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The Impacts of Dams and Reservoirs on Public Health

Health Issues Involving Water

Health issues involving water can be broken into four categories: Waterborne, water-based, water-related, and water-washed illnesses. Water-borne illnesses are those caused by consuming water contaminated by human, animal, or chemical wastes. These diseases are especially prevalent in areas lacking access to adequate sanitation facilities, and include diarrhea, cholera and typhoid. Water-based illnesses are caused by parasites that spend at least part of their life cycles in water. These include guinea worm and schistosomiasis. Water-related illnesses are those transmitted by vectors that live and breed in or around water. Vectors are insects or animals that carry and transmit parasites between infected people or animals. This category of disease includes Malaria, transmitted by mosquitoes. Water-washed illnesses are those that can be prevented through more frequent hand-washing and bathing, including trachoma and onchocerciasis.^{1,2}

The main negative public health impacts associated with reservoirs fall into the categories of water-based and water-related diseases. The reservoirs formed by dams provide large areas of stagnant water ideal in which parasites and vectors can breed. Irrigation canals and drainage network also provide habitats for vector species throughout the farming land. Also, dams provide a steady source of water, sustaining organisms that may have otherwise perished during the dry season.³ The greatest health threats come from diseases endemic to the region. Careful planning regarding the provision of sanitation facilities to resettled populations removes a large part of the risk of waterborne diseases. Water-washed diseases should, if anything, decrease with the introduction of a dam because the amount of water available to people will either stay the same or increase.

Health Impact of Merowe Dam

According to a health impact analysis conducted by Blue Nile Associates, the Merowe Dam Project will have 27 major health impacts, 20 of which are negative. These impacts vary in terms of severity, and timescales; some impacts will only be a concern during the construction of the dam, while others will be more long term. The three

¹Hinrichsen, D., 1997

²Davis, J., 2004

³Jobin, W., 1999, p. 28

greatest positive impacts will be reductions in river blindness, diarrhoeal diseases, and malnutrition. The major negative health impacts include threats or increases in Rift Valley Fever, AIDS, and increased transmission of malaria, bilharzia, and river blindness both in the resettled population and around the reservoir.⁴

Tropical Diseases

Malaria

Malaria is transmitted between humans by female Anopheles mosquitoes. It is caused by a the single-celled protozoa *Plasmodium*. There are four strains of *Plasmodium*, the most serious being *P. falciparum*, which can be fatal, and *P. vivax*, which can spread into temperate areas. All four types of the parasite are found in Africa, with *P. falciparum* being the most common⁵. While the disease used to be widespread, it has been eradicated from most temperate regions and is now found mainly across tropical and sub-tropical regions worldwide. Every year, Malaria causes over 300 million acute illnesses and one million deaths, 90% of which the casualties are young children in Sub-Saharan Africa. The disease also poses an elevated risk to pregnant women.⁶

The parasite is transmitted to humans during a blood meal of an infected Anopheles mosquito, migrating to the humans' liver and red blood cells. Symptoms, which appear 8 to 30 days after transmission, include fever, headache, vomiting and muscle ache. The parasite's cycles of multiplication and destruction of red blood cells is often reflected by cycles of fever, shaking chills and drenching sweats. This process of destroying red blood cells leads to anemia. The infected red blood cells can block the blood supply to the brain or other organs and be fatal.⁷ People living in malaria endemic areas acquire some immunity to the disease and become carriers of the disease, posing a threat to people from non-endemic areas.

