Vital Surveillances

Sentinel Surveillance of Schistosomiasis — China, 2021

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ABSTRACT

Introduction: This report analyzes the national surveillance data for schistosomiasis in 2021 to understand the current status and provide evidence for further policy actions to promote elimination. This analysis is in line with the National Surveillance Plan of Schistosomiasis, which was revised in 2020 to adapt to the new stage of moving towards elimination.

Methods: Data from the 2021 national surveillance of schistosomiasis in humans, livestock, and snails were collected from 13 provincial-level administrative divisions (PLADs) and analyzed using descriptive epidemiological methodology. The antibody-positive rate and area of newly discovered and re-emergent snail habitats were calculated.

Results: In 2021, a total of 31,661 local residents and 101,558 transient population were screened for antibodies using indirect hemagglutination assay (IHA). Of those who tested positive, 745 local residents and 438 transient population underwent further parasitological examination, with only one stool-positive result in the transient population. Additionally, 12,966 livestock were examined using the miracidia hatching test, with no positives detected. The total area of newly discovered and re-emergent snail habitats was 957,702 m^2 and 4,381,617 m^2, respectively. No infected snail was found using the microscopic dissection method, but six pooled snail samples were reported as positive using the loop-mediated isothermal amplification method for detecting specific sequences of *Schistosoma. japonicum*, in Anhui and Jiangxi Provinces.

Conclusions: The prevalence of schistosomiasis among humans and livestock was found to be low, however, a potential transmission risk was identified in certain areas. To reduce the risk of transmission, a comprehensive control strategy should be continued and new techniques should be implemented in the surveillance and early warning system.

Schistosomiasis, one of the 20 neglected tropical diseases listed by the World Health Organization, is classified as a Category B infectious disease and given high priority in China. It is a water-borne infectious disease caused by infection with blood-dwelling flukes of the genus *Schistosoma*. In China, only schistosomiasis japonica, caused by *S. japonicum*, is prevalent, with more than 40 mammals serving as potential definitive hosts (*1*). In the mid-1950s, schistosomiasis japonica was a severe public health issue, with 11.6 million patients and 1.2 million infected cattle (*2*). After 70 years of control interventions, there have been significant decreases in the prevalence and intensity of schistosome infection (*3*). In light of this success and progress, the "Health China 2030" plan has set the goal to eliminate schistosomiasis in all endemic counties, transitioning from transmission control to elimination (*4*).

Since the 1990s, China has implemented a national surveillance project to understand the transmission patterns and trends of schistosomiasis (*5*). In 2020, the National Surveillance Plan of Schistosomiasis was revised and published to adapt to the current status of low endemicity and to identify more settings with potential risk of transmission (*3*,*6*). 2021 was the first year the plan was strictly adhered to. To assess the prevalence and explore areas with potential risk of schistosomiasis transmission, descriptive epidemiological methodology was used to analyze the national schistosomiasis surveillance data from 2021. The results will provide basic evidence for future policy-making and assessments of elimination. Surveillance results showed that infection was rarely found in humans, while no infected livestock was reported. However, potential transmission risk existed in some areas, suggesting that further interventions should be strengthened to consolidate the achievements to date and accelerate the elimination of schistosomiasis.

METHODS

According to the National Surveillance Plan of

Schistosomiasis (version 2020), 455 counties in 13 provincial-level administrative divisions (PLADs) were surveyed, including Anhui, Chongqing, Fujian, Guangdong, Guangxi, Hubei, Hunan, Jiangsu, Jiangxi, Shanghai, Sichuan, Yunnan, and Zhejiang. The counties surveyed were classified into four types based on their transmission status at the end of 2019, as defined by the Criteria of Schistosomiasis Control and Elimination (*7*): Type I, 21 counties at the stage of transmission control; Type II, 263 counties with snails, at the stage of transmission interruption or elimination; Type III, 167 counties with no snails, at the stage of transmission interruption or elimination; and Type IV, 4 counties in the Three Gorges Reservoir area with potential transmission risk of schistosomiasis.

