Acta Tropica 195 (2019) 135–141

Contents lists available at ScienceDirect

Acta Tropica

journal homepage: www.elsevier.com/locate/actatropica

The epidemiological status of schistosomiasis in P. R. China after the World Bank Loan Project, 2002–2017

Li-Juan Zhang[a,b,c,d], Si-Min Dai[a,b,c,d], Jing-Bo Xue[a,b,c,d], Yin-Long Li[a,b,c,d], Shan Lv[a,b,c,d], Jing Xu[a,b,c,d,*], Shi-Zhu Li[a,b,c,d], Jia-Gang Guo[a,b,c,d], Xiao-Nong Zhou[a,b,c,d]

[a] National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai, People's Republic of China
[b] WHO Collaborating Center for Tropical Diseases, Shanghai, People's Republic of China
[c] National Center for International Research on Tropical Diseases, Shanghai, People's Republic of China
[d] Key Laboratory of Parasite and Vector Biology, Ministry of Health, Shanghai, People's Republic of China

ARTICLE INFO

Keywords:
Epidemic status
Schistosoma japonicum
Integrated strategy
World Bank Loan Project
Surveillance

ABSTRACT

World Bank Loan Project (WBLP) for schistosomiasis control conducted from 1992 to 2001, resulted in significant reduction of schistosomiasis morbidity and mortality in People's Republic of China (P.R. China), with implementation of morbidity control. Thereafter, an integrated control strategy, which targeted blocking disease transmission from reservoir hosts to the environment, was initiated in order to conquer schistosomiasis rebound after WBLP completion. Data obtained from the national schistosomiasis control reporting systems was collected and analyzed. The number of confirmed cases and infected cattle decreased significantly from 2002 to 2017, while no infected snails were found by dissection for four consecutive years. However, lake and marshland regions and some parts areas of Yunnan Province require attention for rigorous schistosomiasis control efforts. There is need to strengthen precise interventions and sensitive surveillance to achieve schistosomiasis elimination in P.R. China.

1. Introduction

Schistosomiasis, caused by infection with parasitic trematode of the genus *Schistosoma,* remains a public health problem in developing regions of the world, including Africa, Asia and Latin America (McManus et al., 2018; World Health Organization, 1985). *Schistosoma japonicum* is the only one of the three major human infecting *Schistosoma* species distributed in the People's Republic of China (P. R. China)(Mao and Shao, 1982; McManus et al., 2018), causing intestinal schistosomiasis. Historically, schistosomiasis japonica was endemic in 12 provinces with estimated 11.6 million human cases and 1.2 million infected bovines in the 1950s in P. R. China (Maegraith, 1958; Mao, 1948; Zhou et al., 2005). A partial epidemiological survey showed that prevalence in some villages was higher than 70% (Chen and Feng, 1999; Mao and Fu, 1989). Severe cases with syndromes such as splenomegaly, ascites, colonic tumoroid proliferation and growth retardation were very common at the early stages of new China due to lack of effective interventions and treatment (Chen, 1999).

Being aware of the severity of schistosomiasis on human health and its negative impact on socio-economic development, the central government prioritized the continuous implementation of large scale and intensive national control programme since 1950s(Liu et al., 2016; Shi et al., 2016; Zhang et al., 2016b). Schistosomiasis control strategy in China initially focused on snail control, with the implementation of molluscicide and environmental modification which was, also, combined with agricultural activities while treatment was given to patients with severe cases using antimonials, before praziquantel became available commercially in 1980s (Chen, 2002; Yuan et al., 2002). The strategy led to 11 billion m^2 areas free of snails by 1981(Xu et al., 2016). However, WHO adjusted schistosomiasis control strategy from elimination to morbidity control in 1980s, having realized the difficulty of eliminating schistosomiasis due to scarcity of resources at that time and the significant low price of praziquantel (Ross et al., 2013). Morbidity control strategy was embraced and implemented in P.R. China after several field trials, this was, also, boosted by the World Bank Loan Project (WBLP) for schistosomiasis control implementation in China from 1992 to 2001. Large-scale schistosomiasis treatment with chemotherapy was conducted and was complemented with health education, chemical control of snails and environmental modification where appropriate. These efforts led to significant reduction in schistosomiasis prevalence and infection intensity in P. R. China. The control programme recorded great progress by the end of 2001, with

* Corresponding author.
E-mail address: xujing@nipd.chinacdc.cn (J. Xu).

https://doi.org/10.1016/j.actatropica.2019.04.030
Received 31 August 2018; Received in revised form 26 April 2019; Accepted 27 April 2019
Available online 29 April 2019
0001-706X/

schistosomiasis transmission successfully interrupted in Shanghai (1985), Guangdong (1985), Guangxi (1988), Fujian (1987) and Zhejiang (1995) (Utzinger et al., 2005; Wang et al., 2008). The estimated cases decreased from 1.73 million in 1992 to 0.82 million in 2001(Chen et al., 2002, 2005). However, morbidity control could not prevent re-infection or interrupt schistosomiasis transmission (Liang et al., 2006; Ross et al., 2015; Zhou et al., 2007).

An integrated control strategy was initiated to block schistosomiasis transmission from reservoir hosts to the environment to curtail disease rebound across the country at the end of WBLP. This prompted nationwide implementation of pilot studies with the medium and long term national strategic plan (MLNP) on schistosomiasis control which spanned from 2004 to 2015 in. P. R. China (Council, 2004). This was followed by the 13th five-year national schistosomiasis control plan, which would run from 2016 to 2020. This phase targets the continuous implementation of comprehensive prevention and control strategies with focus on infectious sources control, while surveillance and early warnings are adequately strengthened, with control measures adapted to local conditions according to the plan.

