CHAPTER THIRTEEN

Contribution of NIPD-CTDR to the parasitic diseases control and elimination in China: Memory of the 70th anniversary for NIPD-CTDR

Ning Xiao*,†, Shi-Zhu Li†, Men-Bao Qian†, Zhi-Gui Xia†, Qing Yu†, Qin Liu†, Shan Lv†, Xiao-Nong Zhou*

National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention; Chinese Center for Tropical Diseases Research; Key Laboratory of Parasite and Vector Biology, Ministry of Health; National Center for International Research on Tropical Diseases, Ministry of Science and Technology; WHO Collaborating Centre for Tropical Diseases, Shanghai, People's Republic of China
*Corresponding authors: e-mail address: xiaoning@nipd.chinacdc.cn; zhouxn1@chinacdc.cn

Contents

Abstract

China has achieved a great success in control and elimination of key parasitic diseases. In 2007, the elimination of lymphatic filariasis was verified by WHO. The schistosomiasis incidence and snail-distributed areas have reduced to the lowest level in the history. The transmission and disease burden of echinococcosis have been contained largely, and the populations infected with soil-transmitted trematode and food-borne parasites have also shown a significantly declining trend. Because of rapid globalization and climate changes, however, many new challenges have arisen. In his paper, the 2020–2030 roadmaps towards the control and elimination of these key parasitic diseases are

† These authors equally contribute to this paper.

Advances in Parasitology, Volume 110
ISSN 0065-308X
https://doi.org/10.1016/bs.apar.2020.02.003

described. Moreover, China is actively implementing its global health strategy, and will be more and more engaged into global health affairs, in which a series of China-Africa health cooperation projects have been in planning with a wish of making a greater contribution to the SDGs.

1. Introduction

Parasitic diseases have been one of the most important global public health issues. Because these diseases are closely linked with many socio-economic factors such as poor health knowledge, poor sanitation facilities, and unhealthy life and production ways as well as poverty, the infected populations are mostly living in tropical, sub-tropical and remote areas where are far behind developed. The parasitic diseases severely influence the children's growing, the labour force of the adults, and health of all age groups even life lost, which causes a very high disease burden. Since the establishment of the People's Republic of China (China), under the leadership of Chinese Communist party and governments, the stage-specific strategies and measures have been taken including local conditions based and integrated interventions in China. In 2007 lymphatic filariasis has been eliminated nationwide. Since then, no locally-transmitted cases have been reported yet. The incidence and snail-distributed areas of schistosomiasis have gone down to the lowest point in the history. The transmission and disease burden of echinococcosis have been contained primarily. The populations affected by the soil-transmitted trematode have significantly declined in numbers and density. The infections with food-borne parasites show a down trend as well. Currently three prioritized parasitic diseases, schistosomiasis, malaria and echinococcosis, have been in the list for well control and elimination with a definitive time. According to the China national health action plans and goals, malaria will be eliminated by 2020, and schistosomiasis will be eliminated by 2030, while echinococcosis, soil-transmitted helminths and food-borne parasitic diseases be effectively under control.

Schistosomiasis caused by *Schistosoma japonicum* was one of major infectious diseases in China and endemic over 2100 years (Zhou et al., 2005). This disease caused a plenty of deaths and destroyed many rural villages. The disease was most endemic in the valley of Yangtze River and the south, including 12 provinces, i.e., Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Zhejiang, Yunnan, Sichuan, Fujian, Guangdong, Guangxi and Shanghai. It was estimated that more than 12 million patients (with 5% of advanced

cases) in 322 counties and 100 million people were at risk of schistosomiasis in mid-1950s (Ross et al., 1997). In addition, one million cattle were recorded with the infection. The areas inhabited by *Oncomelania hupensis*, the intermediate host of *S. japonicum*, were 14.3 billion m^2. Schistosomiasis strikingly threatened the health of human and livestock and hence hindered the socio-economic development.

Malaria was once seriously epidemic in China, mainly in 24 provinces. After the establishment of the People's Republic of China, the government at all levels have taken consistent efforts in malaria control and made remarkable achievements (Tang, 1999; Zhou, 1981). Particularly in 2010, China released the China Malaria Elimination Action Plan (2010 – 2020), which is a milestone from malaria control to elimination in China. The action plan calls for two-steps elimination process. By 2015, most parts achieve malaria-free, and by 2020, all of the country achieves the goal of eliminating malaria. Through the implementing the action plan, China achieved zero report of local malaria cases in 2017, and continues maintaining no locally-transmitted malaria case. China's strategies, measures and roadmap for malaria control and elimination are of great significance to other low and middle-income epidemic countries for reference (Feng et al., 2018; MOH, 2010).

Echinococcosis (hydatid disease) is a vital chronic zoonotic parasitic disease, which is widely endemic in the areas with animal husbandry in the world. China has a high prevalence of human cystic echinococcosis (CE) and one of the highest prevalence of human alveolar echinococcosis (AE) worldwide. A Chinese national echinococcosis survey of 2012–2016 indicated that the prevalence of population was 0.28% and 50 million people at risk, and more than 98% of the cases were distributed in the western agricultural and pastoral areas, Inner Mongolia, Sichuan, Tibet, Gansu, Qinghai, Ningxia and Xinjiang. The prevalence appears a westward spreading trend. Therefore, according to the phase goal for echinococcosis control to be achieved in 2020, the Chinese government has formulated a prevention and control plan of 2016–2020 (NHC, 2016; Wang, 2016; Wu et al., 2018).

Soil-transmitted helminthiases and food-borne helminthiases were historically highly prevalent in China (Qian et al., 2019). Soil-transmitted helminthiases once distributed around the country, but nowadays most cases distribute in less developed southwestern areas (Zhou, 2018). Clonorchiasis is caused by ingestion of raw freshwater fish containing the larvae of *Clonorchis sinensis*. It is still ranking the most important food-borne parasitic diseases in eastern China (Qian et al., 2012, 2013, 2016).

Massive control activities promoted the decrease of *Taenia solium* taeniasis and cysticercosis in China especially in northern areas. However, local endemic focuses are still demonstrated in western China where traditional pig husbandry, poor sanitation and the ingestion of raw pork coexist (Qian et al., 2019).

This paper summarizes the achievements made and the lessons learned during the process of parasitic diseases control in China till now, and afterwards to describe a roadmap and strategy for next decade programmes. It aims to provide a technical support in reaching the goals of the Health China 2030 and the sustainable development goals (SDGs) inclusive of tropical diseases control approved by the United Nations.

2. Achievements of parasite disease control programmes in China

Chinese government have paid high attention to the health issues caused by the key parasitic diseases and consistently taken actions to control. After seven decades of efforts with particular in this century, great achievements have been made in control of the key parasitic diseases such as schistosomiasis, malaria, lymphatic filariasis and echinococcosis. Regarding to lymphatic filariasis with an over 50-years period and three phases of control activities including preparation, control and surveillance, the incidence was made a sharp reduction from over 30 million of cases at the beginning of P.R. China establishment down to zero infection, and got the WHO certification on the 9th May 2007, which marks a successfully complete block of filariasis transmission and realizes the lymphatic filariasis-free nationwide. Afterwards, through sustainable epidemiological surveillance and care for the chronic patients, the elimination status has been effectively maintained.

A great success in schistosomiasis control has also been achieved in China. First, the epidemiology of schistosomiasis declines to the lowest level. By the end of 2018, five provinces, Shanghai, Zhejiang, Fujian, Guangdong and Guangxi, maintain the elimination over 20 years. Sichuan province has reached the criteria of the transmission interruption. The rest of six provinces reached the criteria of the transmission control. Up to now, the elimination or transmission interruption was achieved in 387 (86.0%) out of 450 endemic counties. The remaining 63 counties achieved the criteria of the transmission control. The number of human cases reduced to 37,601 (Zhang et al., 2020). No acute human cases, infected snails or

livestock have been reported. Second, the control strategy of infection sources implemented since 2006 has been effective. Only 14 parasitologically-diagnosed patient were found from 8.4 million of populations in 2017, which reduced by 97.67% compared to 2016 (Zhang et al., 2017, 2018a,b). A total of 737,016 cattle were registered in endemic areas in 2017. Only one out of 454,830 examined cattle was found infected. No infected snail has been found since 2013 across the country. Third, the integrated measures were conducted smoothly. A total of 184 thousand of cattle were fenced in endemic areas (Zhang et al., 2017, 2018a,b). There 1.8 million acres of paddy field were transformed into dry land. The area of newly established fishing ponds was 1.4 million acres. A total of 2679 km of irrigation channels and 1004 km of rivers were consolidated to destroy the snail habitats. A supply of safe water covered 3.9 million of people in the endemic areas. The forest for prohibiting infestation of snails reached 1.4 billion m^2. Fourth, the knowledge rate was significantly elevated. The knowledge rate of schistosomiasis control among students and residents were over 90%.