In Type I counties, surveys for infection of schistosomes in local residents, local and imported livestock, and for *Oncomalania hupensis* were conducted in three to five villages that had relatively higher prevalence of schistosomiasis the previous year. Two to three villages with a high snail burden or with a high risk of snail re-emergence or introduction were selected in each Type II or Type III county to conduct a snail survey, while county-level surveillance on the introduction of snails was conducted in Type IV counties. Additionally, a survey on schistosomiasis in the transient population was conducted in the entire administrative area of counties for all four types, while a survey on imported livestock was only conducted in Type I and Type II counties.

At least 300 local residents from each selected administrative village and 200 of the transient population from each surveillance county were initially screened using the indirect hemagglutination assay (IHA) to detect anti-Schistosoma antibodies in the blood. Those who tested positive were then further examined using the nylon silk bag incubation method (three tests per stool sample) and Kato-Katz method (three slides per stool sample), in parallel, to detect the presence of schistosome eggs or miracidia (*8*). The miracidium hatching test (MHT) was used to detect miracidia in livestock feces. The snail survey was conducted in existing, historical, and likely snail habitats by systematic sampling combined with an environmental sampling method. The collected snails were then investigated by microscopic dissection to identify whether they were alive and infected with schistosomes. The sizes of the snail breeding area, newly developed habitats, and re-emergent habitats, the average percentage of frames with snails (No. of frames with snails / No. of survey frames × 100%), and snail densities were calculated in order to reflect the snail burden (*9*). Additionally, the loop-mediated isothermal amplification (LAMP) method was used to detect schistosome DNA in snails, using pooled samples from selected villages in all Type I and Type II counties which had interrupted the transmission of schistosomiasis in the past five years (*10*).

RESULTS

In 2021, a total of 1,032 villages in 13 PLADs were established as surveillance sites. A total of 31,661 local residents in 21 Type I counties in Anhui, Hunan, and Jiangxi Provinces were screened by IHA, and the positive rate was 2.36% (746/31,661) (Figure 1). Of the 745 antibody-positive individuals, none tested positive for parasites upon parasitological examination.

A total of 101,558 transient individuals in all the

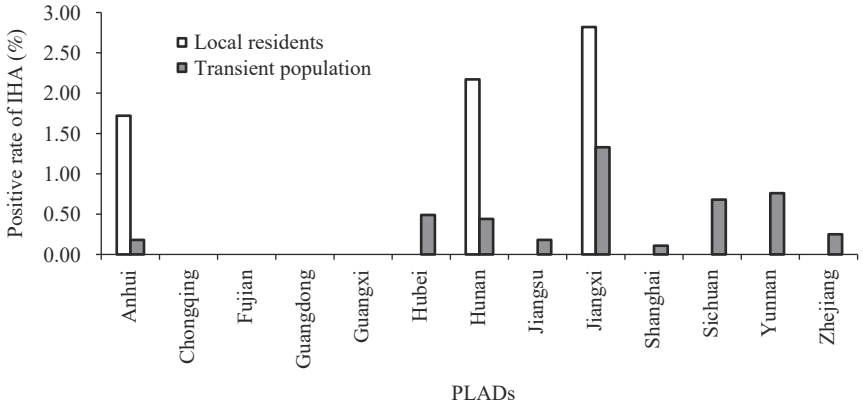

FIGURE 1. Sentinel surveillance results of antibody-positive rate of schistosomiasis using indirect hemagglutination assay (IHA) among local residents and transient population in China in 2021.
Abbreviation: PLADs=provincial-level administrative divisions.

surveillance counties of the 13 PLADs were screened by IHA, yielding a positive rate of 0.44% (442/10,558) (Figure 1). Of the 438 antibody positives, only one positive stool was detected in Zhejiang Province. This individual had traveled in other endemic provinces more than 10 years prior and had been exposed to fresh water near snail-breeding settings.