This article systematically analyzed the epidemic trend of schistosomiasis from 2002 to 2017, after the implementation of WBLP for schistosomiasis control, with focus on schistosomiasis infection in human populations and cattle in order to provide insight on the progress made with schistosomiasis control in P.R. China. We, also, assessed changes in snail infested areas and spatial distribution of new snail habitats to help guide future control activities; *Oncomelania hupensis* is the only intermediate snail host of *S. japonicum* in P. R. China.

2. Materials and methods

2.1. Basic information of national programme for schistosomiasis control after WBLP

The Schistosomiasis control programme continued with implementation of morbidity control strategy from 2002 to 2005 following the termination of WBLP. The measures for morbidity control included expanded chemotherapy for humans and livestock, complemented by health education and snail control in susceptible areas. This integrated control strategy has targeted reservoir host control since 2006. Intervention measures such as replacing cattle with agricultural machinery, raising livestock in herds, forbidding grazing animals in snails infested areas, construction of toilets and adequate supply of safe water for improved sanitation were carried out besides the routine prevention and control measures including chemotherapy and snails control. Human beings and livestock were screened at each stage and snail surveys were conducted annually to understand the endemic status and also provide guidance for implementation of interventions in the 12 schistosomiasis endemic provinces, including Shanghai, Guangdong, Guangxi, Fujian, Zhejiang, Sichuan, Yunnan, Jiangsu, Hubei, Anhui, Jiangxi and Hunan province.

2.2. Survey conducted during the national control programme

2.2.1. Population survey and treatment

Individuals from 6 years of age and above were screened annually using serological tests, initially in endemic areas after the transmission season. Fecal examinations were conducted for serological positive patients. In addition, a small number of individuals at high risk of schistosome infection received stool examination directly (Ministry of Health, 2000; Liu et al., 2017; Sun et al., 2017). Attention was given to identify the number of acute schistosomiasis cases because it is a highly sensitive indicator that reflected the transmission intensity and risk of endemic areas (Li et al., 2014). Praziquantel was administered freely to individuals with schistosomiasis and those residents at high risk of infection.

2.2.2. Cattle survey and treatment

Cattle raised in endemic areas were screened annually, using miracidium hatching test, in order to ascertain livestock potential as a source of infection for snails (Ministry of Health, 2000). All infected cattle were treated with a single dose of praziquantel or removed from endemic areas.

2.2.3. Snail survey and control

Snail survey involved using systematic sampling and environmental sampling methods yearly to provide information on the trends in the distribution and infection of intermediate host snails. A frame with area of 0.1 m^2 was used and set to investigate snails. Systematic sampling method was used directly in environment with snails according to the previous survey. In lake and marshland regions, parallel survey lines and frames were fixed with equal distance according to the areas of surveyed environments. The distance between two neighboring lines was set as 20 m and the frames were set per 20 m along each line in regions with area less than 200, 000 m^2. In surroundings with area larger than or equal to 200,000 m^2, the distance was kept as 30 m between neighboring lines and the frames were set per 50 m. At least 500 frames of snails survey should be investigated. Framing along the water line was made per 5 or 10 m on both banks for linear environment such as ditches, ridges, etc. Frames were set at every 5 or 10 m along the periphery for low-lying land including ponds and other environments. Environmental sampling method was used to conduct snail survey in areas without history of snail infestation but was suspected of being infested, by setting frames strategically in locations suspected to harbor snails. All snails found in the frames were collected and detected under microscopy to determine the snail's survival status and also, screened for schistosome infection (Ministry of Health, 2000). Areas where snails are found were calculated following guidelines of schistosomiasis control handbook in China. Molluscicide was conducted annually in areas habitable for humans and livestock as well as areas with relatively stable water level. Environmental modification was implemented to destroy snail habitats in areas where molluscicide was impracticable.

2.3. Data management and analysis

All data were collected through the national schistosomiasis reporting system based on village level and transferred to Microsoft Excel software for data compilation. The main information on human examination, cattle survey and snail survey were collected and positive rate of serological test and the infection rate of cattle in different years and provinces, number of cases with stool examination positive, number of cattle with stool examination positive, and areas of newly-detected snails in each county from 2002 to 2017 were calculated to analyze the epidemic situation. Microsoft Excel software, version 2013(Microsoft Office, CA, USA) was used to analyze the epidemic trend based on descriptive analysis. ArcGIS software, version 10.1(ESRI, Redlands, CA, USA) was used to present the distribution of cases, infected cattle and newly found snail habitats at county level.

3. Results

3.1. The trend of cases

A total of 135.27 million serological tests were conducted and 7.56 million serological positives were found nationwide after WBLP. We recorded 7–8% positive human serological test from 2002 to 2007 in the 12 provinces, and observed yearly decline rate since 2008 (Table 1). The positive rate of serological test decreased to 2.06% in 2017, indicating lower transmission risk than the previous years. Similarly, the serological positive rates in provinces where schistosomiasis has not been eliminated showed declining trends. Jiangsu province always presented the lowest positive rate of serological tests each year, while Hunan and Hubei provinces were implicated with the highest antibody

Table 1
Case screening conducted nationwide from 2002 to 2017.

