Schistosomiasis Risk and Prevention

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Schistosomiasis, as one of the 20 Neglected Tropical Diseases (NTDs) according to the World Health Organization (WHO), is threatening millions of lives in endemic areas, especially in Africa [1–3]. Schistosomiasis is highly prevalent in many low- and mid-income countries. The road map for neglected tropical diseases 2021–2030 set targets for elimination schistosomiasis as a public health problem in all 78 endemic countries by 2030.

Human schistosomiasis, also called bilharzia, refers to a parasitic disease caused by any of the parasitic blood flukes of *Schistosoma* spp. People get infected when they use fresh water contaminated by eggs of schistosome through daily life, such as farming, fishing, swimming, washing clothes, and other activities. In total, six species of schistosomes are responsible for human infections, which are *Schistosoma haematobium, Schistosoma mansoni*, *Schistosoma japonicum, Schistosoma mekongi, Schistosoma intercalatum,* and *Schistosoma guineensis.* Among these, *S. haematobium and S. mansoni* are the dominating burden attributed to schistosomiasis, especially in sub-Saharan Africa. *S haematobium and S mansoni* occur in Africa, the Middle East, South America, and the Caribbean [4, 5], while *S japonicum* is localized to Asia, primarily the Philippines and China. The other species are more locally distributed [6]. Each species has a specific range of suitable freshwater snail to act as hosts, which determines the geographical distribution of the corresponding disease.

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Millions of infected people suffer from severe morbidity as a consequence of schistosomiasis. It can result in long-term, severe complications, such as intestinal, hepatic, bladder, and ureteric fibrosis, and bladder cancer as well. Schistosomiasis can cause profound negative effects on child development, outcome of pregnancy, and labor force. Growth retardation, weakness, impairment cognitive development, and increased risk of anemia in children infected with schistosoma can result in poor academic performance and hamper their potential [7, 8]. These negative outcomes in children add to the socioeconomic burden of the society. Except for *S haematobium*, which is the engine for urogenital schistosomiasis, the other schistosomiasis mainly affect human intestine and liver. In addition, it is important to know that female genital schistosomiasis, affecting over 56 million women in endemic areas, can cause considerable inequity, social exclusion, and stigma for women and girls.

12.1 Overview of Schistosomiasis in "Belt and Road" Countries

12.1.1 Epidemiological Situation

Schistosomiasis is prevalent in tropical and subtropical areas, especially in poor areas without adequate sanitation and lack of safe water supply. Globally, approximately 240 million people are infected by schistosomiasis, and over 700 million are in endemic areas. According to the WHO estimation, at least 90% of those requiring treatment for schistosomiasis live in Africa. However, the underestimate of the burden of the disease restricts control efforts in those areas, which in turn, further intensifies the threats in public health.

It is estimated that there are at least 290.8 million people who required preventive treatment for schistosomiasis in 2018, out of whom over 97.2 million were reported to have been treated [9]. Recent research showed that there were 207 million infections in the world, of which 93% occurred in Sub-Sahara Africa, with the largest number in Nigeria (29 million) followed by United Republic of Tanzania (19 million), and DRC and Ghana (15 million each) [10, 11].

12.1.1.1 Nigeria

Nigeria, with 20 million people requiring schistosomiasis treatment, is ranked highest among the countries of the world endemic for the disease [10]. Both intestinal and urinogenital schistosomiasis occur in Nigeria. Three species of *Schistosoma* can be found in Nigeria: *S. haematobium* in South, *S. mansoni* in North, and *S. intercalatum* is rarely or misdiagnosed for *S. haematobium* [12, 13]. Previous studies revealed the prevalence rates ranged between 14.2% and 91.4%. However, the exact level of prevalence of urinary schistosomiasis in Nigeria remains unknown. Information are cumulative by many scattered research output and there are no baseline data or nationwide surveys up to now. Urinary schistosomiasis accounts for at least 90% of all cases in Nigeria, indicating that the disease burden is mainly caused by urinary schistosomiasis [14]. Although with 74% coverage of mass drug

administration (MDA), in Nigeria schistosomiasis appears to be a serious health problem. Prevalence in school children can be as high as 70%, and in population once thought not to be at a high-risk group, observed prevalence level is 20%. In some Southwestern part, prevalence appears to be ranging from 44.8% to 71.5% in endemic areas. MDA is the unique intervention to control schistosomiasis in Nigeria, but far from enough to sustain long-term achievements.