Except for Chongqing and Shanghai, which had no imported livestock, a total of 12,966 livestock were registered in the administrative regions, with 8,099 local livestock and 4,867 imported livestock in 11 PLADs. In total, 12,698 livestock were examined using the miracidia hatching technique, but no infected livestock was found.

The snail survey was conducted at 1,032 surveillance sites in the 13 PLADs, covering an area of 577,880,171 m^2. Of the snail breeding settings identified, the total area of newly discovered snail habitats was 957,702 m^2, with Anhui Province accounting for 91.37% (Table 1). The total area of re-emergent habitats was 4,381,617 m^2, primarily located in Jiangsu (43.56%), Anhui (32.06%), and Yunnan (13.16%).

Systematic sampling methods were used for the snail survey, and the average percentage of frames with snails was 6.91% (164,064/2,375,916), ranging from 0–15.01% across the 13 PLADs. The average snail density was 0.16 snails per 0.11 m^2 (369,782/2,375,916), ranging from 0–0.41 per 0.11 m^2 across the 13 PLADs. Dissection methodology was used to examine all snails collected by systematic and environmental sampling methods, but no infected snails were found. Additionally, 15,839 pooled samples containing 172,237 living snails were examined by LAMP, and six were reported as LAMP positive, collected from four sites in Anhui province and two sites in Jiangxi Province. No *O. hupensis* snails were found in the Three Gorges Dam reservoir.

CONCLUSIONS

Compared with the earlier national surveillance plan, the new plan required more extensive surveillance with more mobile sites, and highlighted the importance of snail surveillance, as well as clearly defining the scope and content of risk surveillance (6). The prevalence of schistosomiasis in people and livestock remained at a low level. No infected local residents or infected livestock were detected, and only one positive stool sample was diagnosed as an imported

TABLE 1. Sentinel surveillance results of schistosomiasis on *Oncomalania hupensis* in China, 2021.

PLADs	Survey area (m^2)	Area with Snails (m^2)	Area of newly discovered snail habitats (m^2)	Area of re-emergent snail habitats (m^2)	Average percentage of frames with snails		Snail density (/0.11 m^2)	LAMP		
					Systematical sampling	Environmental sampling		Number of detected snails	Number of detected mixed samples	Positive samples
Anhui	126,312,082	31,466,975	875,052	1,404,802	9.78	1.76	0.41	37,095	863	4
Chongqing	86,979	0	0	0	-*	-*	0.00	0	0	0
Fujian	1,449,140	117,000	0	103,750	5.10	2.20	0.12	1,107	150	0
Guangdong	1,082,104	0	0	0	-*	-*	0.00	0	0	0
Guangxi	5,372,863	34,730	0	1,746	3.34	0.12	0.07	0	0	0
Hubei	98,212,372	37,461,718	0	0	11.67	0.54	0.25	45,619	1,658	0
Hunan	118,406,880	85,737,019	54,200	101,800	5.05	0.12	0.09	14,867	346	0
Jiangsu	85,754,934	6,161,904	26,700	1,908,807	2.84	0.04	0.06	21,848	671	0
Jiangxi	66,621,838	24,685,971	0	173,825	3.91	0.52	0.09	11,011	355	2
Shanghai	1,529,195	1,960	1750	210	0.17	1.99	0.01	960	25	0
Sichuan	37,862,337	4,356,381	0	64,730	15.01	2.06	0.26	34,287	11,041	0
Yunnan	32,464,835	1,036,788	0	576,603	1.82	0.30	0.06	5,443	730	0
Zhejiang	2,724,613	87,171	0	45,344	2.37	1.53	0.04	0	0	0
Total	577,880,171	191,147,618	957,702	4,381,617	6.91	0.79	0.16	172,237	15,839	6

Note: Average percentage of frames with snails = No. of frames with snails / No. of survey frames × 100%.
Abbreviation: PLADs=provincial-level administrative divisions; LAMP=loop-mediated isothermal amplification.
* No snails were found in Guangdong and Chongqing.

case in the transient population in 2021. These results provide strong evidence that the progress made on schistosomiasis control has been consolidated in the past year, despite the coronavirus disease 2019 (COVID-19) pandemic occurring in all the schistosomiasis-endemic PLADs.

