

Schistosomiasis Surveillance — China, 2015–2018

Yinlong Li¹; Hui Dang¹; Lijuan Zhang¹; Guangping Li²; Xiaowei Shan³; Min Yuan⁴; Songjun Ding⁵; Yun Feng⁶; Meifen Shen⁷; Jia Xu⁸; Yanjun Jin⁹; Haijuan Du¹⁰; Wencheng Lu¹¹; Wenqian Tang¹²; Dianwei Jiang¹³; Yi Yuan¹⁴; Shan Lyu^{1*}; Shizhu Li^{1*}; Xiao-nong Zhou¹

Abstract

Background The prevalence of schistosomiasis in China is at the lowest level in history, and sentinel surveillance sites of schistosomiasis have fully covered all epidemic areas of China. This article has analyzed the surveillance data for the last four years and can help guide the next stage of surveillance work at the national level, including the scope of surveillance, surveillance content, and surveillance methods, etc.

Methods Data from the National Schistosomiasis Surveillance System were collected. The infection rate of schistosomiasis among the human population, livestock, snails, and the change of the breeding area of snails in sentinel surveillance sites for four consecutive years were analyzed, and the trends in schistosomiasis prevalence in surveillance sites were determined.

Results The prevalence of schistosomiasis in all sentinel surveillance sites of China showed downward trends from 2015 to 2018 with infection rates decreasing in this time period for local human population (0.05% to 0.00%), the floating population (0.020% to 0.003%), and cattle (0.037% to 0.000%). No infected snails were found during the period. From 2015 to 2018, the total area of newly found habitats of snails (*Oncomelania hupensis*, *O. hupensis*) were 34,730 m², 1,367,694 m², 18,944 m², and 50,420 m², and the total area of re-emergent habitats of snails (*O. hupensis*) were 822,194 m², 1,391,779 m², 1,516,292 m², and 1,750,558 m², respectively.

Conclusions and Implications for Public Health Practice The prevalence of schistosomiasis in human and livestock is going down and is sustained at a very low level, but new and re-emerging habitats of *O. hupensis* are new challenges regardless of the achievement of schistosomiasis control. Therefore, two actions are necessary to effectively further reduce the transmission risk of schistosomiasis: 1) taking effective measures to control the source of infection of schistosomiasis; and 2) reducing the breeding areas of *O. hupensis*.

Introduction

Schistosomiasis is one of the most serious parasitic diseases in China, which has a history of more than 2,100 years. In the mid-1950s, when China's population was about 600 million, an estimated 11.6 million people were infected with *Schistosoma japonicum* (*S. japonicum*). Control strategies were developed and adapted over time to align with epidemiological insights, technological advances, and the political environment, and this progress can be divided into three stages. The first was a mass campaign focused on snail control, which was based on understanding the epidemiology, the second was a morbidity control stage boosted by international cooperation, and the third stage was implementing strategies to block schistosomiasis transmission (1–2).

In 2000, the number of infected people was estimated to have been reduced to 694,778, *Oncomelania hupensis* (*O. hupensis*) breeding areas have been reduced by more than 75.0%, and 5 of the 12 previously prevalent provinces have eliminated the disease (1). Between the mid-1980s and 2003, the criteria of transmission interruption have been reached in 260 counties (60.0%) and transmission control has been achieved in 63 counties (14.5%), but the disease was still epidemic in the remaining 110 counties (25.4%) (1). Since 2005, China has implemented a comprehensive strategy of schistosomiasis control focusing on source control, which preliminary studies have indicated as effective in reducing the prevalence of schistosomiasis in both humans and bovines (3). Passive chemotherapy and health education still have had a significant impact on schistosomiasis control during the maintenance and consolidation phase (4).

By the end of 2014, the Chinese government has successfully interrupted the transmission of schistosomiasis in 313 of 457 epidemic counties and controlled the transmission of schistosomiasis in 135 counties; only 5 counties remain uncontrolled (2). According to *China's Medium-and Long-term Plan for*

Schistosomiasis Prevention and Control (2004–2015), China will accomplish the goal of schistosomiasis transmission control in 2015 with an infection rate of human and animal schistosomiasis of less than 1%, and schistosomiasis control's classification will be transitioned from epidemic control to transmission control accordingly (5). China CDC set up 457 national surveillance sites for schistosomiasis in 2014 to meet the needs of epidemic prevention, control, and surveillance, and have covered the whole schistosomiasis epidemic area (6).