Year	No. people with serological test	No. serological positive	Positive rate of serological test (%)	No. people with stool test	No. stool positive	No. acute schitosomiasis cases
2002	6208090	490390	7.90	1514299	68439	913
2003	6928309	488395	7.05	1228141	64985	1114
2004	6970225	561487	8.06	350656	18952	816
2005	8117318	627906	7.74	515212	27285	564
2006	7972009	622887	7.81	400788	44506	207
2007	8909239	708164	7.95	834634	85888	83
2008	9105333	636119	6.99	884873	58604	56
2009	8789395	587202	6.68	835064	42104	75
2010	9405509	577418	6.14	1047254	41408	42
2011	9764934	529577	5.42	1134949	30334	3
2012	9582496	444339	4.64	904718	22666	12
2013	9491916	394420	4.16	937648	16865	9
2014	9184090	320333	3.49	991661	8270	2
2015	8482778	219482	2.59	873431	3606	0
2016	8188480	182244	2.23	783913	600	0
2017	8172412	168073	2.06	604540	14	1
Total		135272533	7558436	13841781	534526	3897

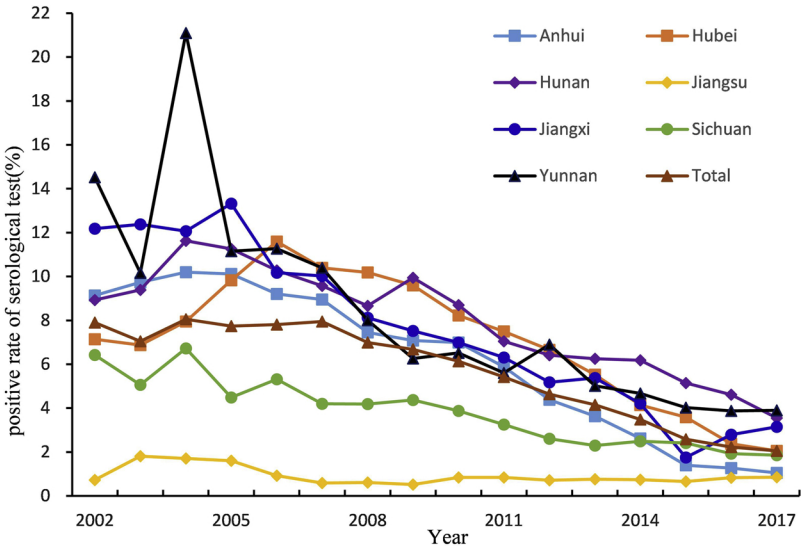

Fig. 1. The trend of positive rates of serological test from 2002 to 2017 in seven endemic provinces.

positive rates from 2002 to 2017 among the seven provinces (Fig. 1).

We conducted 13.84 million stool examinations and 534 526 stool positives were found from 2002 to 2017. The number of stool positives peaked in 2007 with 85,888 but gradually decreased yearly. There were only 14 stool positives found nationwide in 2017. Hubei, Hunan and Anhui provinces accounted for 71.08% (379942/534526), 13.63% (72851/534526), and 5.59% (29906/534526) respectively, of confirmed cases from 2002 to 2017 among the seven provinces where schistosomiasis was not eliminated. Fifteen counties each with more than 10,000 confirmed cases from 2002 to 2017 were distributed in Hubei (12 counties), Hunan (2 counties) and Anhui provinces (1 county), mainly along the Yangtze River Valley (Fig. 2). No local case was found in Shanghai, Guangdong, Fujian, Guangxi and Zhejiang provinces, but 254 imported cases from other endemic areas were monitored. A total of 3897 acute schistosomiasis cases were detected from 2002 to 2017. We observed downward trend in the number of acute schistosomiasis cases and no acute schistosomiasis case was reported in 2015 and 2016.

3.2. Schistosomiasis trends in cattle

The number of cattle raised in endemic villages fluctuated from 2002 to 2009, and declined gradually from 2010. Cattle population decreased to less than one million since 2013. A total of 10.31 million tests were conducted on cattle from 2002 to 2017 and 182 718 infected cattle were detected. Results obtained from the annual survey indicated that schistosomiasis infection rate in cattle increased in the previous three years, peaking in 2004 with 4.49% and then decreased yearly since 2005 (Table 2).

Schistosomiasis infection rate in cattle was the lowest in Jiangsu province (less than 0.5%) among the seven provinces endemic with schistosomiasis and no record of infection in cattle since 2008. Sichuan province reported significant decline trend in cattle infection rate, while no infected cattle was detected since 2012 (Fig. 3). Infection rates fluctuated yearly before 2008 but declined in the following years in the other five provinces. No local and imported infected cattle were detected from 2002 to 2017 in the five provinces where schistosomiasis transmission was interrupted.

Hubei province accounted for the highest number of infected cattle (44.12%, 80618/182718), while Hunan, Jiangxi and Yunnan province accounted for 18.52%(33848/182718), 11.75% (21476/182718) and 9.56%(17464/182718) of infected cattle respectively from 2002 to 2017. Infected cattle were only found in Hunan and Jiangxi provinces in 2016 and 2017. Of the ten counties implicated with infected cattle higher than 5000, six counties were located in Hubei province, while, 2, 1 and 1 counties were located in Yunnan province, Hunan province and

