

*Review*

# An evaluation of the effect of schistosomiasis on human Health

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The effect of schistosomiasis on human health is high especially in resource poor countries like Ethiopia. Intestinal schistosomiasis is the major causes of morbidity in most parts of the country. School age children are the vulnerable segments of the population. Lack of sanitation, potable water, environmental modification, health education, mass treatment, awareness and manageable water harvesting programs like irrigation are the contributing factors for schistosomiasis. Proper health impact assessment for new irrigation schemes and other water resources projects will provide a solid basis for the incorporation of health safeguards at design and construction plans in Ethiopia.

**Key words:** Schistosomiasis, irrigation schemes, sanitation, migration.

## INTRODUCTION

Intestinal parasites adversely affect the health of humans in many parts of the world. They continue to be global problem, particularly among children in developing nations (WHO, 1981). The most prevalent and important helminths in developing countries are the soil-transmitted group and schistosomes (WHO, 2004). Intestinal helminthiasis is intimately related to poverty and most infections are entrenched particularly in tropical regions where the biophysical environment and cultural practices favor transmission (Cheesbrough, 2000). For instance, of the global burden of schistosomiasis, an estimated 85% is found in sub-Saharan Africa (WHO, 2006). Schistosomiasis also known as bilharziasis is a parasitic disease caused by trematode fluke of the genus *Schistosoma*. Schistosomiasis is mainly found in Asia, Africa and South America in areas where fresh water snails serve as the intermediate hosts (Gryseels et al.,

2006). Schistosomiasis is endemic in 74 tropical countries worldwide, affecting over 200 million people while 500 to 600 million people are at risk of becoming infected (Rozendaal, 1997; Steinmann et al., 2006; Siddiqui, 2011).

Schistosomiasis is a disease caused by one of six *Schistosoma* species, namely *Schistosoma haematobium*, *Schistosoma guineensis*, *Schistosoma intercalatum*, *Schistosoma mansoni*, *Schistosoma japonicum*, and *Schistosoma mekongi* (Davis, 2009). A number of animal species as *Schistosoma margrebowiei* or *Schistosoma bovis* may also occasionally infect humans (McManus and Loukas, 2008).

In Ethiopia, infection of intestinal parasites is the second most predominant cause of outpatient morbidity (Tesfa-Yohannes and Kloos, 1988). Of which, intestinal schistosomiasis is the major causes of morbidity in most

parts of the country (Tedla, 1981; Tedla and Jemaneh, 1998) at an altitude of 1000 to 2000 m above sea level (Yomi et al., 2010).

Information on countrywide epidemiology of schistosomiasis in Ethiopia is limited. But numerous studies conducted in different localities showed that the prevalence of *S. mansoni* was high among school children. For instance, 73.7% in Bushulo village near Lake Hawassa (Terefe et al., 2011), 43.2% in Ziway town and 31.6% in Wodogenet (Legesse et al., 2009), 67.6% in Finchaa valley (Haile et al., 2012), 82.8% in Sanja town (Alebie et al., 2014) and 73.9% in Waja-Timuga (Abebe et al., 2014) are prevalence values in some of the areas with high prevalence of *S. mansoni* infection in Ethiopia.

Schistosomes need fresh and still water for their survival. They are therefore found in lake-side communities, around water development schemes like dams. People are in contact with infested fresh water during their normal daily activities of fishing, farming, swimming, washing, bathing, recreation, and irrigation (WHO, 1999; WHO, 2007; NIPD, 2013).

The first step in human infection involves penetration of the skin by cercariae which come out from a freshwater intermediate host. Inside the human host, cercariae develop into sexually mature egg-laying worms in the hepatic portal system. The eggs are passed out from the human body in feces or urine, depending on the species of the parasite. The eggs hatch on contact with water and release free swimming miracidia which infect the intermediate snail host. This chronic infection can persist for decades causing disease of intestinal or urinogenital system depending on species types (Hotez et al., 2007). Children are the most heavily infected, because they spend hours playing and swimming in water and lack partial immunity (WHO, 1999).

The pathological effects of schistosomes cause a range of morbidities which seems to be influenced to a large extent by the nature of the induced immune response and its effects on granuloma formation and associated pathologies in target organs (Dunne and Pearce, 1999).

Diagnosis is made by microscopic identification of *S. mansoni* or *S. japonicum* eggs in stool or *S. haematobium* eggs in urine (Katz et al., 1972). Serologic tests are useful to diagnose light infections (in travelers) and in non-endemic or low transmission areas. Antibody tests do not distinguish between past and current infection (WHO, 2007; CDC, 2007).

The drug of choice for the treatment of schistosomiasis is praziquantel. However, despite successful treatment will improve the health of the people, schistosomiasis treated persons can become re-infected. Prevention is still preferable to treatment since in the absence of obvious symptoms, irreversible damages may be done before the infection is detected (IAMAT, 2012). Improved sanitation and potable water, environmental modification, health education, mass treatment and limiting human-water contact offer long-term control of schistosomiasis.