As one of the most important tropical diseases in the history, the main achievements in malaria prevention and control are as follows: first, the number of malaria cases decreased significantly from more than 30 million a year in the 1940s to zero in 2007. In the early days of the founding of the People's Republic of China, the number of the cases ranked first among all kinds of infectious diseases. Through nearly 70 years of continuous efforts from control to elimination, the epidemic situation has been effectively controlled (Yin et al., 2014). Second, the malaria types and the mortality gradually decreased. In 2017, China reported no locally-transmitted cases, while in 2018 China reported 2678 malaria cases, including 5 clinical, 397 *P. vivax*, 1765 *P. falciparum*, 83 *P. malariae*, 376 *P. ovale* and 52 mixed infections, but all of them were the imported cases either. It has been the second consecutive year of no reported local infections since 2017, indicating a remarkable achievements made (Zhang et al., 2018a,b, 2019).

To date, although it is comparatively slow, echinococcosis control has made an obvious progress in China. First, since the national echinococcosis control programme started in 2006, the project implementation counties have extremely expanded from 10 counties in 2006 to 370 in 2019, with a total of 278.5×10^4 person-time accumulated screening on populations by type-B ultrasonic examination, 2.23×10^4 person-time accumulated treatment with albendazole drugs, 2.66×10^4 accumulated patients operated

by surgery, 190.1×10^6 times dogs population to be given deworming, and 4.73×10^4 registered patients (data till to 2018) during this periods. Furthermore, the a great effect has been achieved that the prevalence rate of the residents living in the endemic areas showed 74.07% decreasing from 1.08% in 2004 to 0.28% in 2016 by combined efforts of multi-sectors including agriculture, water conservancy and education at all the levels (NHC, 2006; Wu et al., 2018; Yu et al., in press). To ensure the national echinococcosis control programme to be implemented as expected, according to incomplete statistics during 2005 to 2019, the central government only has invested a total of 1.5 billion Yuan (RMB) on comprehensive measures consisting of the patients' screening, treatment and management, dogs' deworming and containment, surveillance of endemic situation and factors, and the capacity building inclusive of laboratory construction accordingly. Second, the nationwide surveillance network has been set up to monitor the prevalence and related risky factors in all the endemic counties. In 2015, 20 sentinel sites covering Inner Mongolia, Sichuan, Yunnan, Tibet, Gansu, Qinghai, Ningxia, Xinjiang and Xinjiang Production and Construction Corps (XPCC) were selected for pilot, while in 2016, Chinese Center for Disease Control and Prevention (China CDC) released the national surveillance guideline (as 2016 edition) and the surveillance counties expanded to 140. According to the surveillance data in 2017, it indicated that a higher prevalence of echinococcosis appeared in the areas of the Qinghai-Tibet plateau giving a prevalence rate of 0.56% in human population, a positive rate of 3.21% in the dogs' faecal antigen test, a positive infection rate of 2.08% in domestic animals (yaks or sheep) and a positive infection rate of 2.00% for rodents including pikas. Based on the results collected by this surveillance network, consequently, the National Health Committee of China decides to set up sentinel sites throughout all the endemic counties in 2019 (NHC, 2010). Third, the Provincial Reference Laboratory for diagnosis and test of the echinococcosis pathogens have been established. To strengthen the capacity for the pathogen detection, an establishment of the network of the reference laboratory at provincial level has been in processing in the endemic provinces since 2015. Main tasks are to improve equipment in laboratory and professional training. By 2019, five the reference laboratories have been functioning in Qinghai, Gansu, Sichuan, Xinjiang Ningxia, respectively. Four, based on the effects and key role of the joint control mechanism with focus on control at adjacent zone of the severe endemic between different provinces/autonomous regions as done for schistosomiasis, malaria and other parasitical diseases, the same cooperation

mechanism was first carried out in the five provinces of Tibet, Qinghai, Sichuan, Gansu and Yunnan, in which the synchronous activities are done for dog deworming, patient screening, health education as well as information sharing and communications. Moreover, in 2017 the national expert committees for echinococcosis control and clinical treatment were set under the leadership of the National Health Committee, which strengthens technical supports for the intervention and management of canines infectious source, patients' treatment by drugs, surgery and others. Five, along with the demonstration areas setting up, many innovative techniques for interventions and diagnostic tools have been developed. A good research cooperation mechanism has been established among varies of institutions and universities in China, which most are funded by the National nature and science funds and the national key project, respectively. In particular, to guarantee the target of 2020 to be achieved, the National Health Committee attempts to establish several comprehensive demonstration areas of echinococcosis control and prevention, with a pilot in Shiqu County of Sichuan Province in 2015. And the areas have subsequently been expanded to 28 areas in 2019. In these areas, a series of techniques or products have been developed for field use. The electronic collar and ID identification system for dogs management, an instant diagnosis tool with high sensitivity, specificity and convenience, a iris recognition techniques in combination with fingerprint identification for population screening, molecular detection for the infections of livestock and rodents, praziquantel-laced baits for deworming of stray dogs and wild canines delivered by the unmanned aerial vehicle (UAVs), as well as varieties of health education products have been developed and tested at these zones. All in all, a group of innovations have played a key role not only in the demonstration areas but also in other endemic areas when have been transformed and applied (Jiang et al., 2017).

Soil-transmitted helminthiases were historically highly endemic in China (Qian et al., 2019). Three national surveys have been implemented in China, which promote the mapping as well as subsequent interventions. During 1988–1992, the first national survey on important parasitic diseases was carried out, in which the overall prevalence of soil-transmitted helminthiases reached 53.6%, namely, 646 million of people under infection (Xu et al., 1995). High infection was demonstrated in whole country. The prevalence of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm infections were 47.0%, 18.8% and 17.2%, respectively. Then, the second national survey was conducted in 2001 and 2004, according to which the prevalence of

soil-transmitted helminthiases declined to 19.6% overall and about 129.0 million of persons were estimated to be infected (Coordinating Office of the National Survey on the Important Human Parasitic Diseases, 2005). Correspondingly, the prevalence of *A. lumbricoides*, *T. trichiura* and hookworm infections was 12.7%, 4.6% and 6.1%, respectively. Most of the infections distributed in southern areas. The third national survey was carried out during 2014–2015, in which the prevalence of soil-transmitted helminthiases further dropped to 4.5% and there was an estimation of 29.1 million of people under infection (Zhou, 2018). The prevalence of three species was 1.4%, 1.0% and 2.6%, respectively. Nowadays, soil-transmitted helminthiases are majorly endemic in southwestern China, especially in Sichuan, Yunnan and Guizhou provinces. Clonorchiasis is currently the most important food-borne trematodiasis in China (Qian et al., 2016). Compared to the significant control of many other parasitic diseases in China, the epidemiological status of food-borne clonorchiasis fluctuates (Qian et al., 2019). The prevalence of clonorchiasis was 0.31% in the first national survey between 1988 and 1992 (Chen et al., 2012). High endemicity was demonstrated in the southeast and northeast areas, as well as some central areas. Because of the more accessibility to freshwater fish owing to aquatic development, the prevalence of clonorchiasis increased to 0.58% in the second national survey in 2001–2004 (Chen et al., 2012). During 2001–2004, another special survey was conducted for clonorchiasis in 27 endemic provinces, in which an estimated prevalence reached 2.4% (Chen et al., 2012). Therefore, 12.5 million of people were estimated under infection with *C. sinensis*. Most cases came from four provinces in southeastern and northeastern areas, namely, Guangdong, Guangxi, Heilongjiang and Jilin. Then, according to the updated survey conducted in 2014–2015, the prevalence decreased to 0.47% and about 6.0 million people were under infection (Zhou, 2018). Most cases distributed still in the above four provinces. The significant decrease is attributed to recent implementation of control activities in some endemic areas. However, the number under infection might be underestimated.