12.1.1.2 Tanzania

It was showed that following Nigeria, Tanzania ranks the second top number of schistosomiasis infection in sub-Saharan Africa [15]. The estimation was about 52% of the Tanzanian population, equal to 23 million were infected with schistosomiasis. Both intestinal and urogenital schistosomiasis are prevalent in this country. *S. mansoni* is focally distributed along large water bodies. It is highly ordinarily seen among both school children and adults. More recently, research indicates that even in the population of preschool aged children, schistosomiasis has been detected with heavy intensities.

12.1.1.3 Ghana

Schistosomiasis is prevalent in Ghana and the predominant control strategy is to reduce morbidity in children through annual MDA of praziquantel following WHO recommendations. Ghana has been implementing this strategy since 2007 for STH and 2008 for SCH. A recent study showed as high as 44.2% prevalence of *S. mansoni* and 11.9% of *S. haematobium* in the Greater Accra region, Ghana. In some areas, the prevalence of infection for *S. mansoni* reached 80.1% and 79.1% in school-age children and adults, respectively [14]. For *S. haematobium*, the prevalence was 35.9% and 34.8% in school-age children and adults, respectively. Another research used urine-CCA assay to test the prevalence and showed 90.5%, 87.9%, and 81.2% in 190 preschool-aged children [16]. Therefore, it is conceivable that both intestinal and urogenital schistosomiasis are prevalent in the country.

12.1.2 Control Progress

Currently, the key strategy for schistosomiasis control and elimination is to implement treatment, which is called preventive chemotherapy. Therefore, in many settings, the progress of schistosomiasis depends on the implementation of preventive chemotherapy.

According to the WHO report, it was estimated that 95.3 million populations were affected by schistosomiasis worldwide [17]. In 2018, approximately a number of 124.4 million school-aged children globally were in need of treatment for schistosomiasis, an index for 54.3% of all people globally. Of the 124.4 million, 76.2 million received treatment, showing the global coverage of 61.2%. In the world, a total of 34 countries reported to carry out schistosomiasis treatment in 2018 and the reporting rate was 65.4% [16]. Table 12.1 shows the global implementation of preventive chemotherapy in 2018.

Table 12.1 Population-based data on preventive chemotherapy for schistosomiasis in 2019 (Source: WHO)

Region	Country	SAC population requiring PC for SCH annually	Population requiring PC for SCH annually	Reported number of people treated	Age group	Reported number of SAC treated	National coverage (%)
AFR	Angola	4,068,555	7,089,384	1,116,928	SAC	1,116,928	15.75%
AFR	Benin	1,394,252	2,362,208	804,844	SAC	804,844	34.07%
AFR	Botswana	151,489	177,125				
AFR	Burkina Faso	2,170,725	3,286,767	2,924,740	SAC and adults	1,808,698	88.99%
AFR	Burundi	1,518,749	1,585,087	1,493,458	SAC	1,493,458	94.22%
AFR	Cameroon	3,124,677	5,402,652	5,173,178	SAC and adults	3,050,947	95.75%
AFR	Central African Republic	477,715	1,216,727	448,056	SAC	448,056	36.82%
AFR	Chad	2,331,865	3,891,239	1,543,409	SAC	1,543,409	39.66%
AFR	Congo	218,664	408,975				
AFR	Côte d'Ivoire	2,650,436	4,599,701	1,782,425	SAC and adults	1,419,714	38.75%
AFR	Democratic Republic of the Congo	11,189,444	15,513,369	7,562,926	SAC	7,562,926	48.75%
AFR	Equatorial Guinea	32,196	62,864				
AFR	Eritrea	228,485	417,622	383,072	SAC and adults	211,390	91.73%
AFR	Eswatini	282,396	402,727				
AFR	Ethiopia	7,513,321	14,016,869	5,002,918	SAC and adults	4,513,662	35.69%
AFR	Gabon	189,108	208,406				
AFR	Gambia	98,488	134,990				
AFR	Ghana	4,369,206	10,685,201	3,974,240	SAC	3,974,240	37.19%
AFR	Guinea	1,763,592	4,031,094				
AFR	Guinea-Bissau	430,700	439,899				
AFR	Kenya	1,924,082	3,519,321	545,263	SAC and adults	382,608	15.49%
AFR	Liberia	605,166	1,035,146	539,432	SAC	539,432	52.11%
AFR	Madagascar	4,319,747	10,210,974	2,842,764	SAC	2,842,764	27.84%
AFR	Malawi	4,216,093	9,194,638	4,784,184	SAC and adults	3,956,123	52.03%
AFR	Mali	3,461,508	6,049,294	4,064,696	SAC and adults	3,296,877	67.19%