Proper health impact assessment of new irrigation schemes and other water resources projects will provide a solid basis for the incorporation of health safeguards at design and construction plans (WHO, 2001).

The present review presents current challenges in the prevention and control of schistosomiasis in Ethiopia. The derived models used in prevention approaches are not practically applicable in Ethiopia. There are several reasons why prevention methods are not applicable and become challenging in Ethiopia. For instance, inadequate budget and lack of awareness are the dominant factors.

## WATER HARVESTING PROGRAMS

A major mean of rehabilitating and reconstructing the natural resource base is through comprehensive water harvesting development. The impact of prolonged available surface water in newly developed irrigation areas is a predisposing factor for water and vector-borne diseases. Areas that are periodically affected by schistosomiasis are exposed to continued year round attack due to suitable environment for snails' survival (Behailu and Haile, 2002).

A major factor associated with the rise of schistosomiasis is water development projects, particularly manmade lakes (hydroelectric power) and irrigation schemes (agriculture), which can lead to shifts in snail vector populations (Patz et al., 2000; WHO, 2002). On the other hand, water stagnation and weed growing due to inadequate water management sustain the life of the snails to complete the life cycle of schistosomes (Boelee and Madsen, 2006).

Many surface irrigation systems in Africa create favorable snail-breeding conditions that facilitate the transmission of schistosomiasis (WHO, 2004). For instance, there was an introduction of *S. mansoni* to Mauritania and Senegal after construction of huge Diama dam on the Senegal River (Gryseels et al., 2006), and Koka dam in Ethiopia (Kloos et al., 1988).

Irrigation schemes are dynamic agro-ecosystems that can transport snails a long way along the canals and where local events can either provide habitat-friendly conditions or inhibit snail populations (Dale and Polasky, 2007). Generally, the variability within irrigated areas, the canal type, the distance of sites from the canal, the composition and density of aquatic vegetation (Appleton, 1978; Khallaayoune, 1998a), the season (WHO, 2001), specific local conditions such as water stagnation, water depth and shading (Dale and Polasky, 2007) and water flow velocities and the location of breeding sites affect the presence and density of snails among sites. Low-flow velocities and locations found at the starting point of low-order canals are favorable to get aeration of the water and food availability for snails (Boelee and Madsen, 2006).

Environmental changes linked to water resource

development like water harvesting for irrigation and population growth which lead to sanitation problem in Ethiopia have facilitated the recent spread of schistosomiasis to areas where it was not endemic before (Gryseels et al., 2006; Li, 2007). For instance, there is an introduction of *S. mansoni* into the upper and middle Awash valley in Ethiopia, following the establishment of large-scale irrigation schemes of Wonji sugar factory and the prevalence steadily increased up to 20% in 1980 (Kloos et al., 1988) and 81.9% in 1988 (Simonsen, 1990). Similarly, the prevalence of *S. mansoni* of 10.7% was recorded after the introduction of new irrigation schemes in South and Central Tigray (Dejenie and Petros, 2009).

Currently, agriculture development especially in water harvesting for irrigation in Ethiopia have increased from time to time. Similarly, Ethiopia is now constructing a huge hydroelectric power in East Africa in different rivers. The existence of surface water for irrigation and power will sustain the snails in endemic areas of the countries. Therefore, water harvesting program have a negative impact on the health of community by sustaining the life of the snails unless critical plans are taken by both Ministry of Health and Agriculture for snail control and preventions.

### Vector control

The aquatic snails (*Biomphalaria* and *Bulinus* species) cannot usually survive without water serving as intermediate hosts of *S. mansoni* and *S. haematobium*, respectively. All species of *Biomphalaria* and *Bulinus* are hermaphrodite, possessing both male and female organs and being capable of self - or cross-fertilization. A single specimen can invade and populate a new habitat. A snail lays up to 1000 eggs during its life, which may last more than a year. All the characteristics mentioned earlier make it difficult to eliminate snails in schistosomiasis endemic areas (NIPD, 2013).

Recently, a standard cement tanker which completes the green-house effect heating system is developed to control snails. It constituted movable dark canvas covers, which allowed the temperature to be controlled between 20 to 24°C especially during the coldest months of the year. The tanker facilitates the mortality of *Biomphalaria tenagophila* (Rosa et al., 2013).

Due to the relative high cost of molluscicides, no public health intervention measure is taking place in Ethiopia. However, since 1991 interest has rekindled in the use of local molluscicidal plant called Endod (*Phyllolacca dodecondra*) for community based intervention of snails (Lambert et al., 1991).