Surveillance of intermediate host snails revealed potential transmission risk. The area of newly discovered and re-emergent snail habitats increased from 1.57 hectares and 338.73 hectares in 2020 to 146.90 hectares and 1442.72 hectares in 2021 (*11*). One of the reasons for the spread and re-emergence of snails was the impact of a catastrophic flood which occurred in 2020 (*12*). Another potential cause may be the difficulties of implementing molluscicide in extensive snail habitats along the beaches of the Yangtze River and associated major lakes due to the Yangtze River Protection Law of the People's Republic of China. Therefore, future surveillance should be enhanced to understand the dynamic changes of snail population and explore risky areas, to provide reference for implementing appropriate interventions to decrease the transmission risk of schistosomiasis.

No infected snails were identified using the dissection method; however, positive LAMP results were reported from several sites in Anhui and Jiangxi provinces, which may be due to the higher sensitivity of LAMP to detect early or light infection of snails. These results suggest that potential transmission risk of schistosomiasis still exists in natural surroundings. To ensure effective surveillance, more sensitive detection tools should be introduced, given the current low infection rate and intensity as schistosomiasis control moves towards elimination (*13*).

In conclusion, schistosomiasis was characterized by low endemicity in China, with very low prevalence among humans and livestock. To provide evidence for implementing precise interventions, sensitive surveillance should be strengthened, as transmission risk still exists in restricted areas. However, there are some limitations in this study. Surveillance of local residents was only undertaken in counties at the stage of transmission control, which accounted for a small proportion of endemic counties. To understand the infection status of schistosomes in human beings comprehensively, data collection and analysis should be strengthened, as massive population living in endemic areas are screened for schistosomiasis annually in the national schistosomiasis control program. Additionally, the tools used for detecting schistosomes in humans and livestock are parasitological methods with low sensitivity, which may lead to false negatives in infected definitive hosts due to their low infection intensity. Furthermore, sensitive LAMP testing was not stipulated in all county types due to cost considerations, which may result in snails with schistosomes being missed in some risky areas.

To expedite the elimination of schistosomiasis nationwide, surveillance strategies focusing on risk should be enhanced to provide guidance for precise implementation of interventions. Capability building for rapid and effective responses based on multi-sectoral coordination should be strengthened once endemic foci or areas with potential transmission risk have been identified (*14*). Additionally, comprehensive management of snail control should be maintained to consolidate the progress achieved, thus avoiding the rebound and spread of snails under multiple influencing factors, such as floods, large water conservancy projects, and increased human activities. Finally, novel techniques and approaches for diagnosis and detection should be applied and generalized to enhance the efficiency and capacity of the surveillance and early warning system (*15*).

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REFERENCES

1. Xu J, Steinman P, Maybe D, Zhou XN, Lv S, Li SZ, et al. Evolution of the national schistosomiasis control programmes in The People's Republic of China. Adv Parasitol 2016;92:1 – 38. http://dx.doi.org/10.1016/bs.apar.2016.02.001.
2. Zhou XN, Wang LY, Chen MG, Wu XH, Jiang QW, Chen XY, et al. The public health significance and control of schistosomiasis in China-then and now. Acta Trop 2005;96(2 – 3):97 – 105. http://dx.doi.org/10.1016/j.actatropica.2005.07.005.
3. Hong Z, Li L, Zhang LJ, Wang Q, Xu J, Li SZ, et al. Elimination of schistosomiasis japonica in China: from the one health perspective.

