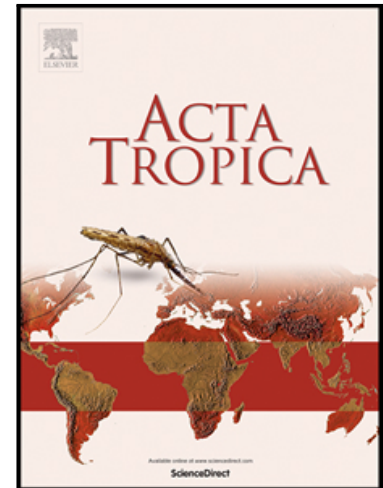


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From parasitic disease control to global health: new orientation of the National Institute of Parasitic Diseases, China CDC

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Abstract

As the only specialized institution for research and control of parasitic diseases at the national level in China for almost 70 years, the National Institute of Parasitic Diseases (NIPD) at the Chinese Center for Disease Control and Prevention (China CDC) has been instrumental in supporting the remarkable progress from high prevalence to transmission interruption or low endemicity of several diseases, lymphatic filariasis, malaria and schistosomiasis in particular. This has taken place through technical guidance, emergency response and scientific research as well as providing technical service, education, training, health promotion and international cooperation. With China's increasing involvement in international cooperation and the increased risk for (re)emerging tropical diseases in mind, the Chinese Government designated in 2017 a new Center for Tropical Disease Research to NIPD. Responding to the expanded responsibilities, the institute is scaling up its activities in several ways: from parasitic diseases to the wider area of tropical diseases; from disease control to disease elimination; from biological research to policy evidences accumulation; and from public health to global health. Based on this new vision and China's previous accomplishments in the areas mentioned, the institute is in a position to move forward with respect to global health and equitable development according to the central principles of the United Nations' Sustainable Development Goals.

Key words: National Institute of Parasitic Diseases, China CDC; Parasitic diseases control; Global health; New orientation

1 Introduction

National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention (NIPD, China CDC - <http://en.ipd.org.cn>) is the only institution at the national level specialized on parasitology research and control of parasitic diseases in the country. The institute has a history for 70 years. Its earliest precursor, the Huadong Branch of the National Institute of Health was established in 1950 when the parasitic diseases were highly endemic in China. It was named as the Institute of Parasitic Diseases (IPD), Chinese Academy of Medical Sciences (CAMS) in 1956. During the following years, it focused on the research of main parasitic diseases, namely malaria and schistosomiasis. Until 1983, the Chinese Academy of Preventive Medicine (CAPM) was created by separating institutions from the CAMS, including the IPD which started to develop in multiple directions, such as the control and treatment of schistosomiasis, malaria, lymphatic filariasis (LF), leishmaniasis, and soil-transmitted helminths. On 23 January 2002, CAPM was formally re-organised the China CDC, and the IPD became the NIPD, which was assigned the responsibility for the control and prevention of all parasitic diseases in the country.

Along the its development within China, the institute actively took part in international cooperation since its establishment and was in 1980 designated the World Health Organization (WHO) Collaborating Centre for Malaria, Schistosomiasis and Filariasis

(Zhou et al., 2005). This status was retained until early 2015, when it was re-designated WHO Collaborating Centre for Tropical Diseases to further expand and enhance cooperation. Responding to the global cooperation in ending tropical disease epidemics, in 2017 the Chinese central Government designated a new Center for Tropical Disease Research (CTDR) with a global health agenda, particularly in the control of LF, malaria and schistosomiasis.

As a national centre of excellence with respect to parasitic diseases, the NIPD/CTDR carries out technical guidance for disease control, emergency response, scientific research, technical services, education and training, health promotion, and international cooperation (Zhou et al., 2005). The institute has 191 staff with 42 senior experts in 11 professional departments (the organizational structure is shown in Figure 1) (2015b). During near 70 years, the growing NIPD witnesses and devotes to the control to elimination of parasitic diseases in China. The increasing international and national responsibilities added to the NIPD make it a more important contributor to global health. The aim of this paper is to summarize the progresses achieved by the NIPD and define the development of NIPD/CTDR with new orientation to global health through a gap analysis.

2 Diseases Control and Elimination

2.1 Surveillance and response: from establishment and preparation to action

In cooperation with provincial institutions of disease control, the NIPD has over the years developed more than 1,000 monitoring sites for LF, malaria, schistosomiasis, soil-transmitted helminths (STH), food-borne trematodes (FBT), echinococcosis, etc.. The epidemic data reported from sites were generated to applicable information through exaction and synthesis on exchange platform for dissemination. Supported by the information management system and an early warning model with computerized prediction, the NIPD constructed an early warning system (EWS) and a dynamic/real-time, epidemical network for the surveillance of the parasitic diseases in the country which can be used to assess disease risk and the effectiveness of target interventions. To make sure that all involved in this scheme were kept abreast, the NIPD regularly released weekly or monthly reports on parasitic diseases endemicity (2015a).