### Sanitation

Sanitation is one basic problem in Sub-Saharan countries. The ova of the parasites can easily access to

the water when infected people urinate or defecate close to a water source. The contaminated water will be used for different purpose for the community. Schistosomiasis is easily spread in communities that do not have access to toilets or sanitation facilities and awareness about the means of transmission (Assefa et al., 2013). Despite of higher coverage of latrine reports in some places of Ethiopia, prevalence of intestinal parasites is significantly higher due to poor water supply (Mengistu et al., 2007). In addition, open air defecation, washing and bathing also favor transmission of schistosomiasis in Tikur Wuha area of Ethiopia (Mitiku et al., 2010).

The awareness of the people regarding how schistosomiasis infection occurs is limited in Ethiopia. Majority of the people practice open field defecation and urination. Most of the people wash their body in the streams and cross the streams during their daily activities. As a result, the possibility of schistosomiasis infection is high. Unless community awareness is created on the transmission, prevention and control of the infection, the impacts of the disease will live for unlimited time in the community.

### Mass deworming

Current population-based schistosomiasis treatment programs are a first step to reduce the global burden of Schistosoma-related disease; however, they might not dramatically reduce parasite transmission in highly endemic areas (King et al., 2006). Praziquantel is given based on the WHO recommendations in a community level; schools with schistosomiasis high prevalence were mass treated with praziquantel annually (Montresor et al., 2013).

Although 42 schistosomiasis endemic countries in Africa have been determined, factors such as absence of disease mapping in endemic areas, limited availability of praziquantel, and lack of health infrastructure hampered programme implementation and medication distribution (NIPD, 2013). The proportion of people treated for schistosomiasis in the African Region in 2011 was only 9.8% of the people requiring treatment (WHO, 2013). Data for 2012 also showed that only 14.4% of people requiring treatments were reached (WHO, 2014).

Periodic treatment of the risk population groups will cure mild symptoms and prevent infected people from developing severe, late-stage chronic disease. However, a major limitation to schistosomiasis control has been the limited availability of praziquantel. Treatment of the infection brings immediately benefit and has long-lasting effect on morbidity and prevent irreversible sequelae in adulthood (WHO, 2002). On the other hand, there are some disadvantages of praziquantel treatment, which include the appearance of drug resistance in the treatment of *S. mansoni* along with allergic or hypersensitivity reactions against praziquantel treatment (Chai, 2013).

Though, 50% of the people suffering from schistosomiasis

are school-aged children, and chemotherapy is mostly targeted at school-aged children; the community-based approach has been well received and implemented in schistosomiasis control to address out-of-school children in Africa (NIPD, 2013).

In Ethiopia, countrywide epidemiology of schistosomes is limited but there were some prevalence reports which showed high infection rates in endemic areas of the country (Terefe et al., 2011; Haile et al., 2012; Legesse et al., 2010). *S. mansoni* has been recorded in all regions of Ethiopia and is rapidly spreading with water resource development and population movements (Erko et al., 2002). But limited availability of praziquantel and absence of community-based mass treatment approach of children based on the WHO guide line in endemic areas are the challenges to control schistosomiasis. Unless mass treatment strategy is not applicable in endemic areas of schistosomiasis, prevention and control of schistosomes may not be effective in Ethiopia.

### Co-infection with HIV

Mass deworming could have beneficial effects on HIV-1 transmission dynamics. *S. mansoni* infections can increase HIV-1 replication, cell-to-cell transmission and HIV progression as measured by reduced CD4+ T lymphocytes counts in HIV infected individuals (Mazigo et al., 2013). On the other hand, HIV affects *S. mansoni* egg excretion which potentially affects parasitic diagnosis of schistosomiasis infection and releasing of circulating schistosome worm antigens which is important for detection of the worm (Mwanakasale et al., 2003).

Immunological studies have demonstrated that T-cells from HIV-1 positive individuals co-infected with *S. mansoni* responded to egg antigens by producing less interleukin (IL)-4 and IL-10 and a lower amount of interferon-gamma (IFN- $\gamma$ ) as compared to those from individuals infected with *S. mansoni* alone, indicating immune skewing from Th2 to Th1 (Mwinzi et al., 2001).

Prevalence of HIV and *S. mansoni* is high in sub-Saharan Africa like Ethiopia. The impact of *S. mansoni* may be high if HIV infected individuals are co-infected with *S. mansoni*. So, deworming of HIV positive individuals living in *S. mansoni* endemic areas may decrease HIV-1 viral loads and increases CD4+ T lymphocyte counts. Deworming of *S. mansoni* will prevent HIV cases to early developing of AIDS stage. Prevention of HIV cases from *S. mansoni* co-infection especially in endemic areas of Ethiopia is limited.

