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Acta Tropica 96 (2005) 97–105
ACTA TROPICA
www.elsevier.com/locate/actatropica

The public health significance and control of schistosomiasis in China—then and now

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Available online 25 August 2005

Abstract

The description of schistosomiasis in China dates back more than two millennia. The disease caused social and economic hardship, and the rates of morbidity and mortality were high. In the mid 1950s, when China's population was approximately 600 million, an estimated 11.6 million people were infected with *Schistosoma japonicum*. Hence, a national control programme was launched, with an emphasis on intermediate host snail control by means of environmental management. Over the past 50 years, the national control programme has made great progress and praziquantel-based morbidity control became the mainstay of control. In 2000, the number of infected people had been reduced to an estimated 694,788, the snail-infested area has been abridged by over 75%, and the disease had been eliminated in five of the 12 previously endemic provinces. Between the mid 1980s and 2003, the criteria of transmission interruption have been reached in 260 counties (60.0%), transmission control has been achieved in 63 counties (14.5%), but the disease was still endemic in the remaining 110 counties (25.4%). Comparison between the number of cases in 2000 and 2003 suggests that schistosomiasis has re-emerged; an estimated 843,011 people were infected with *S. japonicum* in 2003. Here, we provide a short historical account of the pubic health significance of schistosomiasis in China, highlight the progress made to date with the national control programme, and place particular emphasis on the most recent trends. Finally, we discuss remaining challenges for schistosomiasis control with the ultimate goal of disease elimination.
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Keywords: Schistosomiasis; *Schistosoma japonicum*; National control programme; China

1. Introduction

Schistosomiasis was one of the most serious parasitic diseases in China with a documented history of over 2100 years. In the mid 1950s, at the beginning of the national control programme, schistosomiasis was

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0001-706X/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.actatropica.2005.07.005

endemic in 12 provinces, with an estimated 11.6 million people infected. There were 1.2 million infected cattle and an area of 14,300 km^2 infested by the intermediate host snail, i.e. *Oncomelania hupensis* (Chen and Feng, 1999; Chen et al., 2005). The disease caused substantial morbidity, including wasting, weakness, ascites and growth retardation, and mortality was considerable. Hence, the disease was a drain to social and economic development (Chen and Feng, 1999; Chen et al., 2005).

Due to the sustained commitment of the Chinese Communist Party and with support of the central and local governments, China became one of the most successful countries in the world to control schistosomiasis (Chitsulo et al., 2000; Ross et al., 2001; Engels et al., 2002). By 1995, disease transmission had been interrupted successively in five provinces, namely Guangdong and Shanghai (i.e. 1985), Fujian (i.e. 1987), Guangxi (i.e. 1989) and Zhejiang (i.e. 1995) (Zheng, 1988; Sleigh et al., 1998; Pan et al., 2002). However, the disease has not been controlled in the swamp and lake regions of Anhui, Hubei, Hunan, Jiangsu and Jiangxi provinces with vast areas of *O. hupensis* habitats. Schistosomiasis also remained endemic in mountainous regions of Sichuan and Yunnan provinces. These areas are characterised by diverse and complex ecologies, lower human and snail population densities, and weaker economic growth when compared to other provinces of China.

In 2000, shortly before the termination of the 10-year World Bank Loan Project (WBLP) to control schistosomiasis (Chen et al., 2005), the estimated number of *Schistosoma japonicum* cases reached an historical low of 694,788. In the following years, the available data suggest that schistosomiasis has re-emerged, probably due to multiple factors, including increased snail diffusion after major flooding events and somewhat reduced control efforts when the WBLP ceased (Li et al., 2000; Zhou et al., 2004a).

By the end of 2003, an estimated 843,011 people were infected with *S. japonicum*. Among them, there were 1114 cases with acute schistosomiasis and 24,441 cases suffering from advanced schistosomiasis. The population at risk of infection was estimated around 65 million and there were 74,000 infected cattle. The snail-infested area was 3787 km^2. Out of the 433 schistosome-endemic counties (or cities) in the mid 1980s, 260 (60.0%) had reached the criteria of transmission interruption, and transmission control had been achieved in 63 counties (14.5%). In the remaining 110 counties (25.4%), transmission was still ongoing, especially in the Dongting Lake and Poyang Lake areas of Hunan, Hubei and Jiangxi provinces, along the Yangtze River basin of Anhui and Jiangsu provinces, and some mountainous areas in the provinces of Sichuan and Yunnan (Zhou et al., 2004a).