The national surveillance system of schistosomiasis has become important to the prompt control and even elimination of the incidence and transmission of schistosomiasis in China (7). The epidemic situational analysis of schistosomiasis surveillance sites is essential to understanding the epidemic situational changes in surveillance sites and guiding the optimization and implementation of the surveillance program's next stage. These developments can make the monitoring system more comprehensive by providing an important basis for scientific surveillance of schistosomiasis and enhance a data-driven approach for the elimination of schistosomiasis of China in the future.

Methods

Schistosomiasis surveillance sites cover all epidemic counties including 142 transmission control counties, 311 transmission blocking counties (150 counties with snails, 161 counties without snails), and 4 Three Gorges Reservoir area counties (only with snail surveillance, including 2 non epidemic counties). The main work of the surveillance sites is to monitor the local and floating human populations, the livestock, and the snails by testing human blood, human feces, livestock feces, and *Oncomelania* infections in the epidemic area. The indirect hemagglutination assay (IHA) method is used to detect anti-*Schistosoma* antibody of blood samples from the local population and floating population. The nylon silk bag incubation method (one sample of fecal matter for three tests) and the Kato-Katz method (one sample of fecal matter for three tests) are used to detect the pathogens of feces of serum positive populations. For the surveillance of domestic animals, the plastic cup top tube incubation method (one sample of fecal matter for three tests) was used to detect infections of *Schistosoma* in domestic animals with. For the surveillance of *O. hupensis*, systematic sampling combined with environmental sampling were used to investigate the existing and

suspected environments of *O. hupensis*, and the *O. hupensis* samples used will be registered as living or dead. Infections of living samples were detected by anatomical microscopy, and if infections were found, the nucleic acids of *Schistosoma* in the snails would be detected by loop-mediated isothermal amplification (LAMP).

Data from schistosomiasis surveillance sites from 2015 to 2018 were obtained from the National Schistosomiasis Surveillance System, which includes basic information from schistosomiasis surveillance sites and surveillance data of the local and floating populations, livestock, snails, and wild feces and other floating materials in the Three Gorges Reservoir Area. Factors surrounding *S. japonicum* infection were analyzed for the local and floating human population, livestock, and *O. hupensis*, and habitat changes of *O. hupensis* were also monitored. Trends of the epidemic were then observed and used to predict future changes of the schistosomiasis epidemic based on four-year continuous monitoring data.

Results

The overall prevalence of schistosomiasis in 457 surveillance sites across China showed a downward trend from 2015 to 2018. The sero-prevalence in the local population decreased 40.9% by declining from 3.35% in 2015 to 1.98% in 2018, which match sero-prevalence trends in the local populations of lake and marsh regions, water-network regions, and mountainous regions. The sero-positive rate of the floating population decreased by 24.35% from 1.15% in 2015 to 0.87% in 2018 (Figure 1). The prevalence of schistosomiasis in the local population decreased from 0.05% in 2015 to 0.00% in 2018, all of which belong to the lake and marshland epidemic areas. Only 96 parasitologically-diagnosed cases were found from 524,093 individuals in the four years, leading to an overall prevalence of 0.018%. The prevalence of schistosomiasis in the floating population decreased from 0.020% in 2015 to 0.003% in 2018. A total of 34 infected cases were found from 377,088 floating individuals from 2015 to 2018.

The prevalence of schistosomiasis in livestock decreased from 0.037% (5/13,406) in 2015 to 0.000% (0/8,669) in 2018 (Table 1). No snails were found to be infected with *S. japonicum* for four consecutive years. For each year from 2015 to 2018, the total area of newly found habitats of snails was 34,730 m², 1,367,694 m², 18,944 m², and 50,420 m², respectively,

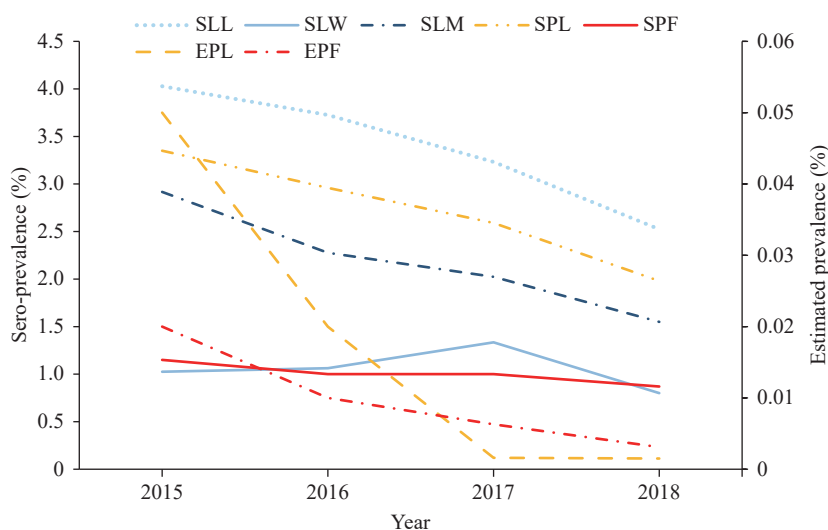


FIGURE 1. Sero-prevalence and estimated prevalence* of the local population and floating population in national schistosomiasis surveillance sites in China from 2015 to 2018.

