Chapter

Epidemiology and Control of Schistosomiasis

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Abstract

Human schistosomiasis is caused by the genus *Schistosoma*. Its prevalence and morbidity are highest among schoolchildren, adolescents, and young adults. It is prevalent in poor communities without access to safe drinking water and adequate sanitation. The agents of etiology of these diseases are *Schistosoma mansoni*, *Schistosoma haematobium*, *Schistosoma guineensis*, *Schistosoma intercalatum*, *Schistosoma japonicum*, and *Schistosoma mekongi*. Symptoms include anemia, stunting, fever, cough, abdominal pain, diarrhea, hepatosplenomegaly, genital lesions, and eosinophilia. Freshwater mollusks are suitable intermediate hosts, and the definitive hosts are the parasitized men. The transmission gap of disease is bridged when people come into contact with unwholesome water sources infested. People are infected through their usual agricultural, domestic, professional, or recreational activities, which expose them to contaminated water. Various animals, such as cattle, dogs, cats, rodents, pigs, horses, and goats, serve as reservoirs. Treatment of at-risk people on a wide scale, access to good water, improved sanitation, hygiene education, and snail control are all used to combat schistosomiasis. The WHO’s schistosomiasis control strategy focuses on reducing disease by regularly administering praziquantel to affected populations on a large scale. It entails the regular treatment of all at-risk populations. Disease transmission should be halted in specific countries where transmission is low.

**Keywords:** schistosomiasis, epidemiology, prevention, control

1. Introduction

Human schistosomiasis (or bilharzia) is a chronic disease caused by parasitic worms. It is a parasitic neglected tropical disease and remains, after malaria, one of the main sources of morbidity and mortality in high prevalence countries, with major consequences on the health of the population and the economy [1].

According to the World Health Organization (WHO), 207 million people may have schistosomiasis in the world [2]. In 2018, it was estimated that at least 229 million people needed preventive treatment for schistosomiasis, while the number of people treated was 97.2 million [3].

Ninety percent of the disease burden is in sub-Saharan Africa, where the main species that cause schistosomiasis in humans are *Schistosoma mansoni* (intestinal
schistosomiasis) and *S. haematobium* (urogenital schistosomiasis), which are transmitted through feces and urine, respectively [4, 5].

Victims are infected through their usual agricultural, domestic, professional, or recreational activities, which expose them to contaminated water. Lack of hygiene and certain play habits of school-age children, such as swimming or fishing in infested waters, make these children particularly vulnerable to infection [3].

Symptoms of schistosomiasis include anemia, stunting, fever, genital lesions, and irreversible organ damage [6–8].

The fight against schistosomiasis aims to reduce the number of patients by means of periodic large-scale treatment of populations with praziquantel; a more comprehensive approach, including access to drinking water, appropriate sanitation and the fight against gastropods, should also reduce the transmission of schistosomiasis [3].

The WHO recommends praziquantel-based preventive chemotherapy for schistosomiasis control; this treatment is given largely to school-aged children aged 5 to 15, who have the largest infection burden and may be reached efficiently through schools [9]. The prevention chemotherapeutic strategy is defined by the prevalence of schistosomiasis in the implementation unit (usually the district). A prevalence of schistosomiasis <10% entails the administration of preventive chemotherapy every 3 years; 10 to 49%, treatment every 2 years; and ≥ 50%, treatment annually [10]. The initial success in the prevention and control of schistosomiasis in some countries [11] had led to the WHO’s more ambitious vision of “a world with zero cases of schistosomiasis infection” [12].

The WHO set goals to reduce schistosomiasis morbidity (referred to as disease control; defined as a heavy-intensity prevalence of infection of less than 5% aggregated across sentinel sites) by 2020 and eliminate schistosomiasis as a public health problem (referred to as elimination; defined as a prevalence of heavy-intensity infection of less than 1% in all sentinel sites) by 2025 in countries where human schistosomiasis By 2025, it is also hoped to have completely stopped the spread of schistosomiasis in some areas [12–14].

The WHO’s strategic plan provides guidance on how programs can move from control of schistosomiasis to elimination and interruption of transmission [12].

Owing to epidemiologic and endemicity heterogeneities of schistosomiasis, one may predict that the timelines for transitioning between goals will not be uniform across all countries.

As a result, quantitative data from program monitoring must be analyzed to evaluate and improve these standards. According to recent theoretical modeling, the 2020 disease control goal outlined in the current treatment guideline is likely to be met in areas with low or moderate prevalence but will be missed in areas with high prevalence [15].