Strategies to reduce the risk of malaria include the use of bednets or insecticides to prevent mosquito bites, and the use of prophylactic drugs when exposure is likely. Infections must be detected based on symptoms and, when possible, a microscopic diagnosis, and promptly treated using locally effective drugs. The malaria parasite is quick to develop resistant to drugs and insecticides, so the effectiveness of these drugs must be evaluated regularly.⁷

Schistosomiasis

Schistosomiasis, also known as bilharzia, is caused by the *Schistosoma* fluke and is transmitted by snails. There are two types of the disease: urinary schistosomiasis, caused by *S. haematobium*, and intestinal schistosomiasis, caused by *S. mansoni*, *S. japonicum*, and *S. mekongi*. Infected snails release the parasites in the cercariae larval form, which enter humans in the water through their skin. Adult male and female

⁴ Jobin, W., 1999, pp. 303-312

⁵ Jobin, W. pp. 62-4

⁶ RBM Malaria Infosheet

⁷ TDR Malaria

schistosomes live in human blood vessels, and the female releases eggs. Some of the eggs are passed out in the infected person's urine or faeces, depending on whether it is the urinary or intestinal form of the disease. If this infected urine or faeces comes in contact with water with snails, the eggs will enter the snails perpetuating the cycle of the disease. The rest of the eggs are implanted in the human's tissues causing immune reactions.⁸

The main symptom of urinary schistosomiasis is painful urination with blood. This is due to damage caused to the urinary tract, and can lead to bladder cancer if the disease is allowed to advance. Intestinal schistosomiasis causes swelling of the liver and spleen and hypertension of abdominal blood vessels. The immune response to the eggs damages the intestine by forming fibrotic lesions. Bleeding from the abdominal vessels, which leads to bloody stools, can be fatal. People with the disease become weak and their organs can be impaired. This disease is especially dangerous to children.⁸ People in frequent contact with water are most likely to acquire schistosomiasis. A study comparing the prevalence of schistosomiasis by occupation in the Nile Delta in 1960 found that farmers, fishermen, and boatmen all had greater than 50% prevalence of the disease, while the prevalence for the total population was only 36%.⁹

Urinary schistosomiasis was introduced to northern Sudan by Egyptian labourers in 1919. Both types of the disease are now common throughout Sudan. Downstream from Khartoum, areas with pumped irrigation systems have schistosomiasis prevalences below 50%, and areas without pumped irrigation have less than 10% prevalence. This prevalence is expected to increase dramatically as irrigation intensity increases, encouraging growth of the snail population.¹⁰

Schistosomiasis is diagnosed by urine filtration and faecal smears, as well as antigen or antibody detection tests. The disease is treated by a single dose of praziquantel for all species, or of oxamniquine for *S. mansoni* only. Prevention methods for the disease include targeted snail control, provision of safe water supply and sanitation, and health education.⁸

River Blindness

River blindness, or Onchocerciasis, is caused by a parasitic worm, *Onchocerca volvulus*. The worm larvae are transmitted between humans through the bite of infected blackflies. The larvae lodge in nodules they create beneath the human's skin. Once mature, the worms mate, producing up to a thousand eggs a day. The eggs develop into microfilariae and migrate in the skin tissue where they eventually die, causing skin rashes, lesions, itching and skin depigmentation. If the microfilariae reach the host's eyes, they can cause blindness. The worms can live in humans for up to 14 years.¹¹

The disease can be safely and effectively treated by a drug developed by Merck & Co. Inc., taken once a year. The blackflies can be controlled by spraying insecticide.¹¹ Blackflies breed in fast moving water. The Blue Nile Associates analysis predicted an

⁸ TDR Schistosomiasis

⁹ Jobin, W., 1999. p. 299

¹⁰ Jobin, W., 1999. pp. 310-11

¹¹ TDR Onchocerciasis

overall decrease in river blindness because the dam and the reservoir will destroy most of the breeding sites. However, the rapid water on the dam spillways could cause a localized increase in the disease.¹²

Rift Valley Fever

Rift Valley Fever is a highly lethal hemorrhagic viral disease that occurs after filling a reservoir either for the first time or after a long drought. It is believed that ticks and mosquitoes transmit the virus from sheep and cattle to humans. This disease is especially of concern at the Merowe Dam because two epidemics occurred at the Aswan Dam in Egypt, each one killing hundreds of people. There were also three epidemics at dams on the Senegal River. Normally, the virus remains within livestock. However when a new reservoir is created, the sudden increase in mosquito habitat causes an explosion in the mosquito population. When these massive numbers of mosquitoes are in close contact with both the infected animals and humans, it is possible for the disease to be transmitted to humans. Because humans normally have so little exposure to the virus, they have no immunity to it and are thus very susceptible to its effects.¹³