*Data include results of serological and fecal tests of local and floating populations in all surveillance sites throughout the country from 2015 to 2018 and all tests are standardized according to the requirements of the surveillance scheme.

SLL: sero-prevalence of the local population in lake and marsh regions; SLW: sero-prevalence of the local population in water-network regions; SLM: sero-prevalence of the local population in mountainous regions; SPL: sero-prevalence of the local population; SPF: sero-prevalence of the floating population; EPL: estimated prevalence of the local population; EPF: estimated prevalence of the floating population. The estimated prevalence is equal to the fecal positive rate, which is the infection rate of *Schistosoma* in the population.

TABLE 1. *Schistosoma* infection rate in cattle in national schistosomiasis surveillance sites in China from 2015 to 2018.

PLADs	2015			2016			2017			2018		
	No. of examined cattle	No. of infected cattle	Infection rate (%)	No. of examined cattle	No. of infected cattle	Infection rate (%)	No. of examined cattle	No. of infected cattle	Infection rate (%)	No. of examined cattle	No. of infected cattle	Infection rate (%)
Shanghai	854	0	0.000	0	0	0.000	369	0	0.000	0	0	0.000
Jiangsu	162	0	0.000	448	0	0.000	138	0	0.000	63	0	0.000
Zhejiang	152	0	0.000	242	0	0.000	243	0	0.000	120	0	0.000
Anhui	2,072	0	0.000	1,753	0	0.000	1,620	0	0.000	1,161	0	0.000
Fujian	712	0	0.000	761	0	0.000	552	0	0.000	958	0	0.000
Jiangxi	1,013	0	0.000	1,862	0	0.000	669	0	0.000	584	0	0.000
Hubei	1,857	0	0.000	1,492	0	0.000	1,778	0	0.000	969	0	0.000
Hunan	2,389	5	0.209	2,367	1	0.042	3,051	0	0.000	1,158	0	0.000
Guangdong	187	0	0.000	0	0	0.000	195	0	0.000	0	0	0.000
Guangxi	739	0	0.000	936	0	0.000	1,158	0	0.000	580	0	0.000
Sichuan	1,434	0	0.000	1,635	0	0.000	4,026	0	0.000	1,081	0	0.000
Yunnan	1,835	0	0.000	1,693	0	0.000	1,778	0	0.000	1,988	0	0.000
Chongqing	0	0	0.000	0	0	0.000	22	0	0.000	7	0	0.000
Total	13,406	5	0.037	13,189	1	0.008	15,599	0	0.000	8,669	0	0.000

Abbreviations: PLADs=provincial-level administrative divisions.

and the total area of re-emergent habitats of snails was 822,194 m², 1,391,779 m², 1,516,292 m², and 1,750,558 m², respectively. The newly found habitats of *O. hupensis* have been minimally changing every year outside of the explosive growth in habitats found

in lake and marsh regions in 2016 (Table 2). But the re-emergent of *O. hupensis* habitats have been increasing year by year from 2015 to 2018, mainly in lake and marsh regions or water-network regions (Figure 2).

TABLE 2. Monitoring results of *O. hupensis* in national schistosomiasis surveillance sites in China from 2015 to 2018.

Items	2015	2016	2017	2018
Surveillance area (m ²)	222,951,328	219,179,774	246,797,869	236,951,253
Area infested by snail (m ²)	74,266,296	69,977,767	69,406,026	65,456,951
Number of sampling frames (0.11 m ²)	1,691,779	1,155,680	1,447,609	1,366,937
Number of samples infested	68,721	70,061	93,479	66,102
Number of live snails	211,545	222,921	272,273	151,968
Number of infected snails	0	0	0	0
Density of live snail (per 0.11 m ²)	0.13	0.19	0.19	0.11
Area of new habitats (m ²)	34,730	1,367,694	18,944	50,420
Area of re-emergent habitats (m ²)	822,194	1,391,779	1,516,292	1,750,558

FIGURE 2. Re-emergent habitats change of *O. hupensis* by different epidemic types in national schistosomiasis surveillance sites in China from 2015 to 2018.