### 2. Epidemiology of schistosomiasis

#### 2.1 Pathogen agents

Human schistosomiasis is caused by eight species of *Schistosoma*: *S. mansoni* (intestinal schistosomiasis agent), *S. haematobium* (urinary schistosomiasis agent), *S. mattheei* (urinary schistosomiasis agent), *S. guineensis* (rectal schistosomiasis agent), *S. intercalatum* (rectal schistosomiasis agent), *S. japonicum* (arteriovenous schistosomiasis agent), *S. maleyensis* (arteriovenous schistosomiasis agent), and *S. mekongi* (arteriovenous schistosomiasis agent) [16].
The most causes of disease are *S. mansoni* and *S. haematobium*. People are infected when *Schistosomes* are transmitted during contact with freshwater contaminated with human excreta containing parasite eggs. A gastropod host must be present in the water for the parasite to complete its life cycle.

### 2.2 Simplified *Schistosoma* life cycle

There exist two phases of *Schistosoma* multiplication: the asexual phase in the intermediate host (freshwater mollusks) and the sexual phase in the definitive host (parasitized man) [1].

In people, the *Schistosome* eggs are eliminated in feces or urine into water (1). In water, under optimal conditions, the eggs hatch and release immature *Schistosome* larvae called miracidia (2). The miracidia swim and penetrate specific snail intermediate hosts (3). Miracidia evolve into sporocysts within the snail (4) Sporocysts mature into cercaria, which are discharged into the water by the snail and penetrate the skin of the human victim (5). Cercariae lose their tail and become...
schistosomula when they penetrate the skin. After that, the schistosomula move to the liver to mature into adults. Male and female worms become corpulent and move to intestinal or bladder veins (depending on their species). *S. japonicum*, for example, is found more frequently in the superior mesenteric veins that drain the small intestine, whereas *S. mansoni* is found more frequently in the inferior mesenteric veins that drain the large intestine. Both species, on the other hand, can live in either location and move between them. *S. haematobium* is found in the bladder’s vesicular and pelvic venous plexus, as well as the rectal venules. *S. intercalatum* and *S. guineensis* are also found in the inferior mesenteric plexus, but they are located lower in the bowel than *S. mansoni*. There, where they remain, the females begin to lay eggs (7). The eggs are moved progressively toward the lumen of the intestine (*S. mansoni, S. japonicum, S. mekongi, S. intercalatum/guineensis*) and of the bladder and ureters (*S. haematobium*), and are eliminated with feces or urine, respectively.

### 2.3 Clinical manifestations of schistosomiasis

Human schistosomiasis symptoms are caused by the body’s reaction to the parasitic eggs, not by the parasites themselves [1]. Many infections are symptomless. Following cercariae penetration, a cutaneous hypersensitivity reaction might occur, manifesting as tiny, itchy maculopapular sores. Katayama fever is a systemic hypersensitivity reaction caused by *S. japonicum* and *S. mansoni* that can occur weeks after the initial infection. Systemic symptoms such as stomach pain, diarrhea, fever, cough, eosinophilia, and hepatosplenomegaly are among the clinical signs.

Infections with *Schistosoma* can cause lesions in the central nervous system. Ectopic *S. japonicum* eggs in the brain can cause cerebral granulomatous disease, and granulomatous lesions around ectopic eggs in the spinal cord can occur in *S. mansoni* and *S. haematobium* infections. Persistent infection can lead to granulomatous responses and fibrosis in the liver and spleen, as well as other symptoms.

Various hepatic complications from inflammation and granulomatous reactions, as well as embolic egg granulomas in the brain and spinal cord, are associated with *S. mansoni* and *S. japonicum* schistosomiasis. Hematuria, scarring, calcification, squamous cell carcinoma, and embolic egg granulomas in the brain and spinal cord are all symptoms of *S. haematobium* schistosomiasis.

### 2.4 Reservoirs of *Schistosoma*

Cattle, dogs, cats, rodents, pigs, horses, and goats serve as reservoirs for *S. japonicum*, while dogs serve as reservoirs for *S. mekongi* [1]. In endemic areas, *S. mansoni* is frequently recovered from wild primates, but it is primarily a human parasite rather than a zoonosis.

### 2.5 *Schistosoma*’s hosts

These parasites develop successively in two hosts: the intermediate host and the definitive host [1]. Intermediate hosts are freshwater snails of the genera *Biomphalaria* (*S. mansoni*), *Oncomelania* (*S. japonicum*), *Bulinus* (*S. haematobium, S. intercalatum, S. guineensis*). The only known intermediate host for *S. mekongi* is *Neotricula aperta*. The definitive host is usually humans but maybe cattle.
The hatched eggs enter a small aquatic snail, to spend the first part of their life there. Then the eggs become small worms, called cercariae, which swim and contaminate the human host, which is in contact with water, by crossing the skin, entering the veins, then in the digestive tract where the eggs are laid and then eliminated by the stools in the aquatic environment.