2. History and impact of schistosomiasis in China

The over 2100-year history of schistosomiasis in China is documented by the confirmed presence of *S. japonicum* eggs in two corpses dating back to the Western Han dynasty that were exhumed in the Hunan and Hubei provinces in the 1970s (Mao and Shao, 1982; Chen and Feng, 1999). In ancient times, Chinese traditional herbalist doctors had only a limited knowledge of schistosomiasis. According to historical records from Anhui, Guangdong, Hubei, Jiangsu and Zhejiang provinces, schistosomiasis was termed ‘potbelly disease’ or ‘big belly’. In these records, the flooding of the Yuan River in the third year of Xianfeng King in the Qing dynasty enhanced schistosomiasis transmission, which resulted in a serious epidemic in the Hunan province. Meanwhile, serious floods in Mianyang county, Hubei province aggravated the epidemic situation there (Zheng, 1988).

It was not until 1905 had Dr. Logan – an American physician – found *S. japonicum* eggs in faeces of a patient with diarrhoea from Changde, Hunan province; hence this represents the first diagnosed case with schistosomiasis in modern China (Logan, 1905). Subsequently, schistosomiasis was confirmed in the Yangtze River basin, first in Anhui province (year 1907), then in the provinces of Hubei, Jiangxi, Shanghai and Zhejiang (year 1910), subsequently in Guangdong province (year 1911), followed by Jiangsu province (year 1913), then Fujian province (year 1924), later the provinces of Guangxi and Sichuan (year 1938), and finally in Yunnan province (year 1940).

A few years after the founding of the People’s Republic of China, in the mid 1950s, the first nationwide survey was carried out by thousands of health workers with the objective to enhance the understanding of the epidemiology of schistosomiasis and to assess its public health significance. The field surveillance revealed that schistosomiasis was highly endemic in the Yangtze River basin in the southern part of China, i.e. in counties of Anhui, Fujian, Guangdong, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Yunnan and Zhejiang provinces, the Guangxi autonomous region and Shanghai municipality. However, in Guizhou province, also located in southern China, no locally infected patients and no *O. hupensis* were found. In Taiwan, animals but no humans were found to be infected with *S. japonicum* (Zhao and Gao, 1996). The schistosome-endemic areas at that time stretched from Baoying county, Jiangsu province (33°15′N latitude), Yulin county, Guangxi autonomous region (22°05′N latitude), Nanhui county, Shanghai (12°51′E longitude), and Yunlong county, Yunnan province (99°50′E longitude). The lowest altitude of the endemic areas was recorded in Shanghai province (sea level) and the highest one in Yunnan province (3000 m above sea level).

The most severely affected areas were located along the Yangtze River, in the areas of the great lakes (i.e. Dongting Lake and Poyang Lake), and their surroundings. In the provinces of Fujian, Guangdong, Guangxi and Yunnan, the public health importance of schistosomiasis was somewhat less significant than in the other provinces where the disease was endemic (Zhao and Gao, 1996).

In the mid 1950s, when the Chinese population was approximately 600 million (United Nations, 2002), an estimated 100 million were at risk of schistosomiasis and an estimated 11.612 million people were infected with *S. japonicum* (cumulative numbers from the mid 1950s to 1984; Table 1). The numbers of advanced cases and those with acute schistosomiasis japonica were estimated around 600,000 and over 10,000, respectively. The mortality due to advanced schistosomiasis was high, probably with a case fatality rate of 1%. Among the 12 schistosome-endemic provinces, the highest proportion of people infected was recorded in Jiangsu province. Here, an estimated 2.477 million people were infected, which translated to 21.3% of the total population. Large numbers of people infected, and hence high infection prevalences, were also found in Hubei province (number of people infected: 2.275 million; infection prevalence: 19.6%) and Zhejiang province (number of people infected: 2.037 million; infection prevalence: 17.5%). The number of infected people in Anhui, Hunan, Jiangxi, Shanghai and Sichuan provinces was between 548,000 and 1,173,000 (infection prevalence: 4.7–10.1%). In the remaining provinces, i.e. Fujian, Guangdong, Guangxi and Yunnan, the number of infected people ranged between 68,000 and 292,000 (infection prevalence: 0.6–2.5%).