China CDC Wkly 2022;4(7):130 – 4. http://dx.doi.org/10.46234/ccdcw2022.024.
4. The Central Committee of the Party of P.R.C., The State Council of P.R.C. The healthy China 2030 plan. Chin J Ophthalmol 2018;54(1):11-22. http://dx.doi.org/10.3760/cma.j.issn.0412-4081.2018.01.004. (In Chinese).
5. Zhang LJ, Li SZ, Wen LY, Lin DD, Abe EM, Zhu R, et al. The establishment and function of schistosomiasis surveillance system towards elimination in the People's Republic of China. Adv Parasitol 2016;92:117 – 41. http://dx.doi.org/10.1016/bs.apar.2016.03.003.
6. Dang H, Li YL, Lv S, Xu J, Li SZ. Interpretation for national surveillance plan of schistosomiasis (version 2020). J Trop Dis Parasitol 2020;18(3):133 – 7. http://dx.doi.org/10.3969/j.issn.1672-2302.2020.03.001. (In Chinese).
7. Zhang LJ, Xu ZM, Dang H, Li YL, Lv S, Xu J, et al. Endemic status of schistosomiasis in People's Republic of China in 2019. Chin J Schistosomiasis Control 2020;32(6):551 – 8. http://dx.doi.org/10.16250/j.32.1374.2020263. (In Chinese).
8. Li YL, Dang H, Zhang LJ, Li GP, Shan XW, Yuan M, et al. Schistosomiasis surveillance — China, 2015-2018. China CDC Wkly 2020;2(3):39 – 43. http://dx.doi.org/10.46234/ccdcw2020.011.
9. Dai SM, Edwards J, Guan Z, Lv S, Li SZ, Zhang LJ, et al. Change patterns of oncomelanid snail burden in areas within the Yangtze River drainage after the three gorges dam operated. Infect Dis Poverty 2019;8(1):48. http://dx.doi.org/10.1186/s40249-019-0562-4.
10. Qin ZQ, Xu J, Feng T, Lv S, Qian YJ, Zhang LJ, et al. Field evaluation of a loop-mediated isothermal amplification (LAMP) platform for the detection of *Schistosoma japonicum* infection in *Oncomelania hupensis* snails. Trop Med Infect Dis 2018;3(4):124. http://dx.doi.org/10.3390/tropicalmed3040124.
11. Zhang LJ, Xu ZM, Yang F, Dang H, Li YL, Lv S, et al. Endemic status of schistosomiasis in People's Republic of China in 2020. Chin J Schistosomiasis Control 2021;33(3):225 – 33. http://dx.doi.org/10.16250/j.32.1374.2021109. (In Chinese).
12. Guo SY, Zhu HQ, Cao CL, Deng WP, Bao ZP, Jia TW, et al. Risk assessment of schistosomiasis transmission along the middle and lower reaches of Yangtze River after flooding in 2020. Chin J Parasitol Parasit Dis 2021;39(6):753 – 9. http://dx.doi.org/10.12140/j.issn.1000-7423.2021.06.005. (In Chinese).
13. Lv C, Deng WP, Wang LP, Qin ZQ, Zhou XN, Xu J. Molecular techniques as alternatives of diagnostic tools in China as schistosomiasis moving towards elimination. Pathogens 2022;11(3):287. http://dx.doi.org/10.3390/pathogens11030287.
14. Xu J, Li SZ, Guo JG, Zhou XN, Djirmay AG. The WHO new guideline to control and eliminate human schistosomiasis: implications for the verification of transmission interruption and surveillance of *Schistosoma japonicum* in China. Infect Dis Poverty 2022;11(1):79. http://dx.doi.org/10.1186/s40249-022-01003-w.
15. Gordon CA, Williams GM, Gray DJ, Clements ACA, Zhou XN, Li YS, et al. Schistosomiasis in the People's Republic of China - down but not out. Parasitology 2022;149(2):218 – 33. http://dx.doi.org/10.1017/S0031182021001724.