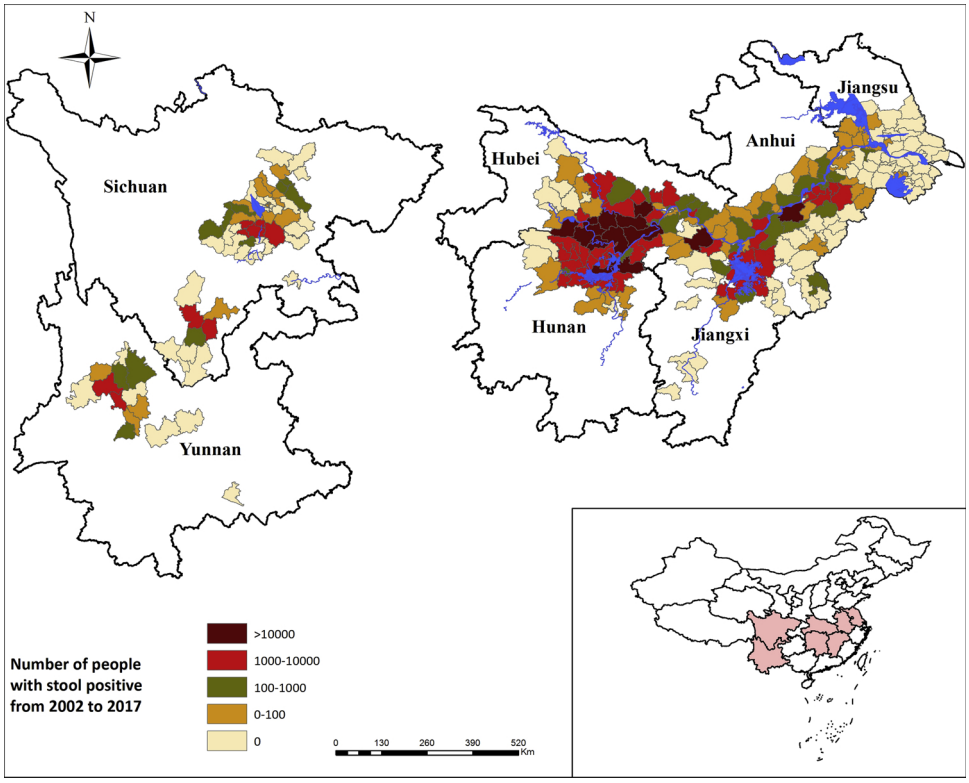

Fig. 2. The distribution of people with stool positive on county level.

Table 2
The epidemic situation of schistosomiasis in cattle from 2002 to 2017.

Year	No. cattle in endemic villages	No. cattle examined	No. infected cattle	The infection rate (%)
2002	1676321	665123	23199	3.4879
2003	1806901	594522	24461	4.1144
2004	1701220	554003	24863	4.4879
2005	1764472	916344	33736	3.6816
2006	1586715	724454	24855	3.4309
2007	1496477	785855	16624	2.1154
2008	1468669	747857	9988	1.3355
2009	1570300	750953	7753	1.0324
2010	1476606	686622	7173	1.0447
2011	1410936	753782	5146	0.6827
2012	1189829	630217	3297	0.5232
2013	962065	516090	633	0.1227
2014	919579	494620	666	0.1346
2015	879373	526062	315	0.0599
2016	881050	510468	8	0.0016
2017	737016	454830	1	0.0002
Total		10311802	182718	–

Jiangxi province respectively (Fig. 4).

3.3. Infection trend in snails

Snail surveys covered 900.14 billion m^2 area from 2002 to 2017 and live *Oncomelania hupensis* were found in 27.79 billion m^2 of areas cumulatively. Total snail area fluctuated between 3.52 and 3.86 billion m^2, but 3.63 billion m^2 area was infested by snails in 2017 and these areas were mainly distributed in the marshland and lake regions. Marshland and lake regions, mountainous and hilly regions and plain region with waterway networks accounted for 94.84% (344337.41/363068.85), 5.13% (18623.10/363068.85) and 0.03% (108.44/363068.85) of areas infested with snails respectively. Hunan province accounted for the highest number of snail infested areas (47.69%, 173129.41/363068.85), while Jiangxi, Hubei and Anhui province accounted for 22.96% (83359.11/363068.85), 18.81%(68281.68/363068.85) and 7.30%(26520.76/363068.85) of snail infested areas respectively. Although the snail habitats areas changed slightly, but areas with infected snails decreased significantly from 10365.31hm^2 in 2004 to zero since 2014 (Table 3).

In addition, a total of 167.00 million m^2 of new snail habitats (environments with no snails initially) were detected during the annual survey carried out from 2002 to 2017. The areas detected in 2002 and 2003 accounted for 32.32% of the total new snail habitat areas. New snail habitats were mainly distributed in Anhui, Hubei, Hunan and Jiangxi provinces, and they accounted for 37.00% (6179.07/16700.21), 23.06% (3850.55/16700.21), 18.87% (3150.98 /16700.21) and 16.21% (2706.54/16700.21) areas respectively, with distribution mainly located in marshland and lake regions. Three counties with new areas of snail habitats higher than 1000 hm^2 were located in Anhui, Hunan and Hubei provinces (Fig. 5). Of the 33 counties with new areas of snail habitats higher than 100 hm^2 and less than 1000 hm^2, Anhui accounted for 9 counties, 7, 6 and 5 counties were located in Jiangxi, Hubei and Hunan provinces respectively while 2 counties each were located in Jiangsu, Sichuan and Yunnan provinces.