AFR	Mauritania	382,778	826,827	213,171	SAC	213,171	25.78%
AFR	Mozambique	5,958,820	15,726,917	5,713,771	SAC	5,713,771	36.33%
AFR	Namibia	203,961	486,997				
AFR	Niger	2,607,881	6,262,985	6,254,428	SAC and adults	2,599,325	99.86%
AFR	Nigeria	17,133,694	25,811,970	21,061,922	SAC and adults	16,930,352	81.60%
AFR	Rwanda	1,623,922	2,652,896	1,242,667	SAC and adults	1,144,650	46.84%
AFR	Sao Tome and Principe	23,124	38,140	14,094	SAC	14,094	36.95%
AFR	Senegal	1,923,202	4,282,543	1,555,894	SAC and adults	1,458,350	36.33%
AFR	Sierra Leone	1,252,782	2,753,175	1,340,150	SAC and adults	1,051,150	48.68%
AFR	South Africa	2,623,952	5,603,448				
AFR	South Sudan	1,336,336	2,884,192	147,138	SAC	147,138	5.10%
AFR	Togo	1,203,304	2,464,417	407,848	SAC	407,848	16.55%
AFR	Uganda	5,573,009	12,274,035	3,417,779	SAC	3,417,779	27.85%
AFR	United Republic of Tanzania	6,576,725	14,874,954	4,260,600	SAC	4,260,600	28.64%
AFR	Zambia	3,040,896	4,756,368				
AFR	Zimbabwe	2,470,412	3,828,849				
AMR	Brazil	1,550,386	1,556,890				
AMR	Venezuela (Bolivarian Republic of)	63,940	63,940				
EMR	Egypt	3,722,983	6,894,411	6,894,411	SAC and adults	3,722,983	100.00%
EMR	Somalia	1,434,961	1,663,712				
EMR	Sudan	4,516,705	8,080,706	3,058,201	SAC and adults	2,483,677	37.85%
EMR	Yemen	3,305,807	3,943,893	3,104,097	SAC	3,104,097	78.71%
SEAR	Indonesia	5800	21,815	19,222	SAC and adults	4103	88.11%
WPR	Cambodia	40,005	108,227	89,908	SAC and adults	32,564	83.07%
WPR	China	No PC required	No PC required				
WPR	Lao People's Democratic Republic	28,780	112,614	90,963	SAC and adults	26,873	80.77%
WPR	Philippines	1,002,165	2,719,004	1,518,370	SAC and adults	559,638	55.84%

PC preventive chemotherapy, *SCH* schistosomiasis, *SAC* school-age children

A number of countries have carried out control programs for schistosomiasis at national level, such as China, the Philippines, Morocco, Brazil, Iran, Egypt, and Tunisia. In these countries, distribution of praziquantel was conducted at large scale. Result showed that transmission of schistosomiasis was significantly reduced in the countries. Some of them reached a low-endemicity status, while others were unable to consolidate their achievements, where the infection returned to preintervention levels [18, 19].

In total, there are altogether 78 countries where schistosomiasis is prevalent, of which 42 are in the WHO African Region [20]. Three additional countries and one territory can be added to the list for a comprehensive database. The additional countries and territories are as follows: Eritrea, Montserrat, South Sudan, and Djibouti [20]. In Asia, prevalence of schistosomiasis in all four endemic countries Cambodia, China, the Lao People's Democratic Republic, and the Philippines has declined significantly. China has shifted from MDAs to selective and targeted treatment. Cambodia and the Lao People's Democratic Republic sustained above 75% coverage with preventive chemotherapy among all school-aged children and adults in endemic villages. As a result, Cambodia, China, and the Lao People's Democratic Republic achieved the criteria for elimination of schistosomiasis as a public health problem by 2017. The Philippines continued to make efforts to improve MDA coverage nationwide [19].