The NIPD also established an outbreak contingency plan and emergence response mechanism for parasitic diseases adhering to the principle of prevention-orientation and target intervention. Epidemic outbreak warnings are regularly issued based on the surveillance data collected. Professional teams conduct emergence surveillances and issue alerts in time in response to any reported epidemic and also follow up by evaluation activities. In the NIPD, the task was assigned to the Emergency Response Office (EOC), which has set up this National Network of Parasitic Diseases Expertise, whose function is to coordinate the work of the Emergency Response Team and the Expert Committee in charge. The EOC ensures that all information on professional equipment and therapies/drugs for emergency response ($N \geq 20$) is regularly updated by a group of trained staff (2015a), and sees to it that staff capabilities is continuously followed up and improved by regular training in China and abroad. Individual self-protection and field

survival is component of staff training. The response makes sense as emergencies have occurred , such as in the management of imported human African trypanosomiasis in 2017 and 2015, and teams have been dispatched to respond in such cases, e.g., the West Africa Ebola outbreak in 2014 and the Wenchuan Earthquake in 2012.

2.2 Disease elimination: from control to elimination

During 70 years, China witness the remarkable progress in the control of parasitic diseases (Figure 2). The NIPD has been exemplary in national control programmes on these diseases, for example, control of LF, malaria and schistosomiasis, which has been the backbone of contributions of the NIPD for decades. While the NIPD also contribute to the dramatic decrease of prevalence of STH and FBT. The NIPD has completed the epidemiology survey of echinococcosis in China towards developing a national strategy for its control. The institute has carried out several projects to other vector-borne parasitic diseases, providing technical support to scaling up the national control programmes.

2.2.1 LF elimination

China is the first country to eliminate LF after nearly 60 years' of control activities (De-Jian et al., 2013). Two large-scale surveys in the late 1950s and early 1970s in China showed that 16 provinces/autonomous regions/municipalities were highly endemic for LF (Figure A.1). The disease was eliminated in 2006 and validated to be so by WHO in 2007. This achievement resulted from the implementation of a set of specific approaches initiated by the NIPD (Yu and Zhou, 2014):

- i. A control strategy focused on sources transmission;
- ii. Surveys based on repeated blood testing;
- iii. Mass drug administration (MDA) with diethylcarbamazine-fortified salt;
- iv. Targeting treatment to carriers; and
- v. An active vertical and horizontal monitoring system.

Since the 1950s, the institute has been devoted to LF control in terms of epidemiology, control strategies, pathogenic biology, transmission dynamics, diagnosis, drugs and treatment and surveillance. The project "Studies on the strategy for interrupting transmission of lymphatic filariasis in China and technical measures" was awarded the First Prize by the State Award for Scientific and Technological Advances. This achievement was accomplished through concerted efforts for 40 years from 17 institutions with NIDP at a core (Fang and Zhang, 2019).

2.2.2 Zero indigenous malaria

Although malaria was once highly prevalent in China, indigenous cases and epidemic areas were dramatically reduced from 1950 to 2017 (Figure A.2), with a particular drop after the launch of national malaria elimination programme in 2010, a multi-sectoral cooperation elimination strategy with clearing out infectious sources and transmission foci with simultaneous support by socio-economic development (Hu et al., 2016). Apart from 2,675 imported cases, mainly from Africa and Southeast Asia, no indigenous malaria case has been reported in whole of China since 2017 (Feng et al., 2018). In order to decrease

malaria incidence, China mobilized social and financial resources which was used for:

- i. MDA with pyrimethamine and primaquine, which involved millions of people (Feng et al., 2018).
- ii. Pyronaridine was started to use for treatment of falciparum malaria cases beginning in the 1980s (Yu and Zhou, 2014).
- iii. Use of mosquito nets and/or insecticide-treated such nets were implemented during the transmission season (Yin et al., 2014).
- iv. Nation-led efforts with multi-sectoral collaboration
- v. A reference laboratory system for prompt and precise diagnosis (Feng et al., 2018).

The progress to elimination also benefits the good performance of surveillance and response system, especially the 1-3-7 surveillance and response approach (Chen and Xiao, 2016; Lu et al., 2016) that means targeting potential cases in transmission foci (1-day case reporting; testing for cases on/before the 3rd day; targeted control on/before the 7th day). During past years, the NIPD led malaria control towards elimination cooperated with other institutions by mainly conducting epidemiological surveys, pathological and vector ecological studies, diagnostic research, drug innovation (e.g. pyronaridine) and formulation of roadmap and criteria (Yu and Zhou, 2014).

2.2.3 Interruption of schistosomiasis transmission

In the 1950s, schistosomiasis japonica was once very prevalent in regions along Yangtze River. The estimated number of infected people reached 11 million and the local infection rate across the country ranged from 10% to 90% (Maegraith, 1958; Utzinger et al., 2005). However, schistosomiasis endemicity has been much reduced during the past years (Figure A.3) (Xu et al., 2016). In addition, there is an absence of *schistosoma mansoni* and *schistosoma haematobium* infection in China, only with few imported cases reported (Habib et al., 2018). In 2017, schistosomiasis has become eliminated in five out of former 12 endemic provinces, among them one has reached the requirement of transmission interruption, and six have met the criteria of transmission control (Li-Juan et al., 2018). The lessons learnt from the national schistosomiasis control programme in highly endemicity areas have been summarised by many authors. This can be contributed by the following efforts (Chen et al., 2018; Wang et al., 2008):

- i. Political commitment promoting control activities and public-health awareness;
- ii. An integrated control strategy adapted in epidemiology settings with control of transmission source as its core;
- iii. MDA with praziquantel; and
- iv. Rigorous surveillance and monitoring of human and bovine prevalence as well as snail-infested areas.