4. Discussion

Here, we present the epidemic trend of schistosomiasis in P. R. China, following the change in control strategy from morbidity control to integrated control. We observed a significant reduction of *S. japonicum* infection in the human population, as well as in livestock and snails from 2002 to 2017. Having recorded that cattle account for 80% of *S. japonicum* transmission in P.R. China (Davis et al., 2002; Guo et al., 2006, 2001), it became imperative to conduct annual survey both on humans and cattle nationwide. Data collected from 2002 to 2017 indicated that the number of stool positives in residents and cattle decreased significantly. We reported only 14 schistosomiasis cases in humans and one infected cattle in 2017. Meanwhile, positive rate of

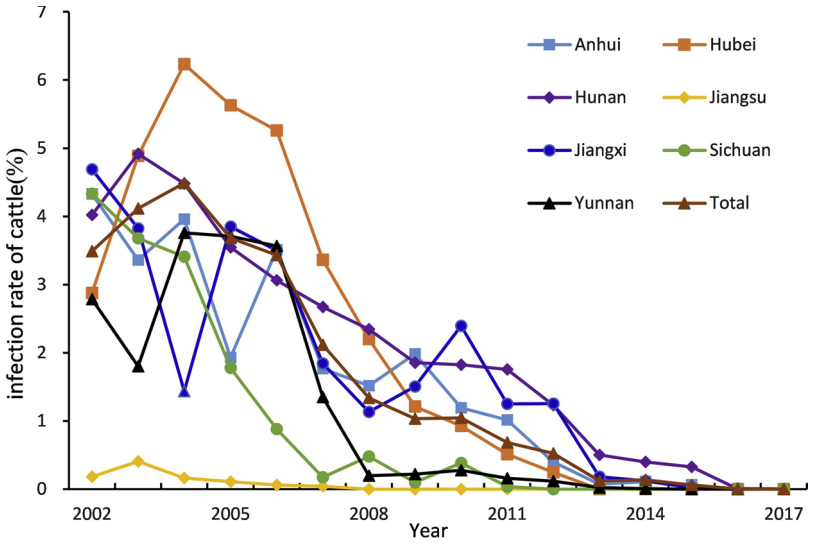

Fig. 3. The infection rate of cattle from 2002 to 2017 among seven provinces with schistosomiasis endemic.

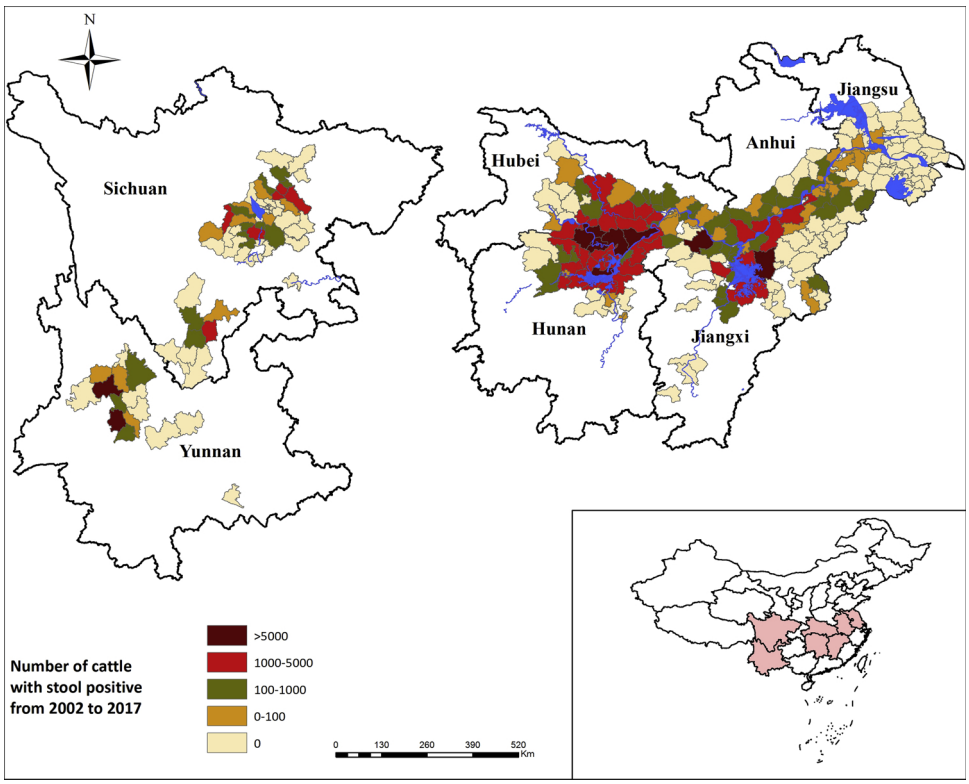

Fig. 4. The distribution of cattle infected with schistosomiasis on county level.

serological test in residents also maintained a downward trend especially from 2008, with values about 2% in the past three years, indicating existing low transmission intensity in endemic areas. We also found no infected snails through microscopy in four consecutive years. All those data indicated that schistosomiasis endemicity had reached a very low level with the implementation of integrated interventions.

O. hupensis is the only snail host species responsible for *S. japonicum* transmission in P.R. China. Theoretically, eliminating snails also could interrupt schistosomiasis transmission and this makes snail control with molluscicide and environmental modification a very important component of China's schistosomiasis control programme (Guan et al., 2017; Li et al., 2016), which is not limited to eliminate all snails but kill infected snails too, in order to reduce the transmission risk in humans and livestock dwellings. Snail infested areas decreased from 14.3 billion m^2 in 1950s to 3.63 billion m^2 in 2017 after more than 60 years' rigorous control efforts (Zhou et al., 2005). Although there were slight observed changes in snail habitats areas in the recent past decade, infected snail areas decreased significantly.