Schistosomiasis has been successfully eliminated in Japan and Tunisia. Morocco and some Caribbean Islands countries have made significant progress on controlling the disease, while Brazil, China, and Egypt are taking steps toward elimination of the disease (Fig. 12.1) [7].

According to the 2021–2030 roadmap of NTD, schistosomiasis elimination as a public health problem is targeted for elimination in the WHO Eastern Mediterranean Region, the Caribbean, and the WHO Western Pacific Region [17].

Group	Countries and territories
Countries requiring preventive chemotherapy	African Region: Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Sierra Leone, South Africa, Swaziland, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe Region of the Americas: Brazil, Venezuela (Bolivarian Republic of) Eastern Mediterranean Region: Egypt, Somalia, South Sudan, Sudan, Yemen South-East Asia Region: Indonesia Western Pacific Region: Cambodia, China, Lao People's Democratic Reblic, Philippines
Countries requiring updating for planning and implementation purposes	Region of the Americas: Saint Lucia, Suriname Eastern Mediterranean Region: Iraq, Libya, Oman, Saudi Arabia, Syrian Arab Republic
Countries requiring evaluation in order to verify if interruption of transmission has been achived	African Region: Algeria Mauritius Redion of the Americas: Antigua, Dominican Republic, Guadeloupe, Martinique, Monterrat, puerto Rico Eastern Mediterranean Region: Djibouti, Iran (Islamic Republic of), Jordan, Lebanon, Morocco, Tunisia European Region: Turkey South-East Asia Redion: India, Thailand Western Pacific Redion: Japan, Malaysia

Fig. 12.1 Status of schistosomiasis endemic countries in the WHO regions

In the past decades, several countries have successfully implemented schistosomiasis control. Large-scale treatment was conducted in a number of countries, such as China, Egypt, Brazil, and Morocco, resulting in significant reduction in both infection and morbidity. After a successful vertical program in Brazil, the disease control program was devolved to local health services. In China, Egypt, and Morocco, programs were implemented through primary healthcare systems but with central direction for significant reduction or interruption of transmission. Few other countries have undertaken large-scale preventive chemotherapy for schistosomiasis, therefore, the goal to have regularly treated at least 75% of school-age children worldwide by 2010 has not been attained. The major impediment to schistosomiasis control is the limited access to praziquantel. Moreover, many endemic countries do not have public health infrastructure or necessary resources to implement schistosomiasis control. In WHO's African Region, no new cases of schistosomiasis have been detected in school-age children from Mauritius since 1991, indicating that the disease can be considered eliminated from it. Algeria is another country with no case reported. According to the WHO Regional Office for the Americas, there have been no cases of schistosomiasis reported from Antigua, the Dominican Republic, Guadeloupe, Martinique, Montserrat, and Puerto Rico. Several countries of WHO's Eastern Mediterranean Region seem to have interrupted schistosomiasis transmission, such as Jordan, the Islamic Republic of Iran, Morocco, and Tunisia. No cases have been reported in the past 50 years from Turkey in the WHO European Region. Only Japan and Malaysia in the Western Pacific Region seem to have eliminated schistosomiasis.

12.2 Schistosomiasis Risk and Control Principles

12.2.1 Schistosomiasis Risk

12.2.1.1 Sustained Risks in Local Schistosomiasis Transmission

12.2.1.1.1 Lack of Safe Water, Inadequate Sanitation, and Behavior

One of the risk factors is water contact in endemic areas where safe water supply, sanitation, and individual hygiene are inadequate in endemic settings. Clean water and hygiene are crucial for local people to prevent from contacting with infested water source. Good practices in personal hygiene are also helpful to avoid being infected. Although WHO set targets for safe water, sanitation, and hygiene [18], many authorities in sub-Saharan Africa are not dedicated to making available clean water sources for their communities, making it still hard to achieve [21–23].

12.2.1.1.2 Widely Distributed Snail Habitats

Schistosomiasis transmission relies on the presence of an appropriate freshwater snail host. The different schistosome species require their own specific snail host species in order to complete life cycles. For example, *Bulinus spp.* Snails are

responsible for the transmission of *S. haematobium*, is transmitted by *Biomphalaria,* is the vector for *S. mansoni*, and the intermediate host of *S. japonicum* is *Oncomelania* snails. Snail colonization of local water habitats, whether rivers, streams, ponds, paddies, or ditches, sets the stage for schistosome transmission to humans [24].