The total area infested by intermediate host snails in the mid 1950s was 14,321 km^2. The largest snail-infested area was observed in Hubei province, i.e. 4300 km^2, accounting for 30.03%. Large areas of

Table 1
Number of people infected with *S. japonicum* and total area infested with *O. hupensis* in the 12 schistosome-endemic provinces in the mid 1950s

Province	Human population		*O. hupensis* snail habitats	
	No. of people infected (in 1000)[a]	Infection prevalence (%)	Total area (in km^2)	Proportion of total area (%)
Anhui	881	7.59	1262	8.81
Fujian	68	0.59	27	0.19
Guangdong	78	0.67	97	0.68
Guangxi	77	0.66	24	0.17
Hubei	2275	19.59	4300	30.03
Hunan	947	8.16	3538	24.70
Jiangsu	2477	21.33	1400	9.78
Jiangxi	548	4.72	2395	16.72
Shanghai	759	6.54	166	1.16
Sichuan	1173	10.10	254	1.77
Yunnan	292	2.51	215	1.50
Zhejiang	2037	17.54	643	4.49
Total	11612		14321	

[a] Cumulative numbers from the mid 1950s to 1984. *Source*: Zheng (1988).

O. hupensis habitats were also found in the provinces of Hunan and Jiangxi with 3538 and 2395 km^2, respectively. Snail habitats exceeding 1000 km^2 were found in the provinces of Anhui and Jiangsu. Together, these five provinces accounted for more than 90% of the total snail-infested area in China. The largest interconnected snail habitats were found around the Dongting Lake and Poyang Lake. Prominent snail habitats were also found around smaller lakes adjacent to the Yangtze River.

In the mid 1950s, an estimated five million cattle were at risk of *S. japonicum* infection and an estimated 1.2 million cattle were infected (Zheng, 1988).

3. Achievements of the national schistosomiasis control programme

Since the mid 1950s, great achievements have been made in the control of schistosomiasis in China. Infection with *S. japonicum*, both in humans and livestock, and the snail-infested areas have decreased dramatically. Many counties have reached the criteria of transmission interruption and in many others, transmission control has been achieved (Chen and Feng, 1999; Zhou et al., 2002).

3.1. Decrease of endemic areas

As revealed by the field surveillance carried out in the mid 1950s, schistosomiasis was endemic in 12 provinces, 433 counties (or cities) and 4078 townships. Progress made in the control of the diseases has been exemplary, as by the end of 2003, the criteria of transmission interruption had been reached in five provinces (41.7%), 260 counties (60.0%) and 2276 townships (55.8%). However, schistosomiasis remained endemic in 110 counties (25.4%) and 1066 townships (26.1%), particularly in the lake areas of Anhui, Hubei, Hunan, Jiangsu and Jiangxi provinces, and the two mountainous provinces of Sichuan and Yunnan (Table 2).

3.2. Decrease of number of people and cattle infected

According to the field surveillance carried out in 2003, among the estimated 843,011 *S. japonicum*-infected people, there were 817,456 chronic cases and

Table 2
Changes of schistosome-endemic areas in China between the mid 1950s and 2003

Province	No. of counties	No. of townships	Transmission interrupted		Transmission under control		Still endemic	
			No. of counties (%)	No. of townships (%)	No. of counties (%)	No. of townships (%)	No. of counties (%)	No.of townships (%)
Transmission interrupted								
Fujian	16	71	16 (100)	71 (100)	0	0	0	0
Guangdong	12	39	12 (100)	39 (100)	0	0	0	0
Guangxi	19	77	19 (100)	77 (100)	0	0	0	0
Shanghai	9	116	9 (100)	116 (100)	0	0	0	0
Zhejiang	54	500	54 (100)	500 (100)	0	0	0	0
Transmission ongoing								
Anhui	41	497	14 (34.1)	256 (51.5)	13 (31.7)	117 (23.5)	14 (34.1)	124 (24.9)
Hubei	58	527	23 (39.7)	156 (29.6)	10 (17.2)	116 (22.0)	25 (43.1)	255 (48.4)
Hunan	34	386	6 (17.6)	131 (33.9)	1 (2.9)	41 (10.6)	27 (79.4)	214 (55.4)
Jiangsu	71	632	49 (69.0)	530 (83.9)	7 (9.9)	42 (6.6)	15 (21.1)	60 (9.5)
Jiangxi	39	337	19 (48.7)	139 (41.2)	9 (23.1)	96 (28.5)	11 (28.2)	102 (30.3)
Sichuan	62	812	27 (43.5)	218 (26.8)	20 (32.3)	309 (38.1)	15 (24.2)	285 (35.1)
Yunnan	18	84	12 (66.7)	43 (51.2)	3 (16.7)	15 (17.9)	3 (16.7)	26 (31.0)
Total	433	4078	260 (60.0)	2276 (55.8)	63 (14.5)	736 (18.0)	110 (25.4)	1066 (26.1)