Abbreviation: RL: Re-emergent habitats of *O. hupensis* in lake and marsh regions; RW: Re-emergent habitats of *O. hupensis* in water-network regions; RM: Re-emergent habitats of *O. hupensis* in mountainous regions.

Discussion

The infection rate of local and floating populations in surveillance sites is decreasing year by year, which is mostly consistent with the downward trend of the schistosomiasis epidemic in China and closely related to the formulation of policies for schistosomiasis control and the implementation of relevant measures (8). For another source of infection, the cattle infection rate has shown decreases every year like that of the population and has eventually dropped to zero in both 2017 and 2018. Previous reports have shown that comprehensive control measures, mainly replacing cattle with machines, can effectively control the transmission of *S. japonicum* and significantly reduce the infection rates of humans and other cattle (9). Although the infection rates of population and cattle have been decreasing year by year, a lack of effective

methods makes the supervision of the floating population of humans inconvenient and brings more severe challenges to infectious sources control (10). At the same time, a large base of cattle in the epidemic area with no long-term mechanism for forbidding depasturing of livestock on marshland and for replacing cattle with the machine have made controlling cattle populations difficult (11). The above conditions indicated that the infection source control is still facing tremendous challenges.

As shown in Table 2, the infection rate of *O. hupensis* at surveillance sites has been zero for four consecutive years, but the total area of the breeding area of *O. hupensis* has not shown much change even though *O. hupensis* control is carried out every year. This demonstrates that existing strategies have limitations on the control of the breeding area of *O. hupensis*, possibly due to environmental factors such as precipitation and change of temperature (12). The

newly found habitats of *O. hupensis* showed explosive growth in area in 2016, which may be related to the flood disasters caused by too much rainfall in the previous year which allowed *O. hupensis* to spread widely.

The epidemic situational analysis reports of national surveillance sites in 2015 and 2016, without continuity analysis of epidemic situation, are limited to analysis of data for that year (13–14). This is the first continuity analysis of the epidemic situation since all surveillance sites in epidemic counties have been fully covered. The 457 surveillance sites cover every epidemic county, and almost all aspects of schistosomiasis transmission are involved in the surveillance contents. The results of each surveillance site may only reflect the local epidemic situation or, to some extent, the epidemic situation of the whole county where the surveillance site is located.

The results indicated that the habitats of *O. hupensis* reemerged and were increasing every year. In addition, people and livestock that are frequently mobile may become sources of infection for schistosomiasis, and the areas with epidemic *O. hupensis* may become areas with high risk of transmission of imported schistosomiasis. Therefore, monitoring of infectious sources of schistosomiasis needs to be strengthened, especially in human populations, and effective control and reduction of snail breeding areas may be an effective method for reducing the risk of schistosomiasis transmission.

* Corresponding authors: Shan Lyu, lvshan@nipd.chinacdc.cn; Shizhu Li, lysz@chinacdc.cn.

¹ National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention; Chinese Center for Tropical Disease Research; WHO Collaborating Center for Tropical Diseases; National Center for International Research on Tropical Diseases, Ministry of Science and Technology; Key Laboratory of Parasite and Vector Biology, Ministry of Health, Shanghai, China; ² Hunan Provincial Institute of Schistosomiasis Control, Yueyang, Hunan, China; ³ Hubei Provincial Center for Disease Control and Prevention, Wuhan, Hubei, China; ⁴ Jiangxi Provincial Institute of Parasitic Diseases Control, Nanchang, Jiangxi, China; ⁵ Anhui Provincial Institute of Schistosomiasis Control, Hefei, Anhui, China; ⁶ Jiangsu Institute of Schistosomiasis Control, Wuxi, Jiangsu, China; ⁷ Yunnan Institute of Endemic of Diseases Control and Prevention, Dali, Yunnan, China; ⁸ Institute of Parasitic Diseases Control and Prevention, Sichuan Center for Disease Control and Prevention, Chengdu, Sichuan, China; ⁹ Shanghai Municipal Center for Disease Control and Prevention, Shanghai, China; ¹⁰ Zhejiang Academy of Medical Sciences, Hangzhou, Zhejiang, China; ¹¹ Center for Disease Control and Prevention of Guangdong Province, Guangzhou, Guangdong, China; ¹² Guangxi Zhuang Autonomous Region Center for Disease Prevention and Control, Nanning, Guangxi, China; ¹³ Fujian Provincial Center for Disease Control and Prevention,

Fuzhou, Fujian, China; ¹⁴ Chongqing Municipal Center for Disease Control and Prevention, Chongqing, China.

Submitted: December 13, 2019; Accepted: January 10, 2020

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