Findings from the 16 years' national survey further demonstrated the importance and difficulties of schistosomiasis control in lake and marshland regions. More than 90% confirmed cases were distributed in Hubei, Hunan and Anhui provinces, with predominantly lake and marshland ecology. Infected cattle were mainly distributed in Hubei, Hunan and Jiangxi provinces from 2002 to 2017, these provinces are either located along Yangtze River or connected with big lakes such as Dongting Lake or Poyang Lake. Also, most of the snail infested areas

Table 3
survey on snails and areas of snails from 2002 to 2017.

Year	Surveyed area (hm^2)	Area found living snails (hm^2)	New snail habitat areas (hm^2)	Snail habitat areas with infected snails(hm^2)	Total snail area (hm^2)
2002	608260.11	135485.69	1151.07	–	351885.06
2003	575544.99	137675.35	4246.24	–	378683.11
2004	701298.34	306532.49	959.97	10365.31	384599.95
2005	479727.90	173427.94	1057.99	10338.52	386268.76
2006	484480.80	163214.97	1381.03	9311.67	380151.74
2007	494673.07	151092.25	494.74	6563.77	372648.31
2008	477852.60	148443.38	1197.89	3819.98	372263.11
2009	420085.96	144568.39	879.42	3904.26	372358.69
2010	459436.62	160874.12	1081.80	2955.24	373596.18
2011	514688.00	163700.33	1163.87	1366.19	372664.10
2012	611893.60	173497.65	46.71	141.00	368741.67
2013	566953.82	169512.49	287.28	9.25	365467.99
2014	576506.37	169518.94	531.13	0.00	364324.42
2015	593572.66	173462.50	666.04	0.00	356287.55
2016	813963.91	235096.04	1346.48	0.00	356834.59
2017	622454.50	172508.11	208.54	0.00	363068.85
Total	9001393.25	2778610.64	16700.20	–	–

were distributed in lake and marshland areas in 2017. Yunnan province, located in the hilly and mountainous regions, was also, implicated with pockets of regions such as Eryuan and Weishan county, presenting higher number of cases or infected cattle in recent years.

Despite the huge progress made with the schistosomiasis control programme in China, there still exists several challenges as we push towards elimination. Some of these challenges include: large number of domestic animals raised in endemic villages and wild animals around surroundings could serve as reservoir hosts. Growing migration of humans and trade in livestock and goods between endemic and non-endemic areas increase the risk of schistosomiasis spread and resurgence. Most thriving snail habitats are distributed widely and predominantly in the lake and marshland regions with complicated environment, making control efforts difficult to implement. Floods, earthquakes and other natural disasters occur from time to time, leading to our inability to achieve the elimination of schistosomiasis transmission risk.

Considering the endemic situation of schistosomiasis and accelerating the process of schistosomiasis elimination, the 13th five-year national plan for schistosomiasis control was issued in 2017. The national plan stressed that schistosomiasis transmission interruption must be achieved in Sichuan, Jiangsu, Yunnan, Hubei and Hunan provinces, while 90% and 70% of endemic counties in Anhui and Jiangxi provinces respectively would also attain transmission interruption by the end of 2020.

It is, therefore, imperative that intensive and novel interventions be implemented precisely in the risk areas to achieve these national plan goals. The use of novel techniques or methods with super sensitivity and specificity should be prioritized, explored and transferred from laboratories to the field(Bergquist et al., 2017), which would help our case finding and snail detection activities, thus, providing accurate estimate of transmission risk. Surveillance-response platform as an intervention, should be strengthened with four systems including; case finding, case reporting, data management and response (Zhang et al., 2016a). Tendency for schistosomiasis transmission should be monitored with advanced techniques and methods to provide guidance for policy makers and evidences to certify that schistosomiasis is eliminated.

5. Conclusion

There is a sharp decline in the endemicity of schistosomiasis in P. R. China, however, attaining the goal of transmission interruption in some regions is still arduous. Effective control and surveillance strategies should be strengthened and sustained to consolidate on the achievements, thereby, reduce endemic situation of schistosomiasis in P.R. China.

