Original article

Schistosomiasis in China: acute infections during 2005–2008

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Keywords: *schistosomiasis; acute infection; control program; China*

Background Significant progress has taken place over the past 50 years in the control of schistosomiasis japonica in China. However, the available data suggested that schistosomiasis has re-emerged shortly after the World Bank Loan Project which was conducted from 1992 to 2001. The national control program with a revised strategy to control schistosomiasis by using integrated measures has been implemented since 2005. In this study, we aimed to evaluate the effect of the national program on schistosomiasis control from 2005 to 2008.

Methods A retrospective study was carried out to analyze the epidemic patterns of acute infections with *Schistosoma japonicum* (*S. japonicum*), based on the number of acute cases annually collected from the web-based national communicable diseases reporting system from 2005 to 2008.

Results A total of 564, 207, 83 and 57 acute cases infected with *S. japonicum* were reported nationwide in 2005, 2006, 2007 and 2008, respectively, with an average annual reduction rate of 46.35% during last four years. Six outbreaks of acute infection with *S. japonicum* were reported in 2005 but none in the period of 2006 to 2008. All acute cases that were reported mainly came from the lake regions and became infected during the higher risk periods from the 27th to 43rd weeks of the year. Most of these cases are students (44.87%), farmers (31.51%) and fishermen (7.79%) who got the infection by water contact mainly through swimming (41.49%) and production activities (40.25%). With time, the proportion of imported cases among all acute cases increased due to more frequent movement of people that has occurred with a more mobile population.

Conclusions The national control program on schistosomiasis aliened with the revised control strategy has been effectively brought into effect. However, there is still a significant risk of infection among students, farmers and fishermen living in the lake regions. Therefore, it is important to strengthen control measures among risk populations in the high risk areas of transmission, or the lake regions.

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Schistosomiasis is one of the neglected tropical diseases, and remains a major public health problem affecting over 200 million people in many parts of the developing world.[1] Schistosomiasis japonica, caused by infection with *Schistosoma japonicum* (*S. japonicum*), was considered to be one of the most serious parasitic diseases endemic in China.[2] As the result of a large-scale, nationwide control program initiated in the mid 1950s, and continued to a 10-year World Bank Loan Project (WBLP) from 1992 to 2001, the number of infected individuals reached a historic low of 694 788 in 2001. Down from 11.6 million previously reported in the 1950s at the initiation of the program. By the year 1995, disease transmission had been interrupted successively in five provinces, namely Guangdong and Shanghai in 1985, Fujian in 1987, Guangxi in 1989 and Zhejiang in 1995. The remaining endemic areas of schistosomiasis are mainly located in the lake regions of Anhui, Hubei, Hunan, Jiangsu and Jiangxi provinces and the mountain regions of Sichuan and Yunnan provinces (Figure 1), harboring vast habitat areas of *Oncomelania hupensis*, the snail intermediate host of *S. japonicum*, despite the intensive control measures that have been undertaken in these regions.[3]

Due to several factors, e.g., diversity and complexity of ecological environment in the endemic areas, increased snail dispersal after major serious floods in 1998, reduced control efforts in the endemic areas with comparatively weaker economic development, schistosomiasis has re-emerged in 38 counties of 7 provinces after termination of the WBLP in 2001.[3,4] The number of infected individuals reported annually reached 843 011 and 842 525 by the end of 2003 and 2004, and among them 1114 and 864 cases of acute infections were recorded, respectively.[5]

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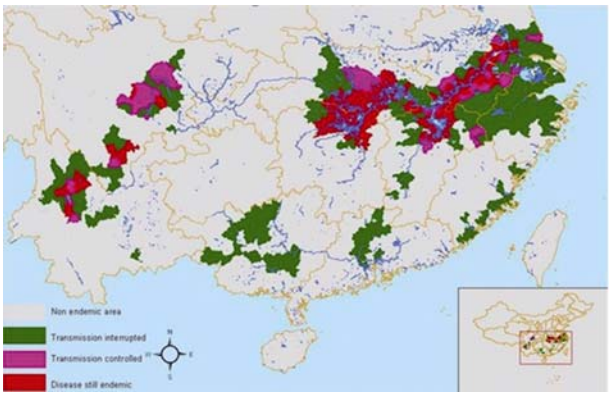

Figure 1. Map of the epidemic status of schistosomiasis japonica in China, 2006.