Table 3
Population living in *S. japonicum*-endemic areas at county, township and administrative village level and number of cases (acute, chronic and advanced) as of 2003

Province	Population living in endemic area (in 1000)			No. of cases			
	County	Township	Village	Acute	Chronic	Advanced	Total
Transmission interrupted							
Fujian	10774.3	3193.1	832.8	0	0	0	0
Guangdong	7735.5	1847.0	732.9	0	0	0	0
Guangxi	12155.2	2781.4	804.6	0	0	0	0
Shanghai	6391.4	4055.7	3056.1	2[a]	0	0	2
Zhejiang	29753.9	17167.7	9570.0	2[a]	0	1187	1189
Transmission ongoing							
Anhui	21036.4	11775.1	6015.6	256	54751	5640	60647
Hubei	36525.2	21446.7	9527.5	247	290879	4257	295383
Hunan	17415.1	9024.8	6125.9	234	199819	5408	205461
Jiangsu	38977.1	23869.0	12421.6	116	22541	2781	25438
Jiangxi	17064.9	8304.1	4426.7	126	127468	3659	131253
Sichuan	31329.5	16554.1	10232.9	58	75321	1509	76888
Yunnan	4911.4	2396.1	1628.6	73	46677	0	46750
Total	234069.9	122414.8	65375.2	1114	817456	24441	843011

[a] Imported cases from transmission areas of *S. japonicum* into other provinces.

24,441 advanced cases. In comparison with the data at the early stage of China's national schistosomiasis control programme, the number of infected people and those with advanced schistosomiasis decreased by 92.7% and 95.9%, respectively (Table 3). The number of patients with acute schistosomiasis was reduced from over 10,000 cases annually in the early stages of the control programme to 1114 cases in 2003.

Among a total of 1,806,900 heads of cattle in schistosome-endemic provinces, 594,500 were examined and 24,500 were found infected in 2003. The positive rate of stool examination was 4.1%; a decrease of 82.8% as compared with that of 24% at the early stage of China's national schistosomiasis control programme.

3.3. *Decrease of snail-infested areas*

In 2003, intermediate host snails were found on a total surface area of 3786.8 km^2. This translates to a decrease of 73.6% compared to the surface area of 14,321 km^2 at the early stage of the national control programme. At present, the large majority of snail-infested areas are located in the lake regions, i.e. 3615.1 km^2 (95.5%), whereas only 4.3 km^2 (0.1%) were found in the plain regions with water-way networks, and the remaining 167.4 km^2 (4.4%) were in the mountainous regions of Sichuan and Yunnan provinces.

4. Recent trends of schistosomiasis

The epidemiology of schistosomiasis japonica is governed by biological, ecological and socio-economic factors. Changes in these factors and the termination of the WBLP on schistosomiasis control in 2001 resulted in important alterations of disease endemicity. Complicated transmission factors, many infection sources, frequent floods and the impact on people's practice and beliefs due to the transition of China's economy are intimately connected with the epidemiology and control of schistosomiasis. The latest available data suggest that schistosomiasis has re-emerged in the recent past.

4.1. *Number of people infected*

The estimated annual number of chronic cases is around 800,000. In some areas, the infection rate of humans (and livestock) has reached levels of up to 60%, and advanced cases were common in areas with a high prevalence of infection. In 2003, a total of 1114 patients with acute schistosomiasis were recorded; a