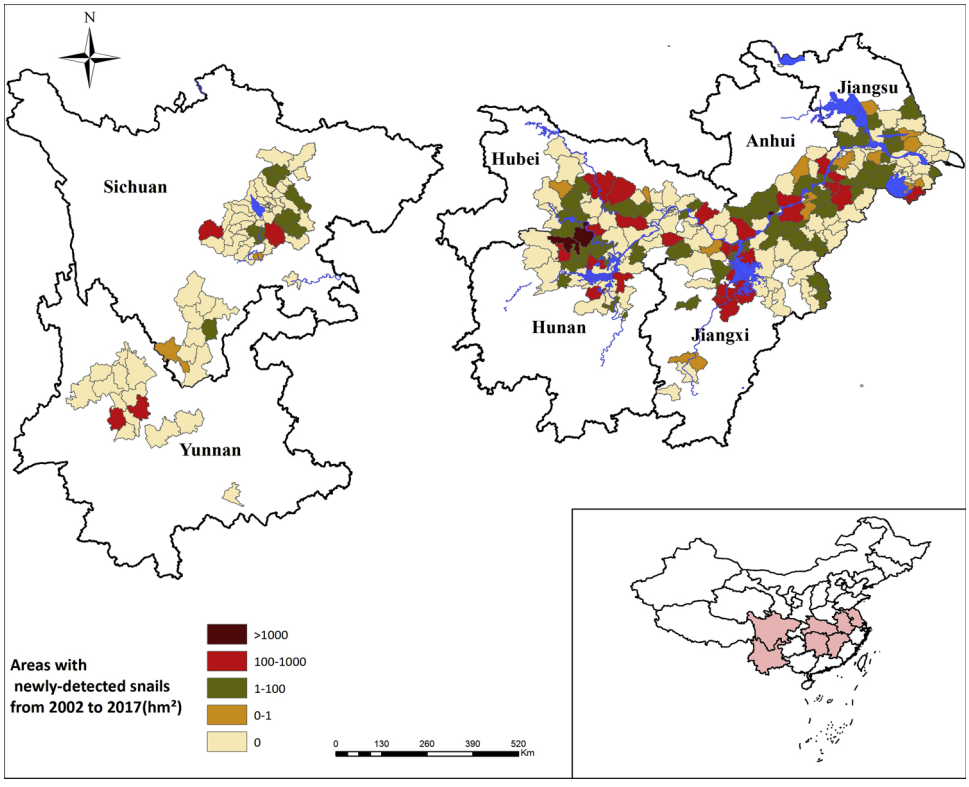

Fig. 5. The distribution of new snail habitats detected during 2002–2017.

Authors' contributions

Lijuan Zhang and Jing Xu participated in manuscript writing design and wrote the first draft. Lijuan Zhang, Simin Dai, Jingbo Xue and Yinlong Li did the search of literature. Xiaonong Zhou, Shizhu Li, Jiagang Guo and Shan LV revised the manuscript and provided important intellectual content. Lijuan Zhang, Jingbo Xue and Simin Dai participated in data collection and figure drawing. All authors have read and approved the final version of the manuscript.

Funding sources

This study was financially supported by the National Science and Technology Major Project of China ((No. 2018ZX10101002-002, 2016YFC1202000) and National Natural Science Foundation of China (No. 81301454, No. 30590373).