2.6 Risk groups

There is no natural immunity in humans. However, the slow development of acquired resistance to reinfection appears with age [1].

The groups most particularly exposed to the risk of schistosomiasis are school-aged children, teenagers, adults belonging to certain professional categories (fishermen, rice farmers), women who come into contact with infested water during their household chores, and entire communities in high-risk areas. The disease can manifest itself in intestinal or urogenital form.

2.7 Risk factors

Schistosomiasis is an important cause of disease in many parts of the world, most commonly in places with poor sanitation [17]. As a result, social-ecological processes control schistosomiasis transmission (e.g., conditions of poverty and living near open freshwater bodies). Humans excrete *Schistosome* eggs in their feces or urine. Miracidia infect particular snails after hatching to produce cercariae. During household (e.g., washing clothes or dishes) and recreational activities, *Schistosome* cercariae penetrate the unbroken skin of humans (e.g., bathing and swimming in unprotected open freshwater bodies).

Living near freshwater bodies (e.g., rivers, small dams, irrigation schemes, and lakes), socioeconomic factors that influence occupational activities (e.g., poor people without running water at home are more likely to contact freshwater bodies), and climate change have all been shown to facilitate schistosomiasis transmission in Africa. The lack of access to proper sanitation encourages open defecation, which pollutes the environment and increases schistosomiasis transmission.

2.8 Geographic distribution

There are many species of *Schistosoma* that are only known for animal infections. Out of the 22 currently recognized species, only eight have been reported from humans and of these, only three are heavily implicated as diseases of public health importance [1].

- *S. sinensium, S. japonicum, S. maleyensis, S. mekongi* are found in East and South-East Asia

- *S. hippopotami* in Africa

- *Orientobilharzia turkstanicum and S. incognitum* in Asia

- *S. mansoni and Sirthenea rodhaini* distributed throughout Africa. *S. mansoni* is in some South American countries (Brazil, Suriname, and Venezuela), and in
Caribbean (Dominican Republic, Guadeloupe, Martinique, and Saint Lucia with sporadic reports in the Arabian Peninsula).

• *S. nasale, S. spindale, and S. indicum* in West and South Asia.

• *S. margrebowiei, S. leiperi, S. mattheei, S. intercalatum, S. haematobium, S. guineensis, S. curassoni, and S. bovis* in Africa. *S. haematobium* is found in areas of the Middle East and a recent focus of ongoing transmission has been identified in Corsica. *S. intercalatum* can be found in parts of Central and West Africa, particularly in the Democratic Republic of the Congo. West Africa is home to *S. guineensis*. In Corsica, France, and certain West African countries, infections with hybrid/introgressed *Schistosoma* (*S. haematobium, × S. bovis, × S. curassoni, × S. mattheei*) have been reported.

3. Prevention and control of schistosomiasis

3.1 Prevention of schistosomiasis

There is no vaccine available but its development is underway. The best way to prevent *Schistosoma* infection is to take the following steps if you are visiting or live in an area where schistosomiasis is transmitted [1]:

• Scrupulously avoid contact with contaminated freshwater by swimming or wading when you are in countries in which schistosomiasis occurs. For prevention, swimming in the ocean and chlorinated swimming pools is safe.

• To avoid scorching, freshwater for bathing should be heated for at least 1 minute to destroy any cercariae, then cooled before bathing. Water that has been stored for at least 1 to 2 days in a storage tank, on the other hand, should be safe to drink without boiling.

• People who are inadvertently exposed to potentially contaminated water (for example, by falling into a river) should dry themselves thoroughly with a towel to try to remove any parasites before they reach the skin.

• Drink safe water. Swallowing contaminated water does not spread schistosomiasis; however, mouth and lip contact with contaminated water could lead to infection. Because water directly from canals, lakes, rivers, streams, or springs could be polluted with a range of infectious organisms, you should either boil it for 1 minute or filter it before consuming it. Any hazardous parasites, bacteria, or viruses will be killed by bringing your water to a rolling boil for at least 1 minute.

• Those who have had contact with potentially contaminated water overseas should see their health care provider after returning from travel to discuss testing.

Preventive chemotherapy has been suggested by the WHO as a morbidity control technique to assist reduce the occurrence, extent, and severity of infection's consequences [12].
While preventive chemotherapy cannot prevent reinfection, it can reduce egg production, reducing the morbidity associated with egg deposition in human tissue [18].