Historically, *T. solium* Taeniasis and cysticercosis were also high endemic in China, especially in northern parts (Qian et al., 2019). Owing to the awareness on the importance of *T. solium* cysticercosis, large-scale intervention was adopted between 1970s and 1990s. Core measures included the deworming for persons with taeniasis, inspection of pork, management of human faeces and pigs, and treatment and management of infected pigs (Ma et al., 1992). Owing to these measures, *T. solium* cysticercosis had

decreased significantly in China, especially in northern areas. As to the three national surveys on important parasitic diseases in China, the estimated population infected with *Taenia* spp. decreased from 1.3 million in 1988–1992 to 0.55 million in 2001–2004 and further to 366,200 in 2014–2015 (Hotez et al., 1997; Yu et al., 1994; Zhou, 2018). However, all three species of *Taenia* spp. (*T. solium*, *T. saginata* and *T. asiatica*) are endemic in China, and most of the cases belong to *T. saginata* and *T. asiatica* (Li et al., 2013a,b). Although the accurate map for *T. solium* cysticercosis is not available, it is nowadays majorly endemic in western China where there exist traditional pig husbandry, poor sanitation and ingestion of raw pork (Zang et al., 2019a,b).

3. Challenges for parasitic disease control

It is obvious that great achievements on control of parasitic diseases have been made in China currently. However, because a lot of changes in public health system and heath policy followed by the economic reform and opening to the outside world, many new challenges have arisen, particular in control of schistosomiasis, malaria and echinococcosis.

The challenges to schistosomiasis control include: (1) The transmission of schistosomiasis is complex with many mammals involved as the reservoirs of *S. japonicum* (Chen, 2014). Although schistosomiasis has well controlled in human and livestock in China, many risk factors still remain. (2) It is very difficult in shrinking the distribution of snail due to a remarkably large range and complex environment. The distribution of snail was around 0.36 billion m^2 in last decades (Wang et al., 2015). In addition, re-emergency of snails are frequently observed in some endemic areas (Liu et al., 2008). (3) The infections among high-risk population are still a big concern in some region. A survey conducted in 2013 indicated that the prevalence of schistosomiasis among fishing and boating people was 5.62%, while the acute infections in human accidentally occurred, such as 13 and 9 acute human cases were reported in 2012 and 2013, respectively (Li et al., 2013a,b, 2014). (4) It is difficult in maintaining the achievement in newly transmission-interrupted areas. Some new infections and re-occurrence of snails were observed in abovementioned areas. As the environments suitable for snail infestation are not completely changed, the transmission of schistosomiasis is thus possible. (5) The capacity of professional agencies and the surveillance system is weakened due to declining investment as well.

The main challenges to malaria prevention and elimination are as follows. First, the number of imported malaria cases is increasing, especially for increasing of the number of the imported cases from Africa year by year, which brings severe challenges to the elimination of malaria in China. At present, there are nearly 3000 imported malaria cases in China every year, including *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi,* posing a potential risk of malaria transmission in areas with vectors' distribution (Yin et al., 2013). Second, after the elimination of malaria, the prevention and control capacity might reduce but the risk of re-transmission remains. Therefore, we still need emphasizing the importance of malaria surveillance and response, and maintaining the essential institutions and capacity, strengthening government leadership, multisectoral cooperation, mobilizing the whole society's participation, and enhancing the joint efforts along the border. Otherwise, we may fail to consolidate the malaria-free achievement (Li et al., 2016).

The challenges for echinococcosis control are as follows. First, it is hard to control definitive hosts' infections. Regarding to a huge number and wide distribution of domestic and stray dogs as well as wild animals (wolves and foxes), it is a big challenge to deal with about 3 million dogs in the endemic areas, which cause environment contaminated seriously (Liu et al., 2017; Xiao et al., 2004, 2006). In addition, under the plateau climatic conditions, it extends the survival of echinococcial eggs, which benefits to maintain the transmission. It is also make the situation worse with a longer breeding cycle in large number of yaks, sheep and other livestock and habit to use animal organs feeding on canines animals (Xiao et al., 2003). Second, a large number of patients have been detected with a huge disease burden and need to be treated effectively. According to national surveys and population screening in the endemic areas, more than 40,000 patients have recorded in the whole country, and since 2011, there has nearly been 3000 new patients diagnosed every year, all of whom wait for medical assistance. Third, the residents have poor knowledge of echinococcosis control and prevention. Based on the relevant surveys, the results indicated that the local residents' awareness of the prevention, hygienic conditions and living habits and customs are very poor, particular in the Qinghai-Tibet plateau region. Fourth, innovation is very crucial for speed-up the disease control. Echinococcosis is one of chronic diseases with a long-term incubation period (up to 30 years). It is very difficult in definitive diagnosis at an early-developed stage due to lack of good tools. Surgery is a radical treatment approach but reports

with 15–20% of recrudescence (Eckert and Deplazes, 2004; McManus et al., 2003; Schantz et al., 2003; Torgerson et al., 2010; Xiao et al., 2012; Zhang et al., 2015).

Although soil-transmitted helminthiases continue decreasing in China, there exist some challenges for further control. First, a high imbalance is demonstrated in geographic distribution of soil-transmitted helminthiases in China (Qian et al., 2019). Significant control has been achieved in developed eastern China and the prevalence even approaches to zero in some provinces, but a high endemicity still occurs in southwestern China, which impacts the national control progress. Second, the composition of dominant species has changed. In first national survey, ascariasis and trichuriasis were the most important (Xu et al., 1995). Currently hookworm infections, however, have become dominant, and this challenges the traditional tools and strategies which are more effective against ascariasis and trichuriasis. However, social and economic development and subsequent improvement of water and sanitation are crucial contributors to further control and even transmission interruption of soil-transmitted helminthiases in China (Qian et al., 2015).

Unlike the significant control of many other helminthiases owing to massive control activities and economic development, the determinants of clonorchiasis persist in the endemic areas in China. First, aquatic development provides the high affordability of raw freshwater fish, that's why the endemicity of clonorchiasis even worsens in some areas (Qian et al., 2014). New techniques promote the cultivation of freshwater fish in many big natural water bodies, which increases the challenges in management of human and animal faeces as transmission sources. Second, the ingestion of raw freshwater fish is rooted in habitants in endemic areas, which is very difficult to change (Qian et al., 2016). Thus, although chemotherapy is high effective, it is usually unsustainable due to high re-infection. Third, compared to other parasitic diseases, the research and development on tools and strategies for clonorchiasis lag behind, which could not meet the need for control (Qian and Zhou, 2019). Thus, on the one hand, more researches are expected to develop new tools and strategies. On the other hand, high priority and more resources should be advocated to control clonorchiasis.

Many determinants drive the persistent endemicity of *T. solium* cysticercosis in local areas in western China (Zang et al., 2019a,b). There still exists traditional pig husbandry, and pigs could roam free in villages. Less economic development in remote areas leads to the inadequate accessibility

to sanitation, and thus there exists open defecation. Thus, roaming pig could access to human faeces. The pork inspection is still inadequate in remote markets. Furthermore, the ingestion of raw pork is still popular in some areas. These factors drive local completion of the cycle of human taeniasis, *T. solium* cysticercosis in human beings and pigs. However, national poverty alleviation programme is improving the living conditions including husbandry and sanitation in these less developed areas, which contributes to the control of *T. solium* cysticercosis there.

