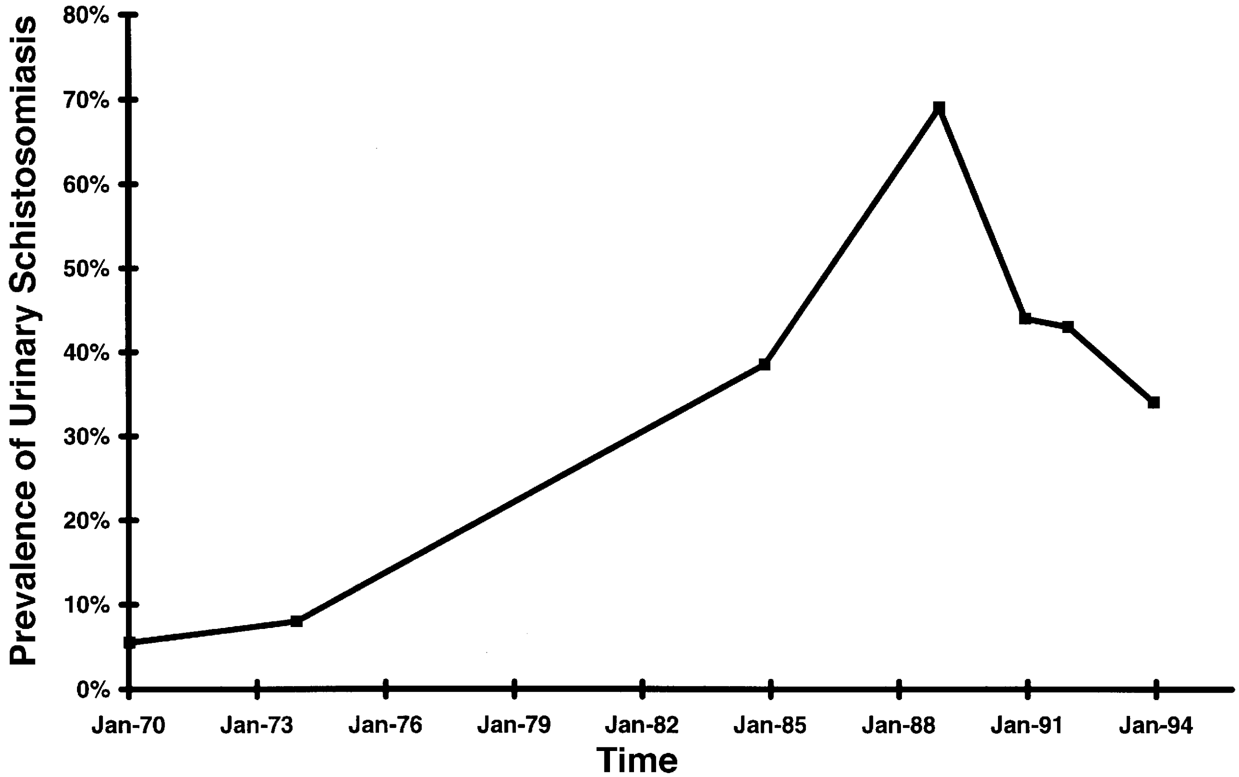

Figure 3. Prevalence of urinary schistosomiasis in children under 15 years of age living in South Senchi.

similar events occurred, and the predominance of schistosomiasis infection increased among villagers living adjacent to the newly created headpond, in the villages of Kpong and South Senchi (6,7,11) (Figures 2 and 3).

The town of Lower Kpong was once an important center for river trade between the mouth of the river, and the interior (15). Before the Kpong Dam was constructed, the village was situated about 25 km downstream of the Akosombo dam, adjacent to the Volta River and Kpong rapids. The disease prevalence was not high since the river flowed at a rate which was too high to support the growth of aquatic weeds or breeding of *B. truncatus*.

When the dam was constructed in 1981, the lacustrine conditions of the headpond now supported the growth of aquatic weeds, and since the fertilizer used by the farmers leaked into the irrigation canals, and then into the headpond, the Kpong shoreline experienced an explosion of aquatic weed growth (9). These weeds supported the growth of the snail vectors, and lead to a tremendous increase in snail density (14). When this problem was noticed, a contractor was hired to harvest the aquatic weeds, and thus clearing activities were immediately undertaken (9). Despite these measures, however, reinfestation always occurred because of drifts of floating mats of weeds, fishermen dumping the weeds that were caught in their fishing nets back into the headpond, and regeneration of the propagative parts of the plants.

Because of the poor sanitary conditions of the shoreline, and increased fishing activities in the area, a high infection rate resulted. The rising incidence of schistosomiasis infection at Kpong was attributed to the local inhabitants' unsanitary water habits.

An intense schistosomiasis control program was initiated by VRA in the 1990s, with more frequent follow-up visits consisting of greater public involvement in maintaining a clean shoreline (7). In addition, the village has been supplied with communal latrines to discourage the pollution of the water. These efforts have been successful in breaking the schistosomiasis life cycle, and decreasing the transmission and prevalence rate of the disease.