Due to the schistosomiasis resurgence in 2004, China redefined schistosomiasis control as one of the highest priority in communicable disease control, together with HIV/AIDS and tuberculosis.[6] To this end, a national program for schistosomiasis control by adopting a revised control strategy, in order to strengthen implementation of integrated measures aiming to reduce the transmission of *S. japonicum* from cattle and humans to snails, has been initiated in 2004.[7] The new goal of the intensified national program was put forward for the 5–10 year plan. It aimed to control the transmission (prevalence rate both in humans and reservoir hosts less than 1%) by 2008 and interrupt the transmission by 2015 in both mountainous and plain regions, and to control the infection (prevalence rate less than 5% without any outbreak of acute infection[8]) by 2008 and control the transmission by 2015 in the lake regions.[5,9]

To reach the goal of the national control program in 10 years, the monitoring of human acute infection with *S. japonicum* is an important process to assess the progress of the current schistosomiasis control program.[10] The purpose of this retrospective study is to assess the epidemic status of human acute infection with *S. japonicum* by analyzing the data of acute cases reported from 2005 to 2008, in order to provide the solid evidence to determine if the expected goal of the control program can be achieved.

METHODS

Data collection

Data on outbreak events and the number of the acute cases infected with *S. japonicum* were collected from the available epidemic-data-reporting systems, e.g., weekly-based reports submitted by the different endemic provinces in 2005 and daily web-based communicable disease reports system through internet from 2006 to 2008.[11] The case-specific databases were established and collated from annual reports.

To ensure the data quality, the National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention in Shanghai[12] was entrusted by the Ministry of Health to design and manage the database and reporting system as well as provide necessary supervision and monitoring for each outbreak event or acute case. For each acute case, the personal information of each individual together with that of transmission patterns, e.g. infection locality, the type of water contact, and the type of endemic areas classified and defined based on the methods used in nationwide schistosomiasis sampling survey in 2004,[2] were recorded.

Definition of acute case and outbreak

An acute case infected with *S. japonicum* was determined either by clinical diagnosis or pathogenical confirmation based on the *Diagnostic Criteria for Schistosomiasis*.[13] An acute case is considered as: (1) clinical case when positive in antibody test, e.g. the indirect haemagglutination test, or (2) pathogenically confirmed case when *S. japonicum* eggs are detected in fecal examination, who was exposed to a body of water infested with schistosome cercaria two or more weeks previously, accompanied with specific clinical symptoms, such as fever, hepatomegaly, diarrhea, eosinophilia in peripheral blood, etc.

An outbreak of acute infection with *S. japonicum* was determined in accordance with the criteria of *Response and Management Scheme for Schistosomiasis Outbreaks*,[14] and confirmed by experts from the National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention,[12] if necessary. An epidemic scenario meeting one of following criteria is considered an outbreak of acute infection in the local setting: (1) in endemic areas where the transmission is on-going, 10 or more acute cases infected with *S. japonicum* are reported in an administrative village during two weeks, including those diagnosed clinically and pathogenically, or 5 or more acute cases are reported and continuously occurred in one place during one week; (2) in the areas where transmission has been controlled, 5 or more acute cases are reported in an administrative village during two weeks, or 3 or more acute cases are reported and continuously occurred in one place during one week; (3) in the areas where the transmission has been interrupted, either locally infected acute cases, or both domestic animals and *Oncomelania* snails infected with *S. japonicum*, are detected; (4) in non-endemic areas, either *Oncomelania* snails or local acute cases, or domestic animals infected with *S. japonicum* are detected.

An imported case of schistosomiasis is recorded when an acute case is confirmed as being infected outside the reported region, e.g. county or province.

Statistical analysis

A database was established by double input of the data, and all data in the established database were analyzed by using SAS version 9.1.3. In the data analysis, the chi-square test was used to explore associations between

the infection status and age, occupation and sex, and the temporal clustering was performed using a scan statistic method with moving window by SatScan V7.0.[15] *P* value less than 0.05 was considered statistically significant.

RESULTS

Classification of acute cases

A total of 911 cases were reported as acute schistosomiasis from 2005 to 2008, and among them 738 (81.01%) cases were confirmed pathogenically by stool examination, 173 (18.99%) were clinically diagnosed, and 60 (6.59%) were recorded as imported cases. A significant reduction in the number of acute cases presented in the study from 2005 to 2008 was an average annual reduction rate of 46.35%. Only 5 outbreak events were reported in Hubei Province and one in Sichuan Province in 2005, but none was recorded from 2006 to 2008 (Table 1).