Additionally, China is also facing an increasing threat of imported parasitic diseases. Some rarely reported or even non-epidemic diseases have been detected, which brings great challenges to the prevention and control of these parasitic diseases in China. Human African trypanosomiasis (HAT) is one of the representatives. Human African trypanosomiasis, also known as sleeping sickness, is a human zoonosis which is transmitted by tsetse fly. The disease is mainly prevalent in 36 sub-Saharan African countries (WHO, 2013) and caused by two sub-species of *Trypanosoma brucei*-*T. brucei gambiense* causes chronic disease in western and central Africa and *T. b. rhodesiense* is associated with acute disease in eastern and southern Africa (Büscher et al., 2017). Since 2014, three cases of imported HAT have been diagnosed and treated in China (Chen et al., 2019c; Liu et al., 2018; Wang et al., 2018). The first case was a 45 years old man who acted as a sailor working on a freighter in Gabon from July 8, 2010 to July 15, 2014. During this period, he often shuttled in tropical jungle and valley with the bites of mosquitoes and flies. In October 2012, he got fever and skin itchy in Gabon and was treated locally pertain to his symptoms. On July 15, 2014, he got fever, drowsiness and mental symptoms and generalized lymphadenopathy. On September 9, 2014, Trypanosoma was detected in the blood smear of the patient and the white blood cell in the cerebrospinal fluid was 90. So, according to the clinical manifestations, epidemiology and laboratory test results it was confirmed that was the first *T. brucei gambiense* infection case in China, and it was in the second stage. The second case was a 41 years old women, who was visited Kenya and Tanzania from July 22 to August 6, 2017. During this process, she was bitten by tsetse fly. After returning to China on August 8, she had a high fever (40.1 °C) along with symptoms of dizziness, fatigue and rigours. On August 11, 2017, Trypanosoma was detected in the blood smear of the patient and the white blood cell in the cerebrospinal fluid was 2. According to the clinical manifestations, epidemiology and laboratory test results, this case was the first imported *T. brucei rhodesiense*

infection in China. And it was in the first stage. The third case was 59 year old men, who was also a sailor working in Gabon from 2009 until 2017. One year ago (in 2016), he was bitten by insect like tsetse fly in Gabon and developed fever (up to 40 °C) and fatigue, headache. Since then the patient's body temperature has been repeated with a high fever, mainly in the afternoon, accompanied by night sweats. Two weeks ago, the patient slept in a coma. On August 30, 2017, Trypanosoma was detected in the patient's blood smear and the white blood cell in the cerebrospinal fluid was 119. So, according to the clinical manifestations, epidemiology and laboratory test results it was confirmed that was the second *T. brucei gambiense* infection case in China, and it was in the second stage.

All these cases were treated by the related drugs which delivered from WHO. Two cases were cured after 2 years follow up, but it was a pity that the first case died due to treatment failure. In the process of treatment of the above cases, there was a thorny problem that the effective drugs such as eflornithine, pentamidine, suramin, nifurtimox and others. Those mentioned above are not reserved in China and it was very complicated for applying them for entry to China, which will waste time and brings huge risks to save the life of the critical patients.

4. Roadmap for parasitic diseases control

Every 5 years, the Chinese central government formulates the control plans regarding to different groups of key parasitic diseases. These plans provide the governments at all levels with strategic direction and guidance to take action towards the goals.

Schistosomiasis: the national conference on schistosomiasis control held by the State Council in November 2014 set forth the goal of elimination, which symbolizes a new stage of schistosomiasis control. Three years later the planning framework of Health China 2030 was issued by the Central Committee of the Communist Party and the State Council of China definitively declares to eliminate schistosomiasis by 2030. The 13th Five-Year Plan of Schistosomiasis Control and the Special Three-Year Tough Plan of Endemic Diseases Control (2018–2020) also clarified a roadmap of schistosomiasis control in China (Fig. 1). According to the plan, the elimination or transmission interruption will be achieved in 437, accounting for 96.5% of counties by 2020; namely, no new infection in human, livestock or snail in those counties was found over five consecutive years. The schistosomiasis elimination strategy is mainly based on following

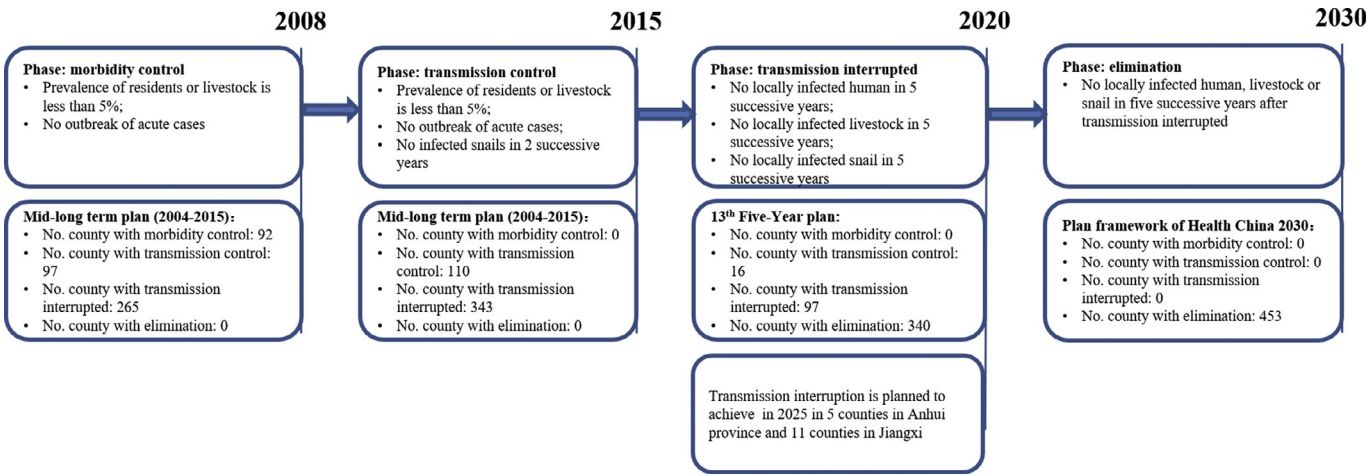

Fig. 1 Roadmap of schistosomiasis control and elimination.

principles: (1) the government leads schistosomiasis control and multiple departments participate, (2) the prevention is first and the treatment is supplementary, (3) the strategy is differentiated for endemic types and the management is differentiated in provinces, (4) multiple measures and goal-oriented management are implemented. Six approaches are recommended to the goal of elimination as following:

First, to strengthen case management and precision strategy. Treatment of symptomatic patients is taken into consideration in the National Program of Poverty Alleviation. Schistosomiasis is listed among diseases supported by the national basic health insurance and assistance plan. The patients including asymptomatic infections will be registered and followed up by community health facilities.

Second, to strengthen implementation of integrated measures focusing on the management of infection source. In endemic area the local government promotes the stable breeding of livestock and forbid the grazing in grassland infested by *O. hupensis*. Replace of farming cattle with machine will be financially supported by government. The utilization of faeces container on boat will be encouraged. The snail control will rely on the joint projects of water conservancy, agriculture, land management and forestry.

Third, to strengthen monitoring and evaluation (M&E). M&E will cover all the endemic communities and run in an informationized system. The M&E information in schistosomiasis control will be shared through the management system of Health and Medical Assistance Program for Poverty Alleviation.

Fourth, to strengthen the mobilization and knowledge delivery. Diversified materials of health education will be developed and forward through multiple media, particularly using popular platforms, e.g., wechat and blog.

Fifth, to strengthen capacity building. The capacity will be maintained or enforced in the counties by the national surveillance and annual national match on pathogen detecting techniques. The national network of labs has also been established to conduct annual training.

Sixth, to enhance research and translation. The following field will be given priorities: elimination roadmap and the verification tools, crucial technology in elimination of schistosomiasis in livestock, spatio-temporal evolution of control and elimination roadmaps, the national survey and collection of specimens of *S. japonicum* and *O. hupensis*, testing of compatibility between *S. japonicum* and *O. hupensis*, sensitive diagnostics for mild infection and asymptomatic infections, development and evaluation of security and effective molluscicide. Establishment of the bio-bank of

S. japonicum, *O. hupensis* as well as positive serum and faeces from the patients is in planning to provide the materials for further research.