The resettlement village of South Senchi is located on the far end of the headpond, upstream of the Kpong dam and 350 m away from the water. The main occupation of this group is fishing. Prior to the construction of the dam in 1981, the river flowed past the village at a rate that was too fast to accommodate growth of *B. truncatus*. As a result, the prevalence of the disease was low, despite the proximity to the water and the fishing activities.

Following the construction of the dam at Kpong, there was a great increase in the infection rate of the

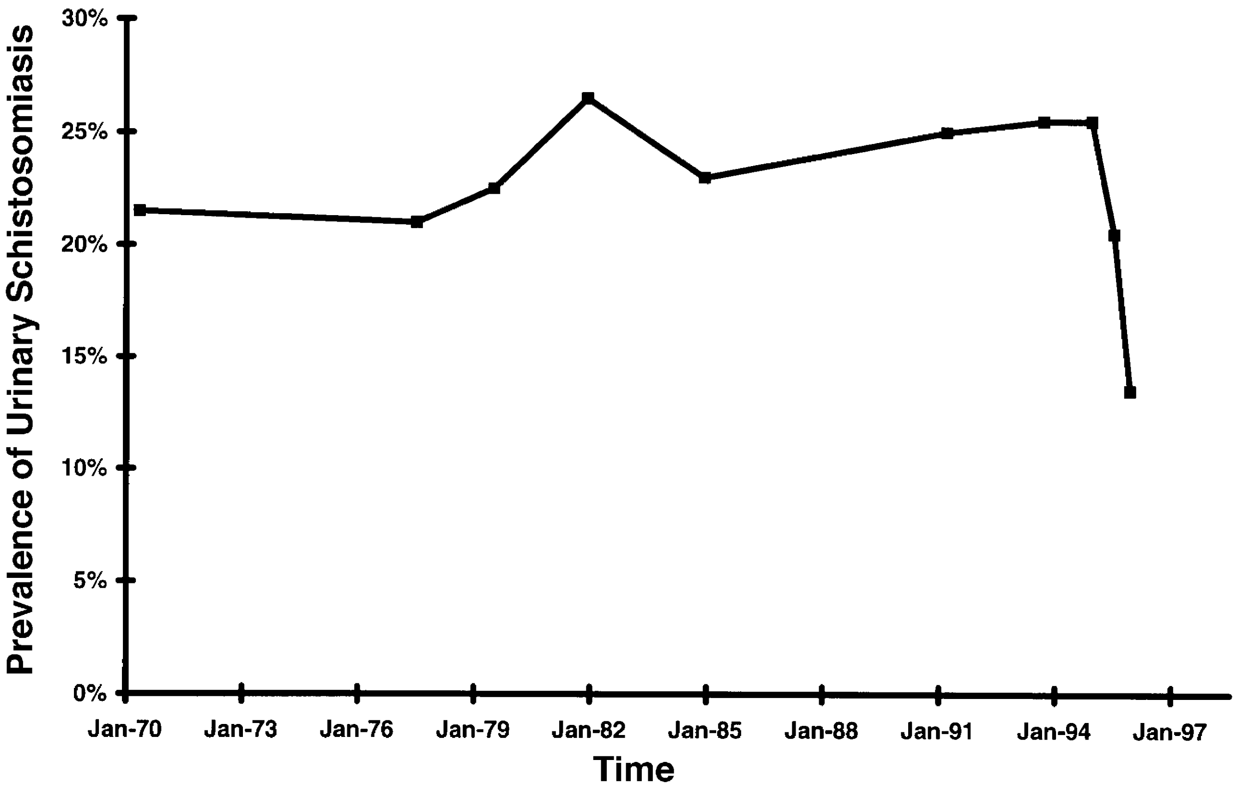

Figure 4. Prevalence of urinary schistosomiasis in children under 15 years of age living in Torgome.

inhabitants of the village, however, the water still flowed past the village sites at a velocity great enough to prevent weed growth in the headpond in this area. In addition, periodic snail investigations in South Senchi revealed a clean fishing wharf and few snails (7). This indicates that the people were likely not being infected in their own village, but rather were becoming infected in another area. They then returned to South Senchi and infected their water supply, where the low snail population was sufficient to ensure a low level of chronic infection (7).

The steady decrease in prevalence rates of schistosomiasis in South Senchi in recent years demonstrates the success of the various schistosomiasis control measures being applied in the village. However, despite these efforts, the inhabitants' total dependence on raw headpond water for their domestic needs, without always applying the cautionary methods that have been suggested in education attempts, prevents a complete break in the schistosomiasis life cycle, and has prevented a complete elimination of disease transmission and prevalence.