Preventive chemotherapy is given to school-aged children in endemic areas because they are at a higher risk of infection. In areas where the prevalence of infection is at least 10%, preventive treatment should be given to those who are at high risk of infection due to their occupation, such as fishermen, farmers, and irrigation workers, as well as women who may be exposed to infected waters while performing domestic chores. Pregnant and lactating women in these areas should be included in preventive chemotherapy campaigns as well, as they are thought to be at a higher risk of schistosomiasis-related morbidity [1].

3.2 Schistosomiasis control and elimination strategies

In the 1920s, Egypt launched the first mass medication administration campaigns in adults and children, using intravenous tartar emetic, in one of the earliest attempts to control schistosomiasis. Following that, a national program was implemented, which included disease-control techniques such as chemotherapy and/or snail control. The development of safe antibiotics for treating human infections, such as niridazole, metrifonate, oxamniquine, and praziquantel, refocused control methods on chemotherapy [19].

The World Health Assembly produced Resolution 54.19 in 2001, endorsing chemotherapy as the primary option for schistosomiasis management by mass medication administration. By 2010, this resolution set a goal of 75–100% frequent chemotherapy coverage for school-aged children (ages 5–14 years) who are at risk of morbidity [12]. However, as acknowledged at the 65th World Health Assembly in May 2012, this goal was not met [20].

In 2010, over 108 million school-aged children required treatment, with at least 21 million receiving treatment (19%), far short of the resolution’s target. This was based on reports from 28 (55%) of the 51 countries where schistosomiasis preventive chemotherapy should have been used [21].

Integrated control of schistosomiasis strategy, combining large-scale preventive chemotherapy, hygiene, improved sanitation, education, provision of potable water, snail control, and environmental modification can lead to interruption of schistosomiasis transmission (elimination). There are five stages to an intensified control program that will result in the abolition of schistosomiasis: [22, 23].

- Morbidity management;
- Abolition as a public health issue;
- Transmission interruption (elimination);
- Post-transmission monitoring; As well as
- Verification of elimination.

As a program progresses from one phase to the next, its objectives should be changed, with scaled-up activities such as appropriate public health interventions (snail control and environmental management, WASH, One Health) and a strong
surveillance system in place to achieve the specific goal. It may take a country 13–50 years to achieve transmission interruption after launching the first group of morbidity-control interventions, and this will necessitate many interventions (not just preventive chemotherapy) that are implemented effectively, sustained, and uninterrupted, with strong political commitment and investment.

There is no “one-size-fits-all” intervention scenario that can guarantee the eradication of Schistosoma infection because the disease is epidemiologically distinct throughout its geographical distribution. Transmission dynamics, disease pathology, the occurrence of reservoir hosts, the habitat of intermediate snail hosts, and the age pattern at which individuals acquire and resolve infection, as well as patterns of infection exposure, are all affected by key species and ecological differences. Furthermore, some countries have advanced schistosomiasis control or elimination programs, whereas others have yet to initiate programs based on the recommended strategies. Integration of schistosomiasis control and elimination activities with existing preventive chemotherapy programs to control and eliminate other NTDs should thus be considered. Treatment for schistosomiasis may be coordinated with preventive chemotherapy for lymphatic filariasis, onchocerciasis, soil-transmitted helminthiasis, and trachoma during the phases of controlling morbidity and elimination as a public health problem [24–26].

In conclusion, Schistosomiasis control focuses on reducing disease through periodic, large-scale population treatment with praziquantel; a more comprehensive approach including potable water, adequate sanitation, and snail control would also reduce transmission. Mass community-based or school-based treatment with praziquantel, education programs, and molluscicides to reduce snail populations are used to control schistosomiasis in endemic areas.

4. Conclusion

Species of the genus *Schistosoma* are various and widespread across the globe, causing infections in humans as well as in animals. In Africa, the public health burden of schistosomiasis, caused primarily by *S. mansoni*, *S. haematobium*, and *S. intercalatum/guineensis*, is enormous. No vaccine is available but the best way to prevent schistosomiasis is to avoid swimming or wading in freshwater, drink safe water and the water used for bathing should be brought to a rolling boil for 1 minute. Schistosomiasis control is based on large-scale treatment of at-risk populations, access to safe water, improved sanitation, hygiene education, and snail control. Praziquantel is the preferred treatment for all types of schistosomiasis. It is efficient, safe, and inexpensive. Monitoring is essential to determine the impact of control interventions.
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