12.2.1.1.3 Risk of Reinfection

Literature shows typical childhood infection/reinfection rates vary from 7% to 26% each year in areas endemic for *S. haematobium*, from 15% to 30% each year for *S. mansoni*, from 4% to 23% each year for *S. japonicum* [25]. The common reason why people get reinfected could be depicted because of the following factors, repeating routine behaviors in lack of access to acceptable water infrastructure, lack of knowledge, and/or risky attitudes and practices [26].

12.2.1.2 Risk of Imported Schistosomiasis Transmission

Population growth and movement is a major factor in schistosomiasis transmission to new areas. In none endemic areas and/or areas where schistosomiasis is eliminated, the risks of imported schistosomiasis and local transmission given that breeding sites present for appropriate snail vectors are undoubtedly steadily rising due to ever-increasing population inflows from endemic areas. In China, since 1970s when the program to aid African infrastructure construction began, imported cases with *S. mansoni* and/or *S. haematobium* infections have been continuously inspected in returners from Africa. As a result, the majority of infection were field workers diagnosed during checkups. Additionally, because of slight or even no clinical manifestations, infection with *S. mansoni* was often neglected by these migrant workers who rarely seek medical services. On the other hand, these non-specific symptoms easily led to missed diagnosis. Therefore, it is presumable that the real number of infections was far from those reported. It was reported that the imported schistosomiasis cases especially from Africa were widely distributed in China. A survey of 263 Chinese workers from Africa infected with *S. haematobium* showed a wide distribution in 17 provinces in China [22]. Another case was seen in eight European students infected with *Schistosoma* after several months stay with freshwater exposure history in Tanzania [27, 28].

12.2.2 Control Strategies

Preventive chemotherapy is referred to the distribution of safe medicines, either alone or in combination, to population groups at risk at a large scale. Preventive chemotherapy can be carried out at regular intervals targeting at decreasing morbidity and ultimately interrupt disease transmission. The WHO strategy of preventive chemotherapy by usage of anthelminthic drugs makes it possible to control schistosomiasis in poor and marginalized communities, alongside lymphatic filariasis, onchocerciasis, soil-transmitted helminthiasis, and trachoma [24]. Praziquantel has been safely co-administered with albendazole and ivermectin, in areas where these drugs have been used separately for preventive chemotherapy. However, in most African countries, preventive chemotherapy is the only control intervention and

often applied in school-age children. For drug only, the inadequate supply of praziquantel and the insufficient distribution system also makes it difficult to carry out control programs. Schistosomiasis control is more of an integrated program than preventive chemotherapy only if the ultimate goal of elimination is to be met. The implementation of complementary interventions combined with preventive chemotherapy is strongly recommended by WHO.

12.2.2.1 Preventive Chemotherapy

The most rapid and cost-effective means to prevent and reduce the morbidity of schistosomiasis is chemotherapy with praziquantel [16, 29]. More than 90% of these people live in sub-Saharan Africa and require preventive chemotherapy. Most countries in sub-Saharan Africa endemic for schistosomiasis are not in a position to establish a country-wide elimination program due to high prevalence rates and transmission potential.

At present, preventive chemotherapy still remains the most important interventions in schistosomiasis control for morbidity control, transmission interruption, and disease elimination and eradication. When the prevalence is very high, preventive chemotherapy aims to reduce severe infections. In the transmission interruption stage, preventive chemotherapy should be expanded to the target population, and the frequency of treatment should be increased. In some cases, such as control of schistosomiasis japonica in China, due to its variety of animal reservoirs, it is key to treat the animals or to prevent them from contaminating the environment.

In practice, preventive chemotherapy interventions can be implemented as modalities, mass drug administration (MDA) referring to treat the entire population in an area, targeted chemotherapy which is implemented to specific risk groups, and selective chemotherapy, which means treatment to be conducted in all infected individuals living in an endemic area as a result of regular screening in a population [17].