References

Bergquist, R., Zhou, X.-N., Rollinson, D., Reinhard-Rupp, J., Klohe, K., 2017. Elimination of schistosomiasis: the tools required. Infect. Dis. Poverty 6, 158.
Chen, M.G., 1999. Progress in schistosomiasis control in China. Chin. Med. J. (Engl.) 112, 930–933.
Chen, X.Y., 2002. The challenges and strategies in schistosomiasis control program in China. Acta Trop. 82, 279–282.
Chen, M.G., Feng, Z., 1999. Schistosomiasis control in China. Parasitol. Int. 48, 11–19.
Chen, X.Y., Jiang, Q.W., Wang, L.Y., Zhao, G.M., Zhao, Q., Gu, G.A., Wei, J.G., Hao, Y., 2002. Schistosomiasis situation in the People's Republic of China in 2001. Chin. J. Schisto. Control 14, 241–243.
Chen, X.Y., Wang, L.Y., Cai, J.M., Zhou, X.N., Zheng, J., Guo, J.G., Wu, X.H., Engels, D., Chen, M.G., 2005. Schistosomiasis control in China: the impact of a 10-year World Bank Loan Project (1992-2001). Bull. World Health Organ. 83, 43–48.
Council, T.S., 2004. The Medium and Long Term National Plan for Schistosomiasis Prevention and Control [Online]. Available: http://www.gov.cn/gongbao/content/2004/content_62905.htm (Accessed 12 December 2017). .
Davis, G.M., Wu, W.P., Chen, H.G., Liu, H.Y., Guo, J.G., Lin, D.D., Lu, S.B., Williams, G., Sleigh, A., Feng, Z., Mcmanus, D.P., 2002. A baseline study of importance of bovines for human Schistosoma japonicum infections around Poyang Lake, China: villages studied and snail sampling strategy. Am. J. Trop. Med. Hyg. 66, 359–371.
Guan, W., Hong, Q.B., Lv, S., Xu, J., Li, S.Z., 2017. Research progress of control technique on Oncomelania hupensis. Chin. J. Schisto. Control 29, 246–251.
Guo, J.G., Ross, A.G., Lin, D.D., Williams, G.M., Chen, H.G., Li, Y., Davis, G.M., Feng, Z., Mcmanus, D.P., Sleigh, A.C., 2001. A baseline study on the importance of bovines for human Schistosoma japonicum infection around Poyang Lake, China. Am. J. Trop. Med. Hyg. 65, 272–278.
Guo, J., Li, Y., Gray, D., Ning, A., Hu, G., Chen, H., Davis, G.M., Sleigh, A.C., Feng, Z., Mcmanus, D.P., Williams, G.M., 2006. A drug-based intervention study on the importance of buffaloes for human Schistosoma japonicum infection around Poyang Lake, People's Republic of China. Am. J. Trop. Med. Hyg. 74, 335–341.
Li, S.Z., Zheng, H., Abe, E.M., Yang, K., Bergquist, R., Qian, Y.J., Zhang, L.J., Xu, Z.M., Xu, J., Guo, J.G., Xiao, N., Zhou, X.N., 2014. Reduction patterns of acute schistosomiasis in the People's Republic of China. PLoS Negl. Trop. Dis. 8, e2849.
Li, Z.J., Ge, J., Dai, J.R., Wen, L.Y., Lin, D.D., Madsen, H., Zhou, X.N., Lv, S., 2016. Biology and control of snail intermediate host of Schistosoma japonicum in The People's Republic of China. Adv. Parasitol. 92, 197–236.
Liang, S., Yang, C., Zhong, B., Qiu, D., 2006. Re-emerging schistosomiasis in hilly and mountainous areas of Sichuan, China. Bull. World Health Organ. 84, 139–144.
Liu, Y., Zhou, Y.B., Li, R.Z., Wan, J.J., Yang, Y., Qiu, D.C., Zhong, B., 2016. Epidemiological features and effectiveness of schistosomiasis control programme in mountainous and hilly region of The People's Republic of China. Adv. Parasitol. 92, 73–95.
Liu, Y., Zhong, B., Wu, Z.-S., Liang, S., Qiu, D.-C., Ma, X., 2017. Interruption of schistosomiasis transmission in mountainous and hilly regions with an integrated strategy: a longitudinal case study in Sichuan, China. Infect. Dis. Poverty 6, 79.
Maegraith, B., 1958. Schistosomiasis in China. Lancet 1, 208–214.
Mao, C.P., 1948. A review of the epidemiology of schistosomiasis japonica in China. Am. J. Trop. Med. Hyg. 28, 659–672.
Mao, S.P., Fu, S., 1989. Schistosomiasis in China. Prog. Clin. Parasitol. 1, 121–141.
Mao, S.P., Shao, B.R., 1982. Schistosomiasis control in the people's Republic of China. Am. J. Trop. Med. Hyg. 31, 92–99.
Mcmanus, D.P., Dunne, D.W., Sacko, M., Utzinger, J., Vennervald, B.J., Zhou, X.N., 2018. Schistosomiasis. Nat. Rev. Dis. Primers 4, 13.
Ministry of Health, 2000. Handbook for Schistosomiasis. Shanghai Sciece &Technology Press, Shanghai.
Ross, A.G., Olveda, R.M., Acosta, L., Harn, D.A., Chy, D., Li, Y., Gray, D.J., Gordon, C.A., Mcmanus, D.P., Williams, G.M., 2013. Road to the elimination of schistosomiasis from Asia: the journey is far from over. Microbes Infect. 15, 858–865.
Ross, A.G., Olveda, R.M., Chy, D., Olveda, D.U., Li, Y., Harn, D.A., Gray, D.J., Mcmanus, D.P., Tallo, V., Chau, T.N., Williams, G.M., 2015. Can mass drug administration lead to the sustainable control of schistosomiasis? J. Infect. Dis. 211, 283–289.
Shi, L., Li, W., Wu, F., Zhang, J.F., Yang, K., Zhou, X.N., 2016. Epidemiological features and control progress of schistosomiasis in waterway-network region in The People's Republic of China. Adv. Parasitol. 92, 97–116.
Sun, L.-P., Wang, W., Zuo, Y.-P., Hong, Q.-B., Du, G.-L., Ma, Y.-C., Wang, J., Yang, G.-J., Zhu, D.-J., Liang, Y.-S., 2017. A multidisciplinary, integrated approach for the elimination of schistosomiasis: a longitudinal study in a historically hyper-endemic region in the lower reaches of the Yangtze River, China from 2005 to 2014. Infect. Dis. Poverty 6, 56.
Utzinger, J., Zhou, X.N., Chen, M.G., Bergquist, R., 2005. Conquering schistosomiasis in China: the long march. Acta Trop. 96, 69–96.
Wang, L.D., Utzinger, J., Zhou, X.N., 2008. Schistosomiasis control: experiences and lessons from China. Lancet 372, 1793–1795.
World Health Organization, 1985. The Control of Schistosomiasis. Report of a WHO Expert Committee, Geneva.
Xu, J., Steinman, P., Maybe, D., Zhou, X.N., Lv, S., Li, S.Z., Peeling, R., 2016. Evolution of The National Schistosomiasis Control Programmes in The People's Republic of China. Adv. Parasitol. 92, 1–38.
Yuan, H., Jiang, Q., Zhao, G., He, N., 2002. Achievements of schistosomiasis control in China. Mem. Inst. Oswaldo Cruz 97 (Suppl 1), 187–189.
Zhang, L.J., Li, S.Z., Wen, L.Y., Lin, D.D., Abe, E.M., Zhu, R., Du, Y., Lv, S., Xu, J., Webster, B.L., Rollinson, D., Zhou, X.N., 2016a. The establishment and function of schistosomiasis surveillance system towards elimination in The People's Republic of China. Adv. Parasitol. 92, 117–141.
Zhang, S.Q., Sun, C.S., Wang, M., Lin, D.D., Zhou, X.N., Wang, T.P., 2016b. Epidemiological features and effectiveness of schistosomiasis control programme in Lake and marshland region in The People's Republic of China. Adv. Parasitol. 92, 39–71.
Zhou, X.N., Wang, L.Y., Chen, M.G., Wu, X.H., Jiang, Q.W., Chen, X.Y., Zheng, J., Utzinger, J., 2005. The public health significance and control of schistosomiasis in China–then and now. Acta Trop. 96, 97–105.
Zhou, X.N., Guo, J.G., Wu, X.H., Jiang, Q.W., Zheng, J., Dang, H., Wang, X.H., Xu, J., Zhu, H.Q., Wu, G.L., Li, Y.S., Xu, X.J., Chen, H.G., Wang, T.P., Zhu, Y.C., Qiu, D.C., Dong, X.Q., Zhao, G.M., Zhang, S.J., Zhao, N.Q., Xia, G., Wang, L.Y., Zhang, S.Q., Lin, D.D., Chen, M.G., Hao, Y., 2007. Epidemiology of schistosomiasis in the People's Republic of China, 2004. Emerg. Infect. Dis. 13, 1470–1476.