Table 1. Composition of acute cases infected with *S. japonicum* from 2005 to 2008

Years	Reported cases (*n*)	Diagnosed cases (%)	Clinically cases (%)	Imported cases (%)	Reduction rate (%)
2005	564	460 (81.56)	104 (18.44)	35 (6.21)	30.88
2006	207	161 (77.78)	46 (22.22)	10 (4.83)	63.30
2007	83	71 (85.54)	12 (14.46)	9 (10.84)	59.90
2008	57	46 (80.70)	11 (19.30)	6 (10.53)	31.33
Total	911	738 (81.01)	173 (18.99)	60 (6.59)	46.35

Distribution of acute cases

Spatial distribution

Among the reported cases, 515 (91.31%), 203 (98.07%), 81 (97.59%) and 56 (98.25%) were located in the lake regions and only 49 (8.7%), 4 (1.9%), 2 (2.4%) and 0 in the mountainous regions during 2005 to 2008, respectively (Table 2). A significantly lower proportion of acute cases from the lake region was present in 2005 than in 2006, 2007 and 2008 (χ^2=18.6383, *P*=0.0003). While the pattern in spatial distribution of acute cases did not change significantly from 2006 to 2008 (χ^2=1.2583, *P*=0.5331).

Table 2. Composition of acute cases infected with *S. japonicum* in different regions from 2005 to 2008 (*n* (%))

Regions	2005	2006	2007	2008
Lake region	515 (91.3)	203 (98.1)	81 (97.6)	56 (100)
Mountainous region	49 (8.7)	4 (1.9)	2 (2.4)	0
Total	564	207	83	56*

χ^2=18.6383, *P*=0.0003. *An imported case from Ethiopia was not included.

However, in the lake region, the number of acute cases was ranked as the highest (27.58%) in Hubei province, followed by Jiangxi (24.40%), Anhui (23.96%), Hunan (16.15%) and Jiangsu (1.87%) provinces, respectively. It was noticed that even in the lake regions of Jiangsu Province, very few cases were recorded in 2005, 2006 and 2008, and none was reported in 2007 (Table 3).

During the study years, 6 outbreaks were reported in 2005 with a total of 55 cases. Among them, 2 outbreaks were reported in areas that previously recorded having reached the criteria for transmission interruption, namely Xide county in Sichuan Province, and Qichun county in Hubei Province. Other outbreaks occurred in the lake region of Hubei Province (Table 4).

Temporal distribution

Figure 2 shows the temporal distribution curves of acute cases reported weekly from 2005 to 2008. In 2005 and 2006, the number of the reported cases started to increase during the 16th or 17th week and peaked from the 30th to 39th week of a year, after which the number of cases then significantly dropped. No significant reporting fastigium in the number of cases appeared in 2007 and 2008, with only a little peak during the 33rd and 43rd week.

Temporal clustering analysis for acute infection from 2005 to 2008 presented a similar time frame, with significant clusters during the 27th–43rd weeks every year (*P* <0.001, Table 5). Although the total cases and likelihood ratio of acute infection decreased significantly from 2005 to 2008, the time windows of case concentration or high risk for acute infection did not obviously change.

Population distribution

Acute cases were found across different age groups, the youngest acute case was a 2-year-old child, while the oldest was 80 years of age. The proportions of acute cases in different age groups did not significantly change from 2005 to 2008 (χ^2=15.6779, *P*=0.4038). Most cases were school-age children in the 7–18-year age group (44.87%) (Figure 3A). Although the proportion of student cases in 2008 increased compared with 2007, and the proportion of farmers and fishermen dropped, neither of them presented a significant change (χ^2=5.0263, *P*=0.5404). During the 4-year investigation, the occupation of acute cases was always higher in students (ranging from 39.02% to 50.88%) and farmers (ranging from 26.32% to 35.37%) each year (Figure 3B). The proportion of imported cases varied from 6.21% to 10.84% without significant changes (χ^2=5.0526, *P*=0.1680), although it has increased slightly from 2006 to 2008 (Figure 3C). The proportion of males/females remained high (equal to or greater than 4/1) without significant changes from 2005 to 2008 (χ^2=7.1343, *P*=0.0677) (Figure 3D).

DISCUSSION

It had been previously noticed that schistosomiasis re-emerged in China shortly after the WBLP that ceased in 2001.[16] This was due to multiple factors, including historically severe floods in 1998,[17] major ecological transformation caused by water resource development projects,[18] climatic changes,[19] and the other.[20] By the end of 2003, an estimated 843 011 people were infected with *S. japonicum* in the country.[5] However, a longitudinal observation of the epidemiology of schistosomiasis from 1999 to 2008 showed that two stages could be classified, in consideration of the number of acute cases infected

Table 3. Number of acute cases infected with *S. japonicum* and outbreaks of acute infections in endemic provinces from 2005 to 2008 (*n*)