Malaria: according to China Malaria Elimination Action Plan (2010–2020) and the report on malaria epidemic situation from 2006 to 2008, the country is divided into the following four categories by county: Type 1 county with local infection in 3 years and the incidence rate is greater than or equal to 1/10,000. Type 2 county, at least 1of 3 years with local infection and the incidence less than 1/10,000. Type 3 counties, no local cases for 3 years. Type 4 counties, non-malaria-endemic areas. Different malaria elimination roadmaps and strategies have been developed according to the type of endemic counties. In Type 1 counties, to strengthen the source of infection control and vector control measures to reduce the incidence of malaria. In Type 2 counties, to remove the source of malaria infection and block the local transmission of malaria. In Type 3 counties, to strengthen surveillance and imported cases disposal to prevent secondary transmission. In Type 4 counties, to take a quick response to any imported cases for detection and treatment. Based on the elimination roadmap, the Type 3 counties achieve the goal of eliminating malaria by 2015, while all the Type 2 counties and the Type 1 counties to achieve no local cases of malaria by 2015 and the goal of eliminating malaria by 2018, with an exception of some border areas in Yunnan. Type 1 counties in the border areas in Yunnan achieve the incidence of malaria less than 1/10,000 by 2015, no local malaria cases by 2017, and the goal of eliminating malaria by 2020 (Fig. 2) (Tang, 2016).

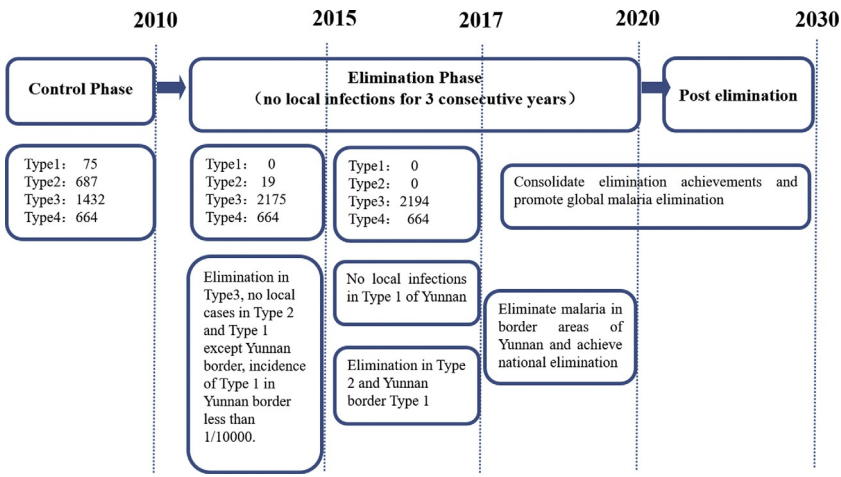

Fig. 2 Roadmap of malaria elimination in China.

From 2020 to 2030, it will continue to strengthen capacity of the public health system and malaria surveillance system, timely take action to the threat of imported malaria, and respond to the construction of human destiny community and the "healthy silk and road" initiative, actively participate in global health cooperation, provide technical support to Africa and southeast Asia in malaria control and elimination, share the Chinese experiences and lessons, and promote the process of global malaria elimination (Lai et al., 2017).

Echinococcosis: A national long-term control programme through comprehensive interventions has been implemented to target the morbidity reduction by the year of 2020 in endemic areas, in which human echinococcosis prevalence rate and dog infection rate at least in 70% endemic counties will achieve <1% and <5%, respectively. Furthermore, the echinococcosis infection rate in livestock should achieve less than 8% under age of 2 years old, and 90% coverage of the patients' management, surveillance on disease endemics and factors, and other control index. Meanwhile, safe water supply will ensured with a coverage of 95% in residents' settlements in endemic areas.

By 2030, it will achieve: (1) echinococcosis prevalence rate in primary school children is <1‰; (2) dog infection rate of *Echinococcus* spp. <1%; (3) echinococcosis infection rate in livestock <1%; and (4) echinococcal infection rate in rodents <1‰. To reach the objectives above, it will depend on implementing the comprehensive strategies and measures, consisting of strengthening control of the infection source of canines and intermediate hosts, slaughtering management and livestock immunization, decreasing of rodent density, clean water supply, health education and development of innovation tools (Fig. 3) (NHC, 2016; PR China, 2016).

Soil-transmitted helminthiases and food-borne helminthiases: Based on the national control plan, the prevalence of soil-transmitted helminthiases by 2020 targets to be decreased by 20% compared to that in 2015 in major endemic provinces and that of clonorchiasis by 30% meanwhile (NHC, 2016). The target of soil-transmitted helminthiases is promising owing to continuing economic development and further improvement in provision of clean water and sanitation (Qian et al., 2019). To achieve the target for clonorchiasis is challenging because of high popularity in eating raw freshwater fish and limited control activities. Nowadays, the plans for soil-transmitted helminthiases and food-borne helminthiases are not yet available for 2025 and beyond. However, it is expected to further control soil-transmitted helminthiases nationally. It is argued to implement hierarchical targets (Fig. 4): to achieve infection control in southwestern China

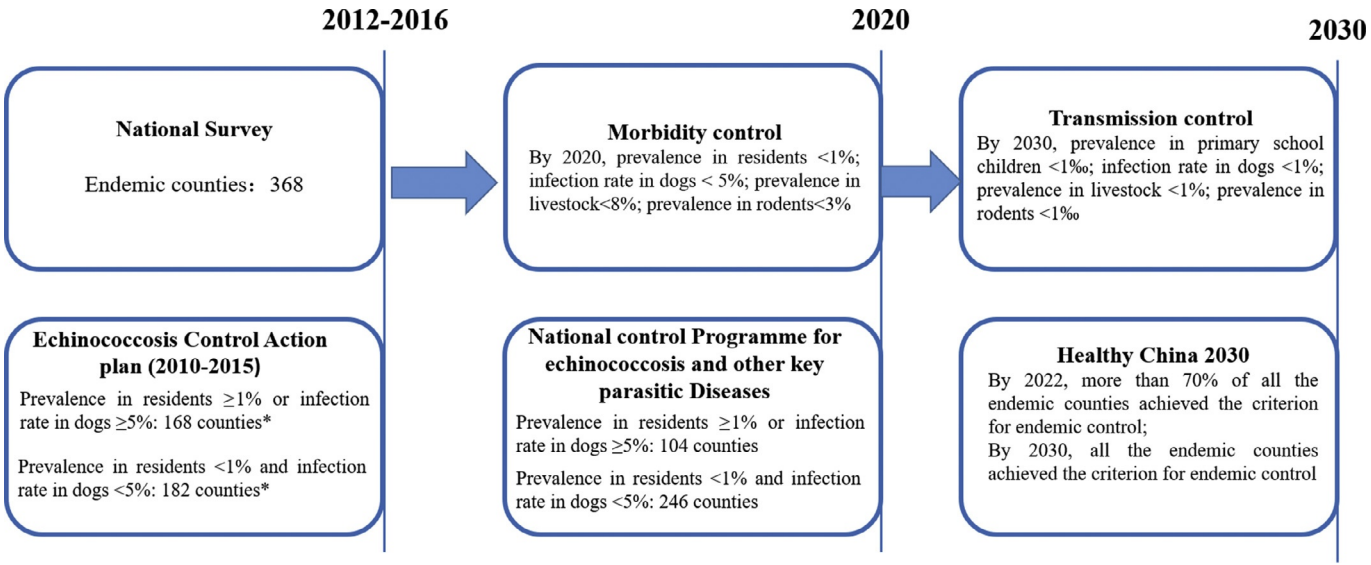

Fig. 3 Roadmap for echinococcosis control and prevention in China.

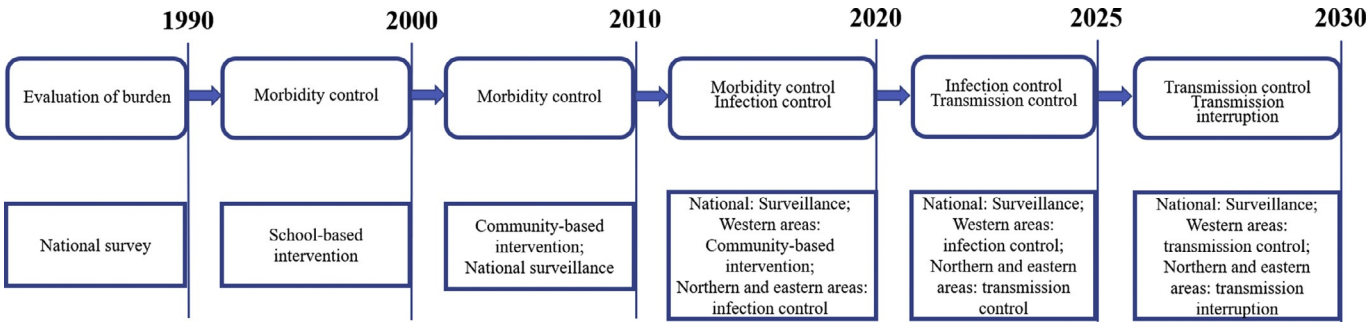

Fig. 4 Roadmap for control of soil-transmitted helminthiases in China.

and transmission control in northern and eastern China by 2025. Then, by 2030 more ambitious targets should be set, namely, transmission control in western China and transmission interruption in northern and eastern China. As to clonorchiasis, the overall target is argued to further control the morbidity in major endemic areas (Qian et al., 2019). Some pilots for *T. solium* cysticercosis are being implemented to explore the control strategy in western areas and elimination strategy in other low-endemic areas (Qian et al., 2019).