Approaches to Minimize Negative Impacts

In their analysis, the Blue Nile Associates proposed three options of changes to the irrigation system that would lessen the negative health effects of the dam. Option 1 was to reduce or eliminate storage ponds and increase the velocity through canals to reduce habitat available for vectors. Sudanese blackflies lay eggs in water traveling between 100 and 150 cm/s, but can breed at speeds as low as 50 cm/s. Snails carrying schistosomiasis cannot survive water going faster than 60 cm/s in canals with flowrates around $1\text{m}^3/\text{s}$, or 80 cm/s in larger canals with flowrates of $20\text{-}50\text{ m}^3/\text{s}$. Mosquito larvae can only withstand water velocities of 10 cm/s. Option 2 was to protect people from vectors by placing hamlets at least 5 km away from vector habitats and to provide them with plentiful, clean water. Option 3 was to restructure the irrigation system so that crops requiring constant irrigation would have water delivered by a closed pipe system, and the rest of the system would remain as open canals, but would be dried frequently to reduce or prevent snail and mosquito breeding. They recommend provision of 100 liters per person, per day, of clean drinking water to the resettled community, which would minimize bilharzia and diarrheal diseases. Snail and mosquito populations can be reduced by controlling weeds in the irrigation canals as well as around the reservoir. This can be achieved through biological, manual, mechanical, or chemical approaches. Stopping flow through the dam at strategic times during the black fly's breeding period can prevent their growth, thus reducing river blindness.¹³

As these options show, there are many approaches to reducing the incidence of disease. The following strategies are more generalized and can be applied in dam project planning. Irrigation can be conducted in a manner that will prevent or destroy vector

¹² Jobin, W., 199 pp 307-11

¹³ Jobin, W., 1999. pp. 65-6

¹⁴ Jobin, W., 1999. pp. 311-21

habitats. Exposure to disease can be minimized by locating settlements out of vectors' range. The careful screening of construction workers and resettled population before they mix with local populations can help avoid epidemics. Resettled communities can be provided with safe drinking water and sanitation, health education, mosquito netting, medical facilities and drugs to promptly diagnose and treat infected persons. The water level and shorelines of reservoirs can be managed to reduce vector breeding. Weeds, as well as vectors, can be destroyed biologically, chemically or manually.¹⁵ Table 1 summarizes many of these measures for minimizing the occurrence of schistosomiasis, malaria and river blindness. Each of these approaches has costs and benefits, which must be carefully considered in order to formulate an appropriate course of action. Clearly no one solution will solve all of the health problems associated with a dam, and not every solution will be appropriate in every case; the optimal solution will involve an integrated combination of strategies, chosen according to local characteristics and requirements.

Table 1 Engineering data for disease prevention

Structure	Biharzia snails	Malaria mosquitoes	River blindness blackflies
Recommended canal velocity (m/s) for canal discharge 1 m ³ /s	>0.58	>0.1	<0.5 or >3.0
10 m ³ /s	>0.71		
50 m ³ /s	>0.81		
Drains - drying Half-life for rapid drop Half-life for slow drying	adults 1-2 weeks, eggs 1 hour adults 3-40 weeks	eggs 1 hour	larvae 1 hour
Reservoir fluctuations Height Period	0.5 m 1 week	0.5 m 1 week	close spillway 1 day each week
Communities Minimum size			1000 people
Distance to habitats (km)	2	5	30
Daily water supply (l/per capita)	100		
Housing	water tap in house	window screen, bed nets	

Source: W. *Dams and Disease*. London: E & FN Spon, 1999.

¹⁵ Jobin, W., 1999. chpt. 21

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