Torgome is situated on the eastern shore of the Volta river, 2 km downstream from the Kpong dam. The river at Torgome is deep and fast flowing, there are no aquatic weeds in the river, and snail density is low (4). The people are primarily subsistence farmers, and the river is used mainly for drinking. Very few people go in to swim, and water contact is very low. The prevalence rate of the schistosomiasis has not increased in Torgome since the creation of the Volta Lake and Headpond since this village is not situated in close proximity to either of them, and contact with the contaminated water is minimal.

However, inhabitants from Torgome occasionally travel other areas for festivals and trading purposes, where schistosomiasis is endemic causing them acquire the disease and bring it home to their village. This accounts for the sustained low prevalence of schistosomiasis, shown in Figure 4 (6,7,11).

Measures Being Taken to Solve the Schistosomiasis Problem

The VRA's Volta Lake Research and Development Project Health and Safety department is responsible for health services, and consists of several elements. The hospital at Akosombo has an Lakeside Health Unit, which provides various environmental sanitation services. The *Onipa Nua*, the VRA's medical boat, was launched in December 1990 and delivers voluntary health services to the rural population along the catchment areas of the Volta Lake where medical amenities are beyond villagers' reach.

The Lakeside Health Unit is responsible for environmental health, epidemiology and vector control.

Periodically, the Lakeside Health Unit team travels to certain random resettlement towns and carries out epidemiological surveys on schistosomiasis. VRA's Lakeside Health Unit has also been valuable in teaching fundamental principles of good health care, and encouraging public participation in disease control. Schistosomiasis control methods employed by the VRA Lakeside Health Unit use several approaches. Local inhabitants are involved in clearing aquatic weeds which harbor the snail vector of the disease, and in sanitation exercises (e.g., building pit latrines that are easy to maintain). The Lakeside Health Unit also provides health education concerning the causes and prevention of schistosomiasis, personal hygiene instruction, and mass chemotherapy treatment.

In the 1970s and early 1980s, although large scale treatment for schistosomiasis was available, and administered to lakeside communities, it was not generally effective in lowering the prevalence of the disease (12). The reason for this was that the treatment involved metrifonate chemotherapy at 3 doses per week for two weeks. Although the villagers readily started the series, they often did not complete it, and the parasite was never cleared from their bodies. In addition, as the lake still harbored the schistosomiasis host and parasite, reinfection rates were high (2).

In 1989, praziquantel was introduced (7). This one dose treatment ensured complete cure of the disease, therefore, in that respect, it was more effective at controlling schistosomiasis infection. Prevalence of the disease was still high into the 1990s, despite the chemotherapy, since the unsanitary conditions at the lakeshore still allowed for easy reinfection and transmission. It was realized that in order to prevent the continuing transmission of the disease, a long term education program, together with effective sanitary measures, including an efficient waste disposal system, a safe water supply and adequate bathing and washing facilities would be necessary. Therefore, the chemotherapy was coupled with weed control and education activities as discussed above(7).

Outcome of Schistosomiasis Control Methods

So far, progress in disease prevalence control has been effective in some communities. Improvement is slow, however, due to lack of properly organized community efforts as well as financial and human resources. Despite efforts to treat as many lakeside residents as possible with the limited resources available, many of these villages are not visited often enough (7). Although village residents are treated for schistosomiasis, there is often too long of a delay between the treatment and the follow-up examinations, allowing for re-infection and entry of newly infected people into the community. In addition, due to a lack of resources with which to carry out schistosomiasis surveys by urine sampling, the sample size of villagers examined is sometimes too small to allow for an adequate assessment of disease prevalence within the community. Therefore, monitoring of progress is very difficult.

From the reports available, it can be concluded that from the public health point of view, while the Volta River Hydro Development Project helped to solve some problems, it has, in the meantime, created other serious health and sanitation problems which are still lingering. Before the Akosombo dam was built, there was virtually no schistosomiasis in this area (5). Since the lake and the headpond were formed, the main health problem has been the rapid and uncontrolled rise in schistosomiasis at many points around the lake shore. Following the construction of the Kpong dam, this problem has intensified in villages bordering the newly formed headpond (6,7,11).

To mitigate these health problems, the VRA's Lakeside Health Unit has implemented environmental sanitation and schistosomiasis control programs. These programs involve: aquatic weed clearing, vector snail survey and sampling, new treatment strategies as well as evaluation of previous schistosomiasis treatment, construction of low-maintenance pit latrines, and health education. In some of the villages in which these methods have been used, there is some evidence that schistosomiasis incidence has declined. Despite this decline, occurrence of the disease is still relatively high when compared to the situation before the creation of the lake and headpond.

The object of creating water impoundments in developing countries is to improve the economic conditions of the people. In the long term, however, such projects may be associated with adverse impacts on the health status of the people living in the surrounding area. Often, the diseases associated with these water development projects tend to be caused by lack of planning and is perpetuated through ignorance and unhygenic practices. It is therefore imperative, during the initial stage of any such project, to carefully assess the risks of future problems and to be properly prepared to institute control measures against these diseases and their vectors.

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