12.2.2.2 Snail Control

With the adoption of resolution WHA65.21 by 65th World Health Assembly in 2012, the elimination of schistosomiasis where appropriate reshapes the global agenda of the schistosomiasis control community. Evidence showed that regular molluscicide is likely to advance schistosomiasis elimination, particularly in high-risk areas. As a matter of fact, for many years snail control as the one of the key methods to control schistosomiasis has been implemented by molluscicides, and environmental and biological methods. While the attention and resources focused on preventive chemotherapy over the past two decades have yielded many benefits, the focus on chemotherapy in Africa has perhaps hindered the development of new approaches for snail control and, consequently, led to a general decline in global malacological expertise [25]. Snail control was successfully carried out to achieve schistosomiasis eradication in Morocco and Japan and it has been implemented in control program in Egypt and China. However, toxicity of the chemical to fish and other water-dwelling organisms should be attached great importance both ecologically and economically. Alternatives to chemical-based molluscicides include the use of plant-based derivatives and biological control with snail competitors [30].

12.2.2.3 Sanitation Improvement and Safe Water Supply

Access to and use of clean, safe water and improved sanitation are proved to be essential in preventing infection in endemic areas. Also, it is important to point out that better access to safe water and sanitation does not necessarily intensify transmission control and/or interruption because of various water source for difference purposes. For instance, latrines may impact on the transmission of intestinal schistosomiasis, but they may not have same impacts on that of urogenital schistosomiasis. While preventive chemotherapy can be used to produce immediate impacts in reducing disease burden, such interventions in sanitation and access to safe water sustain effects and achievements can further decrease infection rate and interrupt transmission. Also, clean water and hygiene are essential for provision of appropriate care and rehabilitation services for those affected by residual morbidities and chronic disabilities [26].

12.2.2.4 Hygiene Education

Since contacting open water bodies contaminated with excreta of infected people in most rural settings is inevitable, behavior change and health education of the population is necessary. Comprehensive health education activities for all population to guide behavioral change, especially avoid water contact is in need. Health education to both children and adults has been proved to impact health-seeking behavior, which may reduce prevalence of infection.

Intensified efforts of behavior change need to be made to the population on the risk of infection and transmission regarding waste elimination and personal exposure to open water sources. Residents in endemic areas need to be encouraged to reduce water contact for the purpose of transmission reduction [31]. It is necessary that health education must be carried out in consideration of local settings, and should be practiced through interaction rather than one-direction instructions. Cultural sensitivity is a sensitive component when health education tools are designed and developed.

12.2.2.5 Disease Surveillance

Surveillance is always a key component of schistosomiasis control and elimination. In control stage, when the goal is to lower the heavy disease burden, routine surveillance is carried out to dynamically monitor the reduction in infections, which serves as a good tool for intervention guideline and effect assessment of control activities. All transmission foci should be identified, and appropriate interventions undertaken. When the goal is disease elimination, surveillance should be gradually strengthened in all previously endemic areas for the purpose of case detection and quick response to prevent reintroduction from endemic areas. Sentinel sites should be systematically set up for routine disease surveillance, as one part of the health systems. Surveillance is an essential component of an elimination program so that each transmission foci is identified to consolidate achievements. For example, schistosomiasis is notifiable in China and each case is promptly reported to the national health system in 24 h. Nevertheless, other routine interventions, such as snail control, health education, and sanitation improvement still work as components of an elimination program.

12.3 Case Study

Schistosomiasis Control in China

In China, the first case was recorded by an American doctor in Changde, Hunan province, in 1905. However, the disease carries a long history in China which could be dated back to over 2000 years ago when eggs of Schistosoma japonicum were discovered in the Changsha Mawangdui tumulus [27]. Only schistosomiasis japonica is endemic in China and Oncomelania hupensis is the unique intermediate host.

Schistosomiasis in China was of high prevalence in 12 provinces (municipality and autonomous region) along south of the Yangtze River. The highest estimation of patients was 12 million in the 1950s. Since then, schistosomiasis control has been always a high priority led by the Chinese central government. From 1950s till now, national strategies on schistosomiasis control changed from disease elimination through snail control focused to morbidity control by preventive chemotherapy, and now integrated control with an emphasis on management of infection source. In addition, as domestic animals play an important role as reservoirs, livestock, especially buffaloes, were also treated at the same time.