5. Role and how to influence the global situation of the new roadmap from China

Great achievements on control of parasitic diseases made in China greatly attribute to government's leadership, multisectoral cooperation, scientific and characteristic control strategy at different periods, phases and regions, community mobilization and experts' technical support. Because Chinese experiences also are highly regarded as the part of global knowledge, it is worth sharing it with other endemic countries. China is actively implementing its global health strategy, by which all-round international cooperation on health has highlighted with emphasizing the countries along one belt and one road (B&R). Through strengthening of the south-south cooperation and of the capacity building on the systems related to key diseases control, a series of China-Africa health cooperation projects have been designed and carried out. Fully utilizing high-level dialogue mechanism between nations, China is actively engaged into global health governance and make its impacts on formulation of the international criteria, regulations and guidelines, all of which will make great contribution to the SDGs (Fig. 5).

For schistosomiasis, great achievements in schistosomiasis control have been made in China. The experience from China is being recognized by international researchers and organizations. The China Government emphasizes the health cooperation with African countries. The first trial of schistosomiasis control is ongoing in Zanzibar with mass drug administration (MDA) and snail control. The primary results imply that the experience is working in the trial. We believe that the China's experiences could contribute more to achieving the goal of the global control of schistosomiasis.

For malaria, in order to further promote malaria control process globally, the world health organization (WHO) put forward the global

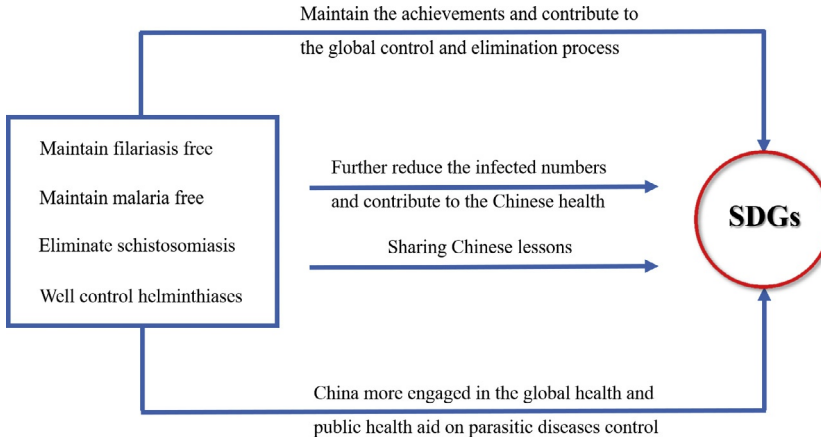

Fig. 5 China's contribution towards the global tropical diseases.

malaria technical strategy for 2015–2030, with the goals set: by 2030, the global malaria morbidity and mortality will decrease by more than 90%, and at least 35 countries achieve malaria elimination and prevent malaria re-transmission. China's malaria elimination path planning provides evidence support to the national malaria elimination goals, strategies, technical measures and timeframe, which ensures the realization of the goal. With China's success in controlling malaria, other endemic countries are looking forward to learning from China's experiences and lessons, while China will assume more international obligations and responsibilities. China's action to set up anti-malaria centers in 30 African countries has aroused the expectation of African countries. China will push forward the China-Africa cooperation at a higher level and provide greater help to African countries in combination with the investment on production export and technological research and development besides its experience on malaria control. It is anticipated that there will be more international cooperation projects in the future, which will also require China to send more CDC professionals oversea to provide technical support (WHO, 2015; Xia et al., 2014, 2017).

For echinococcosis, a national survey in 2012 and 2016 indicated that China has the highest prevalence of echinococcosis and the disease burden, accounting for 40% estimation of the world. It is known that the target against echinococcosis has been set by 2020 and 2030, and great progress made by means of implementing the comprehensive control strategy and measures. Based on the experiences accumulated, it would be very helpful

to share with neighbour endemic countries and regions under the co-operation framework along "The Belts and Roads" initiated by China. Moreover, it will also benefit other endemic countries by sharing the technology and products, by which the process of the disease control will be accelerated (Angela et al., 2016; Chen et al., 2019a,b,c; PR China, 2016; Xiao et al., 2013; Yu and Zhou, 2019).

For soil-transmitted helminthiases and food-borne helminthiases, historically, China harboured a large number of the populations under infection. Thus, on the one hand, the significant control in China contributes to the global control progress (Qian et al., 2015, 2019). On the other hand, China's experiences could also be shared with other endemic countries to contribute to the people's health (Chen et al., 2019a,b,c). As to soil-transmitted helminthiasis, the experiences could be learned and applied in Africa, Southeast Asia and Latin America. Although the prevalence of clonorchiasis is still high in China, many tools and techniques have been developed (Qian and Zhou, 2019). Because clonorchiasis and another human liver fluke-*Opisthorchis viverrini* infection are highly endemic in Southeast Asia, thus these useful tools and techniques could be tried and adopted in other endemic countries. The successful control of *T. solium* cysticercosis in northern China could also provide experiences for other endemic countries.

6. Conclusion and perspectives

Parasitic diseases and infections are accompanied with poverty, unhealthy living styles and production patterns as well as environmental contamination. Therefore, with greatly developing the economy and promoting civilized society, China has formulated the Planning Outline of the Health China 2030, proposed the concept of guaranteeing Chinese residents all life-cycle health, and implemented the Three-year Action Tackling Key Endemic Diseases and Health China Action (2019–2030), which aim to carry out a series of health-specific poverty alleviation projects with focus on the populations living at remote, ethnic minority, border and endemic areas. From 2020 to 2030, under the strong governmental leadership, multisectoral cooperation and community participation, China will further strengthen the capacity building of its public health system and diseases surveillance. Through these efforts, China strives for maintaining the achievements of lymphatic filariasis and malaria elimination, effectively dealing with the potential risk caused by the imported pathogens and vectors. Simultaneously China continues to promote eliminating schistosomiasis

threat, controlling echinococcosis transmission, getting the infections further down at scale and degree, and reducing health damage from food-borne parasitic diseases.

As only national institute for parasitic diseases control and research and national center for tropical diseases research, the National Institute of Parasitic Diseases (NIPD) of Chinese Center for Disease Control and Prevention will consistently play a leading role in developing control and elimination strategies, scientific and technological innovation, professional training and degree education. NIPD will effectively serve as a key advisory institution for the National Health Commission of China and make greater contribution to achieving eliminating parasitic disease threat to health. Based on previous accumulated cooperation experiences on disease control and public health aid, China will be more and more engaged into global health affairs, deepen and widen the cooperation network and partnership, share the Chinese experiences and lessons on tropical diseases control and elimination. All of these efforts will greatly promote global progress of parasitic diseases control and elimination, and contribute to building a community with a shared future for mankind.

References

Angela, M., Cadavid, R., Yang, Y.R., et al., 2016. The landscape epidemiology of echinococcoses. Infect. Dis. Poverty 5, 13.

Büscher, P., Cecchi, G., Jamonneau, V., et al., 2017. Human African trypanosomiasis. Lancet 390, 2397–2409.

Chen, M., 2014. Assessment of morbidity due to *Schistosoma japonicum* infection in China. Infect. Dis. Poverty 3, 6.

Chen, Y.D., Zhou, C.H., Xu, L.Q., 2012. Analysis of the results of two nationwide surveys on *Clonorchis sinensis* infection in China. Biomed. Environ. Sci. 25, 163–166.

Chen, J., Bergquist, R., Zhou, X.N., Xue, J.B., Qian, M.B., 2019a. Combating infectious disease epidemics through China's belt and road initiative. PLoS Negl. Trop. Dis. 13, e0007107.