Provinces	2005			2006			2007			2008		
	Local cases	Imported cases	Outbreaks	Local cases	Imported cases	Outbreaks	Local cases	Imported cases	Outbreaks	Local cases	Imported cases	Outbreaks
Hunan	81	4	0	36	0	0	15	1	0	15	0	0
Hubei	165	6	5	52	3	0	26	0	0	8	1	0
Jiangxi	137	1	0	57	0	0	19	1	0	9	0	0
Anhui	121	2	0	55	0	0	21	0	0	21	0	0
Jiangsu	11	9	0	3	4	0	0	1	0	3	1	0
Sichuan	34	0	1	2	0	0	1	0	0	0	1	0
Yunnan	15	0	0	2	0	0	1	0	0	0	0	0
Shanghai	0	0	0	0	1	0	0	1	0	0	0	0
Zhejiang	0	3	0	0	1	0	0	1	0	0	2	0
Fujian	0	1	0	0	1	0	0	3	0	0	0	0
Guangdong	0	2	0	0	0	0	0	1	0	0	0	0
Guangxi	0	1	0	0	0	0	0	0	0	0	0	0
Guizhou	0	5	0	0	0	0	0	0	0	0	0	0
Henan	0	1	0	0	0	0	0	0	0	0	0	0
Beijing	0	0	0	0	0	0	0	0	0	0	1*	0
Total	564	35	6	207	10	0	83	9	0	56	6	0

*An imported case from Ethiopia.

Table 4. Geographic distribution of outbreaks of acute infection with *S. japonicum* in 2005

Infected areas	Types of infected areas	Types of endemic areas	Modes of infection	Confirmed acute cases (*n*)
Jiangling, Hubei	Ditch	Transmission on-going	Halieutics and swimming	5
Xide, Sichuan	Inland lake beach	Transmission interrupted	Swimming and farming	13
Yangxin, Hubei	Watercourse to river	Transmission on-going	Swimming	5
Qichun, Hubei	Beach of Yangtze river	Transmission interrupted	Swimming	1
Xiantao, Hubei	Ditch	Transmission on-going	Farming	26
Gongan, Hubei	Ditch	Transmission on-going	Mowing in trench	5

Table 5. Temporal clustering of acute cases infected with *S. japonicum* analyzed by scan statistic method with moving window

Years	Clustered date (week)	Observed cases (*n*)	Expected cases (*n*)	Relative risk	Log-likelihood ratio	*P* values
2005	June 12 to November 26 (24th–47th)	544	256	53.159	371.67	0.001
2006	June 19 to October 22 (25th–43rd)	184	72	15.175	133.24	0.001
2007	June 19 to October 29 (25th–44th)	73	30	14.149	49.40	0.001
2008	July 3 to November 19 (27th–47th)	53	23	19.779	35.99	0.001

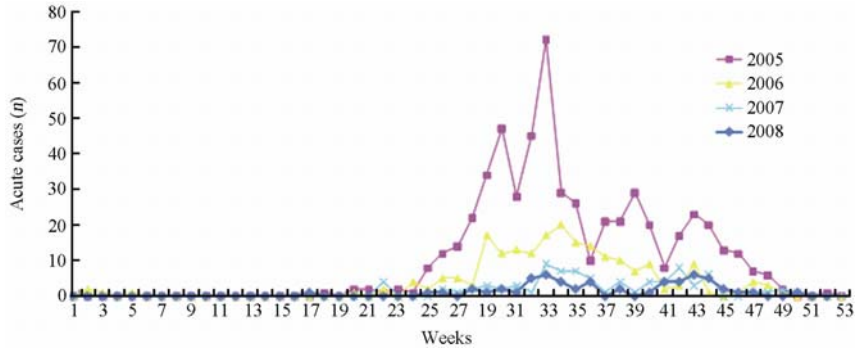

Figure 2. Weekly temporal distribution of acute cases infected with *S. japonicum* in different years from 2005 to 2008.

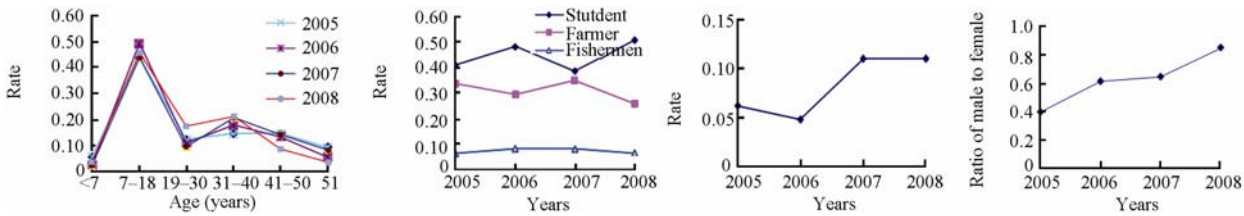

Figure 3. Population distribution of acute cases infected with *S. japonicum* from 2005 to 2008. **A:** Age distribution. **B:** Occupational distribution. **C:** Annual distribution of imported cases. **D:** Annual ratio of male to female.