By the end of 2019, 5 of the 12 provinces (municipality and autonomous region) continued to consolidate the achievements of schistosomiasis elimination, one achieved transmission interruption, one newly achieved the standard of transmission interruption, and the rest of the five maintained transmission control. According to the 2019 national report [28], a total of 327,475 individuals received stool examinations and five were positive, of which one was acute schistosomiasis. These significant achievements are attributed to the strong political commitment, the uninterrupted implementation of the cross-sectional national control program led by the government, the scientific research and development of new tools and technology, and the continuous surveillance activities. Research programs pertaining to schistosomiasis were listed as key programs in the ministries of health, agriculture, and water resources. By the end of 2011, except one national institute, there had been 365 agencies for schistosomiasis control in seven provinces. Among them, 282 were responsible for schistosomiasis control, and the others were in charge of prevention and clinical case management. New technologies such as remote sensing, geographical information system, predictive statistical modelling, and xeno-monitoring based on loop-mediated isothermal amplification techniques are also adopted. These activities provide basic information for decision-makers and facilitate the assessment of the achievements obtained through decades of efforts [2].

China-Zanzibar Schistosomiasis Control Project

With more than 70 years of schistosomiasis control activities, China have gained a great success on the disease control, and the experience can be shared to other countries. China also expressed its willingness to cooperate with

African countries in the field of public health. On May 21, 2014, China, Zanzibar, and WHO jointly signed a memorandum of understanding on cooperation in schistosomiasis control in Zanzibar. The goals of the project are as follows: (1) to master the epidemiology of schistosomiasis in Pemba island and explore the localized comprehensive prevention methods and strategies of schistosomiasis control; (2) to eliminate the schistosomiasis as a public problem in project areas (Prevalence < 1%) by conducting effective schistosomiasis control activities; and (3) with the construction of practical and effective integrated of schistosomiasis control strategies, cooperate with Zanzibar and WHO to make a standard operating procedures (SOPs) for schistosomiasis control in Zanzibar.

From February 2017 to February 2020, 30 Chinese experts involved in the project of schistosomiasis control. To achieve these goals, the project helped local NTD office to scale up its ability of schistosomiasis control. The projected had renovated a new project office and laboratory which were equipped with advanced office and laboratory equipment. The office consisted of work rooms, rest rooms, and meeting rooms, it was equipped with new office supplies like computers, printers, projector, etc. Testing room and vector room are the major part of laboratory, which was equipped with microscopes, refrigerators, sample storage cabinets, centrifuges, dissecting microscopes, computers, etc. With the new office and laboratory, it provided a good base for carrying out schistosomiasis control activities. Some successful experience and methods like Geographic Information System (GIS) technology and computer-based schistosomiasis information system were trained to local team to scale up their abilities. By carrying out a comprehensive strategy including schistosomiasis infection source control and snail control and health promotion. The prevalence of schistosomiasis in all three project areas had reached the goal in 2 years, and the status can be maintained for a least 1 year. Patients were treated by watching them taking the medicine to secure the effect of treatment. By using new type of niclosamide and spraying machine, the infested snails were eliminated to zero in risk areas. Sound alarms and schistosomiasis control slogans were set up near communities and schools, and various types of health promotion and implementation activities had been carried out in cooperation with other departments. By implementing the schistosomiasis control water supply project, the project helped about 2500 people to get safe tap water, which also could help to control other kind of disease.

The project was evaluated by an international no-stakeholder expert group in May 2019. By reviewing data, listening to reports, field and laboratory visits, visiting schools and communities, and interviewing local government officials and the public, the project implementation plan, intermediate host control, team capacity building, population health education, data and information management, health economics, and other aspects were evaluated.

The evaluation team believed that the impact of interventions, reducing prevalence of infection below 1% in the intervention shehias over the 2-year period of the project, is the best that has ever been achieved in the island, and the work carried out during this pilot project has contributed to the establishment of WHO guidelines for laboratory and field testing of molluscicides for the control of schistosomiasis. They also thought that the success of the tripartite cooperation project will serve as a model for other African countries to learn from. This evaluation was also reported to the President of Zanzibar, Dr. Ali Mohamed Shein, who praised the contribution of the Chinese expert group, and said that he would continue to support Chinese experts and strive for the sustainable development of the project.

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