### Vaccination

Vaccine represents an essential component for the future control of schistosomiasis as an adjunct to chemotherapy. The immune response to schistosome infection, both in animal models and in humans, suggests that

development of a vaccine may be possible (McManus and Loukas, 2008). For instance, DNA-based vaccines protect against zoonotic schistosomiasis in water buffalo and schistosome vaccines capable of reducing water buffaloes' fecal egg output by 45% (Dadara et al., 2008). The vaccine against the schistosomes decreases the fecundity of the adult worm, the worm burden or egg production and viability. But difficulties in obtaining good expression levels and in scaling up production for the limited number of antigens selected have turned out to be another major obstacle (Bergquist et al., 2005). Therefore, absence of vaccine in the country is also another challenge in the prevention and control of schistosomiasis in Ethiopia.

### CURRENT POLICY OF THE COUNTRY

The major challenges in schistosomiasis control remain the scale-up of treatment and to the need to advocate for increased resources for implementation of treatment programmes, provision of potable water, adequate sanitation, hygiene education and snail control. In some countries, schistosomiasis transmission may have been interrupted through active control programmes and/or changing the socio-economic conditions (WHO, 2013).

Still today, most sub-Saharan African countries endemic for schistosomiasis are in a position to establish a country-wide elimination program. While elimination should be considered at the national level, there may be low prevalence areas within each country where elimination could be achieved given adequate resources and political commitments (Rollinson et al., 2012). For instance, schistosomiasis was endemic in Egypt since the ancient times and the most important public health problem but the present findings revealed a decrease in the prevalence of schistosomiasis due to the current policy of schistosomiasis control in Egypt (Zaher et al., 2011).

In Ethiopia, schistosomiasis infection is recorded in all regions of the country and the prevalence is significantly high, but there is no specific policy launched to decrease the disease burden especially in endemic areas.

### POPULATION MOVEMENT AND MIGRATION

Population movement, rural to urban migration, forced displacement migration of workers and the rise of ecotourism have all contributed to the increase in schistosomiasis (WHO, 2007). Environmental changes linked to water resource development and migrations have facilitated the recent spread of schistosomiasis to areas where it is not endemic before (Gryseels et al., 2006; Li et al., 2007).

Migration of workers from endemic areas to irrigation projects or major hydroelectric power plants, followed by contamination of reservoirs with human feces, and

subsequent inevitable increasing contact of communities adjacent to the reservoir for the purpose of bathing, laundering in adults or swimming and playing in children will result in an expansion of infection in regions once free of infection (Steinmann et al., 2006).

The people of Africa move from one place to another for different reasons such as war, famine, food and water. Migration is commonly cited as a significant factor in the spread of other infectious diseases (Lurie et al., 2003). Immigrants and refugees originating from areas where infections persist can pose a significant challenge for national disease control and/or elimination strategies.

The prevalence levels of infectious diseases in a world of increasing travel and migration make national disease control or elimination almost impossible (Gushulak and MacPherson, 2004). For instance, high schistosomiasis seroprevalence was reported from Sudanese lost boys and girls (Posey et al., 2007) and a single *S. hematobium* positive case was also identified from Somali migrants in America (Neal, 2004). The transmission of schistosomiasis is also high around water bodies due to movement of people around the great lakes such as Lake Victoria in Uganda (Standle et al., 2009). There is also a report that confirmed displacement of population has introduced *S. mansoni* into Somalia and Djibouti (Gryseels et al., 2006). In addition, 80% of the tourists were positive for schistosomula tegument antigens (Sm-Teg) which helps in community-based schistosomiasis control programs from non-endemic areas (Grenfell et al., 2013).

Due to its geographical position, as well as environmental and geo-political developments in the region, Ethiopia is likely to continue to receive migrants from neighborhood countries including Eritrea, Somalia, South Sudan and Sudan in 2014 and 2015 (UNHCR, 2014). Control and prevention of *Schistosoma* may be very difficult in Ethiopia due to migrant people from endemic countries like Sudan (Ahmed et al., 2012), Somalia and Eritrea (IAMAT, 2014) and South Sudan (Deribe et al., 2011).

It is very difficult to totally avoid sanitation problems in refugee camps of Ethiopia. In addition, there is no screening policy of migrants' people in the refugee camps for schistosomiasis as soon as they arrive. This will have its own contribution on the prevalence of schistosomiasis infection in the country unless measure is taken.

## RECOMMENDATION

Environmental modification preventing snail vectors and limiting human water contact offers long-term control of schistosomiasis. Health education is a fundamental component that ensures community participation in control interventions. In areas of high prevalence and intensity of infection, community-based mass treatment of high-risk groups with praziquantel offers the most efficient way to achieve the recommended strategy for morbidity control.

Proper health impact assessment of new irrigation schemes and hydroelectric water resources projects will provide a solid basis for the incorporation of health safeguards at design and construction plans. Considering migration as a risk factor, screening of schistosomiasis should be adopted for migrants from endemic areas in East Africa to Ethiopia.

## Conflict Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

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