with *S. japonicum.* The first one was the inclining stage from 1999 to 2003 with a peak that occurred in 2003 when 1114 acute cases were recorded, and the second one was the declining stage from 2004 to 2008 when the yearly number of cases significantly dropped (Figure 4).[9,21] In 2008, the reported number of acute cases reached a historic low with only 56 acute cases in the country. This number excluded the imported cases that

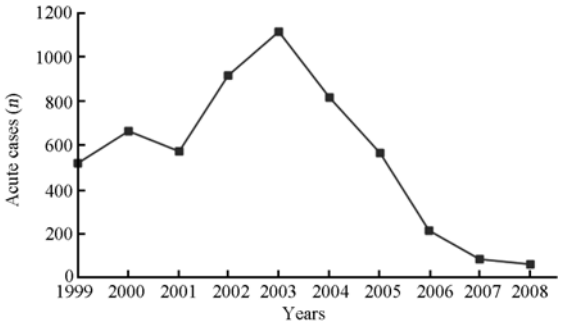

Figure 4. Number trend of acute cases infected with *S. japonicum* in China from 1999 to 2008.

were recorded, and compared to the numbers reported in 2005, 2006 and 2007, represented a mean annual decrease rate of 46.35% per year. No any outbreak event was recorded in 2006, 2007 and 2008. It indicates that the re-emergence trends of schistosomiasis during 2000–2003 has ceased after intensive control efforts with implementation of the revised strategy since 2005.[7,22]

As the epidemic status of schistosomiasis, and particularly the annual number of acute cases, are the key indices for evaluation of the endeavor to control schistosomiasis,[23] our analysis focuses on these important indices only. During the past 4 years, the strengthened national program for schistosomiasis control in China was brought into effect by implementation of the revised control strategy with integrated measures.[7,24] These include such strategies as the replacement of cows with machines in the lake regions, treatment of night-soil and the safety water supply,[25] breeding of domestic animals in barns, change of snail habitats aliened with the construction of water conservancy project,[26] flourishing forests aimed at reducing snail populations in addition to chemotherapy and health education.[24] All these integrated measures, with an emphasis on control of infectious targets both in humans and reservoir hosts to reduce the possibility of snail infection, have undoubtedly improved conditions in the higher risk endemic areas, which utilized financing of more 200 millions every year than before. As a result, not only has the number of acute schistosomiasis cases dropped significantly from 2005 to 2008, but a more dispersive trend of acute infections in transmission season is also presented in the temporal clustering analysis by SatScan.[27] Consequently, all the evidence from the study suggests that the revised strategy with integrated control measures that were brought into effect in the national control program during last four years has been successsful.

Although the total number of acute cases decreased significantly, transmission of schistosomiasis is still at an unstable stage in the higher risk endemic regions which are reflected in the following four aspects in our study. First, the total number of acute cases infected with *S. japonicum* was higher in Hubei, Jiangxi and Anhui provinces in the last four years, and a higher prevalence rate of *S. japonicum* was still found in Hunan Province (4.2%),[2] therefore, the risk of schistosomiasis re-emerging in the above 4 provinces is higher than in other provinces. Second, outbreaks of acute infection in 2005 and the appearance of acute cases which mainly occurred in Hubei and Sichuan provinces implies that control efforts and surveillance have been weakened in these endemic areas which had previously reached transmission interruption.[28,29] Third, insights into the characteristics of acute cases showed that most of the cases are students, farmers and fishermen who got the infection mainly by swimming and production activities that were reported during the 27th-43rd week, which is consistent with other investigations.[10,28] Fourth, the proportion of imported acute cases was increased in 2006 which was reported not only in endemic provinces but also in non-endemic provinces. Therefore, the underlying risk of re-emergence of acute schistosomiasis poses a threat in the endemic counties, particularly in the lake regions.

It seems to be obvious that the comprehensively revised national strategy for schistosomiasis control in China has been effective based on the evidence and analysis results of acute infection in the country. Our study also shows that there is still a risk of infection among students, farmers and fishermen living in the lake regions. Therefore, there is a need to take measures to protect the high risk population from infection during transmission season, together with a need for improving the surveillance tools[30] to monitor acute infection which will provide important epidemiological information or insights to improve the progress on control of schistosomiasis in China.

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