Table 4
Snail-infested areas as of 2003, stratified by province

Province	No. of endemic villages	No. of villages with *O. hupensis* (%)	Current snail-infested area (all figures in ha)				
			Lake region		Plain region	Mountainous region	Total
			Inside embankment	Outside embankment			
Transmission interrupted							
Fujian	320	20 (6.3)	0	0	0	6.95	6.95
Guangdong	176	0	0	0	0	0	0
Guangxi	260	0	0	0	0	0	0
Shanghai	1521	23 (1.5)	0	0	4.43	0	4.43
Zhejiang	7106	285 (4.0)	0	0	7.54	67.36	74.90
Transmission ongoing							
Anhui	3333	899 (27.0)	0	26166.70	0	2455.05	28621.75
Hubei	5652	2614 (46.2)	23171.73	55451.61	0	1968.30	80591.64
Hunan	3987	725 (18.2)	2378.26	170837.23	0	2036.90	175252.39
Jiangsu	5478	420 (7.7)	0	7062.53	419.22	80.99	7562.74
Jiangxi	2318	405 (17.5)	675.90	75769.86	0	1088.39	77534.15
Sichuan	6222	2915 (46.8)	0	0	0	7018.62	7018.62
Yunnan	462	202 (43.7)	0	0	0	2015.54	2015.54
Total	36835	8508 (23.1)	26225.89	335287.93	431.19	16738.10	378683.11

22% increase over the estimate in the previous year. School-age children accounted for 51% of all the acute cases.

4.2. Snail-infested areas

Over the past 5 years, intermediate host snail habitats have increased. Table 4 summarises the snail-infested areas as of 2003, stratified by province and main eco-epidemiological settings (i.e. lake, plain and mountainous region). Compared to 2002 there were 268 km^2 of new potential snail habitats that were mainly located in the lake region. An estimated 11.51 km^2 were identified as new areas infested with *O. hupensis*. Annual surveillance carried out since 2000 in a total of 20 sentinel sites revealed that in 17 of these sites, intermediate host snails were spreading into new areas, and hence the risk of *S. japonicum* transmission has increased (Zhao et al., 2005).

4.3. Re-emerging regions

The latest available data suggest that schistosomiasis transmission has re-emerged in 38 counties belonging to 7 provinces, as both snail habitats and local transmission had been observed. It had previously been declared that in these counties, the criteria of transmission interruption or control had been reached. For instance, since the late 1990s, *O. hupensis* were found in six previously non-endemic counties (three in Zhuzhou city, two in Changsha city and one in Taoyuan county), and infected snails were found in 16 counties in the marshlands of the Xiang River, in parallel with the occurrence of acute cases of schistosomiasis. Both snail-infested areas and newly infected cases also occurred in urban areas, i.e. the cities of Anqing, Changde, Changsha, Nanjing, Tongling, Yangzhou, Zhenjiang and Zhuzhou along the Yangtze River (Zhou et al., 2004a).

5. Remaining challenges of schistosomiasis control

Despite the large body of experience and expertise gained through 50 years of implementation of the national schistosomiasis control programme, there are still huge challenges ahead to ultimately eliminate the disease as a public health problem in China (Chen, 2002). The experience gained thus far can be summarised as follows. First, insisting on the system of 'government planning, inter-sectoral collaboration and broad-based community participation' was a key factor for setting up and implementing the control programme in an integrated manner. Second, progress in schistosomiasis control goes hand-in-hand with socio-economic development. Third, results obtained from pilot studies with different packages of control measures proved useful to design and implement control activities at a larger scale that are readily adapted to specific eco-epidemiological settings. Fourth, collaboration of the health sector with various other governmental sectors (notably with the agriculture, education, water conservancy and forestry sectors) is a key feature for successful and sustainable schistosomiasis control. Finally, tightly linking control efforts with operational research can enhance programmatic outcomes.

5.1. Scientific and technical challenges

Nowadays, further progress in the control of schistosomiasis in hyper-endemic regions and elimination of the disease in low-endemic regions will depend on research and development of improved tools and control strategies in relevant areas. For instance, decreased compliance rates for case detection due to residents' unwillingness to cooperate with personnel from anti-schistosomiasis control stations for faecal sample collection, low sensitivity of the Kato-Katz technique in areas where the overall endemicity has become low (Wu, 2002), and high costs and environmental toxicity of the only available molluscicide (i.e. niclosamide) are some of the factors that might compromise further progress in schistosomiasis control. Hence, there is a need to overcome these shortcomings, with research and technical innovations playing important roles.