Chen, J., Ding, W., Li, Z., et al., 2019b. From parasitic disease control to global health: new orientation of the National Institute of Parasitic Diseases, China CDC. Acta Trop. 201, 105219. https://doi.org/10.1016/j.actatropica.2019.105219.

Chen, N., Jin, K., Xu, J., Zhang, J., et al., 2019c. Human African trypanosomiasis caused by *Trypanosoma brucei gambiense*: the first case report in China. Int. J. Infect. Dis. 79, 34–36.

Coordinating Office of the National Survey on the Important Human Parasitic Diseases, 2005. A national survey on current status of the important parasitic diseases in human population. Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi 23, 332–340, (in Chinese).

Eckert, J., Deplazes, P., 2004. Biological, epidemiological and clinical aspects of echinococcosis: a zoonosis of increasing concern. Clin. Microbiol. Rev. 17, 107–135.

Feng, J., Zhang, L., Huang, F., Yin, J.H., Tu, H., Xia, Z.G., Zhou, S.S., Xiao, N., Zhou, X.N., 2018. Ready for malaria elimination: zero indigenous case reported in the People's Republic of China. Malar. J. 17, 315.

Hotez, P.J., Zheng, F., Long-qi, X., Ming-gang, C., Shu-hua, X., Shu-xian, L., Blair, D., McManus, D.P., Davis, G.M., 1997. Emerging and reemerging helminthiases and the public health of China. Emerg. Infect. Dis. 3, 303–310.

Jiang, B., Zhou, X.N., Zhang, H.B., Tao, Y., Huo, L.L., Liu, N., 2017. Slow-release praziquantel for dogs: presentation of a new formulation for echinococcosis control. Infect. Dis. Poverty 6, 140.

Lai, S.J., Li, Z.J., Nicola, A.W., Sun, J.L., Michael, G.H., Huang, Z.J., et al., 2017. Malaria in China, 2011–2015: an observational study. Bull. World Health Organ. 95, 564–573.

Lei, Z.L., Zheng, H., Zhang, L.J., Zhu, R., Xu, Z.M., Xu, J., Fu, Q., Wang, Q., Li, S.Z., Zhou, X.N., 2014. Endemic status of schistosomiasis in People's Republic of China in 2013. Chin. J. Schisto. Control 26, 591–597.

Li, S.Z., Zheng, H., Gao, J., Zhang, L.J., Zhu, R., Xu, J., Guo, J.G., Xiao, N., Zhou, X.N., 2013a. Endemic status of schistosomiasis in People's Republic of China in 2012. Chin. J. Schisto. Control 25, 557–563.

Li, T., Chen, X., Yanagida, T., Wang, H., Long, C., Sako, Y., Okamoto, M., Wu, Y., Giraudoux, P., Raoul, F., Nkouawa, A., Nakao, M., Craig, P.S., Ito, A., 2013b. Detection of human taeniases in Tibetan endemic areas, China. Parasitology 140, 1602–1607.

Li, Z., Zhang, Q., Zheng, C., Zhou, S., Sun, J., Zhang, Z., Geng, Q., Zhang, H., Wang, L., Lai, S., Hu, W., Clements, A.C., Zhou, X.N., Yang, W., 2016. Epidemiologic features of overseas imported malaria in the People's Republic of China. Malar. J. 15, 141.

Liu, H.X., Zhang, Y., Hu, L., Zhu, D., Wu, Y., Lv, S., Guo, J.G., Wu, X.H., Zhou, X.N., 2008. Analysis of re-emergence of *Oncomelania hupenis* in area where schistosomiasis transmission-interrupted in China. J. Pathogen. Bio. 3, 440–442.

Liu, H., Xiao, N., Yang, S.J., Wang, D., Peng, J., 2017. Epidemiological characteristics of canine *Echinococcus* infection in Qinghai-Tibet Plateau of China. Chin. J. Schisto. Control 29, 129–138.

Liu, Q., Chen, X.L., Chen, M.X., et al., 2018. Trypanosoma brucei rhodesiense infection in a Chinese traveler returning from the Serengeti National Park in Tanzania. Infect. Dis. Poverty 7, 50.

Ma, Y.X., Xu, C.B., Shao, L., Zhu, Y.G., Xu, J.T., Kang, Q.D., 1992. Achievements, status and countermeasures on control of taeniasis and cysticercosis during past 40 years in China. Zhongguo Gong Gong Wei Sheng 8, 244–246, (In Chinese).

McManus, D.P., Zhang, W., Li, J., Bartley, P.B., 2003. Echinococcosis. Lancet 362, 1295–1305.

MOH, 2010. National Malaria Elimination Action Plan (2010–2020). Beijing, Ministry of Health.

National Health and Family Planning Commission of the People's Republic of China, 2016. National Control Plan on Echinococcosis and Other Key Important Parasitic Diseases in China (2016–2020). http://www.nhc.gov.cn/jkj/s5873/201702/dda5ffe3f50941a29fb0aba6233bb497.shtml, (in Chinese).

National Ministry of Health of the People's Republic of China, 2006. National Control Plan on the Prevention and Control of Key Parasitic Diseases (2006–2015). http://www.moh.gov.cn/mohbgt/pw10604/200804/27592.shtml.

National Ministry of Health of the People's Republic of China, 2010. National Action Plan for the Prevention and Control of Echioncoccosis (2010–2015). http://www.nhfpc.gov.cn/zwgkzt/wsbysj/201012/50041.shtml.

Qian, M.B., Zhou, X.N., 2019. Human liver flukes in China and ASEAN: time to fight together. PLoS Negl. Trop. Dis. 13, e0007214.

Qian, M.B., Chen, Y.D., Liang, S., Yang, G.J., Zhou, X.N., 2012. The global epidemiology of clonorchiasis and its relation with cholangiocarcinoma. Infect. Dis. Poverty 1, 4.

Qian, M.B., Chen, Y.D., Yan, F., 2013. Time to tackle clonorchiasis in China. Infect. Dis. Poverty 2, 4.
Qian, M.B., Chen, Y.D., Yang, Y.C., Lu, M.F., Jiang, Z.H., Wei, K., Wei, S.L., Zhou, C.H., Xu, L.Q., Zhou, X.N., 2014. Increasing prevalence and intensity of foodborne clonorchiasis, Hengxian County, China, 1989-2011. Emerg. Infect. Dis. 20, 1872–1875.
Qian, M.B., Xia, S., Zhou, X.N., 2015. Soil-transmitted helminths in China. Lancet Infect. Dis. 15, 1262–1263.
Qian, M.B., Utzinger, J., Keiser, J., Zhou, X.N., 2016. Clonorchiasis. Lancet 387, 800–810.
Qian, M.B., Chen, J., Bergquist, R., Li, Z.J., Li, S.Z., Xiao, N., Utzinger, J., Zhou, X.N., 2019. Neglected tropical diseases in the People's Republic of China: progress towards elimination. Infect. Dis. Poverty 8, 86.
Ross, A.G.P., Li, Y.S., Sleigh, A.C., McManus, D.P., 1997. Schistosomiasis control in the People's Republic of China. Parasitol. Today 13, 152–155.
Schantz, P.M., Wang, H., Qiu, J., et al., 2003. Echinococcosis on the Tibetan plateau: incidence and risk factors for cystic and alveolar echinococcosis in Tibetan populations in Qinghai Province, China. Parasitology 127, S109–S120.
Tang, L.H., 1999. Chinese achievements in malaria control and research. Chin. J. Parasitol. Parasit. Dis. 17, 257–259, (in Chinese).
Tang, L.H., 2016. Goal, strategies and roadmap of malaria elimination in China. China Trop. Med. 16, 301–304, (in Chinese).
The People' republic of China, 2016. Healthy China 2030. [EB/OL]. [2016-10-25]. http://www.nhfpc.gov.cn/xcs/wzbd/201610/21d120c917284007ad9c7aa8e9634bb4.shtml.
Torgerson, P.R., Keller, K., Magnotta, M., Ragland, N., 2010. The global burden of alveolar echinococcosis. PLoS Negl. Trop. Dis. 4, e722.
Wang, G.Q., 2016. Epidemiological Survey on Echinococcosis in China. Shanghai Science and Technology Press.
Wang, Q., Xu, J., Zhang, L.J., Zheng, H., Ruan, Y., Hao, Y.W., Li, S.Z., Zhou, X.N., 2015. Analysis of endemic changes of schistosomiasis in China from 2002 to 2010. Chin. J. Schisto. Control 27, 229–234.
Wang, X., Ruan, Q., Xu, B., et al., 2018. Human African trypanosomiasis in emigrant returning to China from Gabon, 2017. Emerg. Infect. Dis. 24, 400–404.
WHO, 2013. Control and surveillance of African trypanosomiasis. Report of a WHO Expert Committee. World Health Organ. Tech. Rep. Ser. 881, 1–114. I-VI.
WHO, 2015. Global Technical Strategy for Malaria 2016–2030. World Health Organization, Geneva.
Wu, W.P., Wang, H., Wang, X., Zhou, X.N., Wang, L.Y., Zheng, C.J., Cao, J.P., Xiao, N., Wang, Y., Zhu, Y.Y., 2018. A nationwide survey on echincoccosis in China during 2012–2016. Chin. J. Parasitol. Parasit. Dis. 36, 1–14.
Xia, Z.G., Wang, R.B., Wang, D.Q., Feng, J., Zheng, Q., Deng, C.S., et al., 2014. China–Africa cooperation initiatives in malaria control and elimination. Adv. Parasitol. 86, 319–337.
Xia, Z.G., Xu, M., Zhao, J.K., Lai, S.J., Zhou, X.N., 2017. An overview on cooperation strength between China and the Global Fund to Fight AIDS, Tuberculosis and Malaria in developing multilateral malaria control projects. Chin. J. Parasitol. Parasit. Dis. 35, 520–526, (in Chinese).
Xiao, N., Qiu, J.M., Nakao, M., Nakaya, K., Yamasaki, H., Sako, Y., Mamuti, W., Schantz, P., Craig, P.S., Ito, A., 2003. Identification of *Echinococcus* species from a yak in the Qinghai-Tibet Plateau region of China. Am. J. Trop. Med. Hyg. 69, 445–446.
Xiao, N., Li, T.Y., Qiu, J.M., Nakao, M., Chen, X.W., Nakaya, K., Yamasaki, H., Schantz, P.M., Craig, P.S., Ito, A., 2004. The Tibetan hare *Lepus oiostolus*: a novel intermediate host for *Echinococcus multilocularis*. Parasitol. Res. 92, 352–353.

Xiao, N., Nakao, M., Qiu, J.M., Budke, C.M., Giraudoux, P., Craig, P.S., Ito, A., 2006. Dual infection of animal hosts with different *Echinococcus* species in the eastern Qinghai-Tibet plateau region of China. Am. J. Trop. Med. Hyg. 75, 292–294.

Xiao, N., Zhou, Z.J., Chen, X.W., Zeng, Y.Z., Wang, Z.Y., Lei, Y., Tian, Y., Huang, Y., Yi, D.Y., Li, Y.Q., Wu, W.P., 2012. Assessment of health education against echinococcosis in Tibetan region of Sichuan Province, China. Chin. J. Parasitol. Parasit. Dis. 30, 6–11.

Xiao, N., Yao, J.W., Ding, W., Giraudoux, P., Craig, P.S., Ito, A., 2013. Priorities for research and control of cestode zoonoses in Asia. Infect. Dis. Poverty 2, 16.

Xu, L.Q., Yu, S.H., Jiang, Z.X., Yang, J.L., Lai, L.Q., Zhang, X.J., Zheng, C.Q., 1995. Soil-transmitted helminthiases: nationwide survey in China. Bull. World Health Organ. 73, 507–513.

Yin, J.H., Yang, M.N., Zhou, S.S., Wang, Y., Feng, J., Xia, Z.G., 2013. Changing malaria transmission and implications in China towards National Malaria Elimination Programme between 2010 and 2012. PLoS One 8, e74228.

Yin, J.H., Zhou, S.S., Xia, Z.G., Wang, R.B., Qian, Y.J., Yang, W.Z., et al., 2014. Historical patterns of malaria transmission in China. Adv. Parasitol. 86, 1–19.

Yu, Q., Zhou, X.N., 2019. Discussion on strategies of health literacy promotion for chinococcosis control in China. Chin. J. Schisto. Control 31, 94–97.

Yu, S., Xu, L., Jiang, Z., Xu, S., Han, J., Zhu, Y., Chang, J., Lin, J., Xu, F., 1994. Report on the first nationwide survey of the distribution of human parasites in China. Regional distribution of parasite species. Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi 12, 241–247, (in Chinese).

Yu, Q., Xiao, N., Wu, W.P., Tian, T., Wang, L.W., Wang, Y., Han, S., Yang, S.J., Zhou, X.N., 2020. Effectiveness over 10 Years (2004–2014) of the Echinococcosis Control Progamme in China. Acta Trop. in press.

Zang, X.Z., Li, H.Z., Liu, H.K., Liu, Y.H., Zhou, C.H., Chen, Y.D., Qian, M.B., Li, S.Z., 2019a. Epidemiological analysis of new cases of cysticercosis in Dali Prefecture, Yunnan Province from 2014 to 2017. Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi 31, 143–147, (in Chinese).

Zang, X.Z., Li, H.Z., Qian, M.B., Chen, Y.D., Zhou, C.H., Liu, H.K., Liu, Y.H., Li, S.Z., 2019b. Extensive disseminated cysticercosis: a case report in Yunnan province, China. BMC Infect. Dis. 19, 535.

Zhang, W., Zhang, Z., Wu, W., Shi, B., Li, J., Zhou, X., et al., 2015. Epidemiology and control of echinococcosis in Central Asia, with particular reference to the People's Republic of China. Acta Trop. 141, 235–243.

Zhang, L.J., Xu, Z.M., Qian, Q.J., Dang, H., Lv, S., Xu, J., Li, S.Z., Zhou, X.N., 2017. Endemic status of schistosomiasis in People's Republic of China in 2016. Chin. J. Schisto. Control 29, 669–677.

Zhang, L., Feng, J., Zhang, S.S., Xia, Z.G., Zhou, S.S., 2018a. The progress of national malaria elimination and epidemiological characteristics of malaria in China in 2017. Chin. J. Parasitol. Parasit. Dis. 36, 201–209, (in Chinese).

Zhang, L.J., Xu, Z.M., Dai, S.M., Dang, H., Lv, S., Xu, J., Li, S.Z., Zhou, X.N., 2018b. Endemic status of schistosomiasis in People's Republic of China in 2017. Chin. J. Schisto. Control 30, 481–488.

Zhang, L., Feng, J., Zhang, S.S., Xia, Z.G., Zhou, S.S., 2019. Epidemiological characteristics of malaria and the progress towards its elimination in China in 2017. Chin. J. Parasitol. Parasit. Dis. 37, 241–247, (in Chinese).

Zhang, L.J., Xu, Z.M., Dai, S.M., Dang, H., Lv, S., Xu, J., Li, S.Z., Zhou, X.N., 2020. Endemic status of schistosomiasis in People's Republic of China in 2018. Chin. J. Schisto. Control 31, 576–582, accepted.

Zhou, Z.J., 1981. The malaria situation in the People's Republic of China. Bull. World Health Organ. 59, 931–936.
Zhou, X.N., 2018. Report on the National Survey of Important Human Parasitic Diseases in China (2015). People's Medical Publishing House, Beijing, (in Chinese).
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.

Further reading

Wang, Q., Huang, Y., Huang, L., Vuitton, D.A., Giraudoux, P., Craig, P.S., Wu, W.P., 2014. Review of risk factors for human echinococcosis incidence on the Qinghai-Tibet Plateau, China: a prospective for control options. Infect. Dis. Poverty 3, 3.
Yu, Q., Xiao, N., Yang, S.Y., Han, S., 2017. Deworming of stray dogs and wild canines with praziquantel-laced baits delivered by an unmanned aerial vehicle in areas highly endemic for echinococcosis in China. Infect. Dis. Poverty 6, 117.
Yu, Q., Liu, H., Xiao, N., 2018. Unmanned aerial vehicles: potential tools for use in zoonosis control. Infect. Dis. Poverty 7, 49.