In addition, the available serological diagnostic techniques and rapid diagnostic reagents need to be standardised. Furthermore, repeated large-scale administration of praziquantel for morbidity control poses the risk of resistance development. Rapid changes in the social and economic environment due to market reforms (Bian et al., 2004) and major ecological transformations can pose additional challenges for control efforts, especially when the control strategy is largely dependent on a single measure, i.e. chemotherapy. In turn, effective and sustainable control of schistosomiasis becomes elusive.

5.2. Challenges for control programme managers

With the ongoing and rapidly occurring market reform in China (Banister and Zhang, 2005), it is difficult to maintain the old infrastructure of organizations, so that the present needs for schistosomiasis control can be met. Especially the re-emerging nature of the disease calls for a more efficient management structure in concert with other sectors. There are, for example, pressing needs to further adjust control strategies, to effectively handle surveillance data, so that epidemic trends can be forecasted, and to design and implement sound control measures that are adapted to specific eco-epidemiological settings (Chen, 2002).

5.3. Challenges due to ecological factors

It has been noted that re-emergence of schistosomiasis in the Yangtze River basin in recent years is closely associated with flooding events that occurred in schistosome-endemic areas along the Yangtze River. The floods in 1998, for example, were accompanied by snail diffusion, which in turn enlarged the *S. japonicum*-endemic areas (Zhou et al., 2002).

Concurrently, global warming has two potential impacts on the frequency and transmission dynamics of schistosomiasis. First, it is likely that the current distribution of *O. hupensis* will shift northwards into currently non-endemic areas. The underlying reason is that the current distribution limit of the intermediate host snail, which is determined by the temperature of the coldest month of the year (i.e. January), is likely to expand further north (Hong et al., 2003). Hence, disease transmission is also likely to shift northwards (Yang et al., 2005a). Second, humans are at an elevated risk of becoming infected with *S. japonicum*, because more schistosomes might develop from a single snail due to elevated temperatures (Zhou et al., 2004b).

5.4. Challenges due to social factors

It is conceivable that over the course of the ongoing market reform in China, various social factors conflict with the traditional counter measures against schistosomiasis. For example, mobilization of people involved in schistosomiasis control activities need to be supported by the new systems. Furthermore, regulations should foster inter-sectoral collaboration, as integrated control methods need support by different governmental sectors.

Going hand-in-hand with the economic development are major water conservancy projects, often implemented in schistosome-endenmic areas. There is particular concern with regard to the construction and operation of the Three Gorges dam and the South-to-North water transfer project (Xu et al., 2000; Yang et al., 2005b). Both projects are likely to have negative health effects, i.e. spread of schistosomiasis into previously non-endemic areas; and hence there is a need to develop and implement sound mitigation strategies.

In addition, some of the anti-flood policies, such as 'returning reclaimed land into lake, levelling dykes between main levees and building new towns for resettlement', will cause many snail-free areas to become snail habitats again, which not only increase the transmission risk but also change the transmission patterns. It is estimated that the 6670 km^2 restored lakes from previous farmland is at considerable risk of intermediate host snail infestation.

6. Conclusion

In conclusion, data assembled over the past 5 years suggest that schistosomiasis is re-emerging in part of the mountainous areas (i.e. provinces of Sichuan and Yunnan) and some foci in the Yangtze River basin in central China. Several factors have been suggested as underlying causes, such as the unusually severe floods that occurred in 1998 (Zhou et al., 2002), major ecological transformations due to water resources developments (Xu et al., 2000), the potential impact of climate change (Zhou et al., 2004b; Yang et al., 2005a), market and health sector reforms (Bian et al., 2004), and the termination of the WBLP on schistosomiasis control with insufficient attention given to further consolidate achievements made until 2001.

When taking the aforementioned biological, ecological and socio-economic factors into account, together with the transmission dynamics of the disease that is governed by the seasonal character of the beaches in the low and middle reaches of the Yangtze River and important water level fluctuations in the great lakes connecting the Yangtze River (Guo et al., 2001; Chen, 2002), the extent of flooded areas and the frequency of floods is likely to further increase. This, in turn, will render control or even interruption of schistosomiasis transmission more challenging. Therefore, besides chemotherapy, there is a pressing need to improve capacities for surveillance, so that subtle changes in transmission dynamics can be captured promptly. At the same time, more pointed emphasis should be placed on environmental improvement to interrupt transmission of schistosomiasis. Finally, there is a need to reorganize the infrastructure in the national control programme to improve the management models, and strengthen operational research to cope with the requirements of the control programme and provide more advanced techniques in control activities.

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