NIPD has been contributing to schistosomiasis control varying from biological study to

intervention strategies, moving the control forward towards elimination. The comprehensive control strategy, concluded from the pilot study conducted by the NIPD and other intuitions, was adopted as the national strategy to control schistosomiasis through interventions to reduce the rate of transmission of *Schistosoma japonicum* infection from cattle and humans to snails (Wang et al., 2009).

2.3 Diseases control: from survey to intervention

2.3.1 Echinococcosis

A national survey on echinococcosis was carried out in order to formulate a long-term programme for its control. The survey, led by NIPD between 2012 and 2016, estimated the prevalence of this type of helminth infection to be 0.28% of the population consisting of 166,098 patients living in endemic areas, mainly in the western and north-western region (Figure A.4) (Wu et al., 2018). In this condition, the interventions should be implemented through target control, improved control of transmission source, early detection, diagnosis and treatment, and health education for further interventions (Wang and Cao, 2018; Wu et al., 2018).

2.3.2 STH and clonorchiasis

According to three national-scale surveys on important, parasitic diseases during 1998 – 2015 (2018), the prevalence of soil-transmitted helminth infections in China has dropped sharply (Table 1). However, the prevalence of clonorchiasis fluctuated. The decline has taken place along with the social-economic development, mechanised agricultural activities. Sustained public health movement and control efforts, including treatment and health education, promoted this progress.

Table 1. The prevalence trend of important parasitic diseases in China

Survey	Infection rate (%)	
	Soil-transmitted nematode infection	Clonorchiasis
First national survey (1988–1992)	53.6	0.31
Second national survey (2001–2004)	19.6	0.58
Third national survey (2014–2015)	4.5	0.47

2.3.3 Vector-borne diseases

Some other vector-borne parasitic diseases are prevalent in China. An estimated number of 530,000 patients were infected with visceral leishmaniasis according to the national survey in 1951. The anthroponotic visceral leishmaniasis was eliminated in 1983 mainly thanks to long-lasting insecticide initiated by the NIPD which laid the foundation to WHO guideline. As an emerging parasitic diseases, the first outbreak of *Angiostrongylus*

cantonensis infection in Wenzhou was caused by eating *Pomacea canaliculata* snails. Cooperated with other institutes, the NIPD also determined its natural foci and launched the monitoring and early warning system. In addition, the institute guided and/or operated the detection, diagnostics and treatment of some imported parasitic disease cases, such as malaria and human African trypanosomiasis.

3. Research

3.1 Innovative research: from the bench to the field

The NIPD has also deployed considerable efforts to scientific and technological development for the control of parasitic diseases, including biology of parasites and vehicles, research on parasitic infection and immunity, pathogenic and resistant mechanisms, and research on epidemic pattern and control strategies. Over the years, the NIPD has obtained more than 80 awards, particularly Prizes of National Science and Technology Progress Awards. The NIPD had 33 patents authorized and two national primary new drugs approved, and innovated about 20 diagnostic products.

Ground-breaking work has been carried out to innovate a new compound, tribendimidine, which was tested in animal and clinical trials systematically, was finally approved for production against human infection with soil-transmitted nematode. Other examples are pyronaridine for treatment of falciparum malaria cases; slow-release, molluscicidal formulations of niclosamide; and an encapsulated liquid formulation of albendazole for the long-term treatment of human echinococcosis (Yu and Zhou, 2014). As for treatment of intermediate host of schistosomiasis, the institute developed bromoacetamide in 1980s and recent PPU07 as molluscicide with less toxicity. For the (simplified) treatment of dogs, slow release formulation of praziquantel was used against echinococcosis (Yu and Zhou, 2014) (Jiang et al., 2017).

In terms of the development of novel diagnostics, the point-of-care test for the diagnosis of human clonorchiasis (Yu and Zhou, 2014), as well as loop-mediated isothermal amplification (LAMP), an isothermal nucleic acid amplification technique for the detection of *S. japonicum* DNA in pooled crushed snail material (Qin et al., 2018) and its potential role in the documentation of interruption of schistosomiasis transmission, merit to be mentioned (2015b).

A batch of advanced technologies and products has empowered the NIPD a leading role in diagnostic and detection techniques for parasitic diseases. Some research innovation at high level has been worked out, for instance, discovery of immune response and adjustment mechanism of parasitic infections, establishment of transmission mechanism models of tropical diseases, and the monitoring and forecast system for elimination of parasitic diseases (Weng et al., 2018) (2015a).

In order to make these technology contribute more to disease control, the NIPD has established field stations in five target provinces. This has led to field stations implementing innovative diseases control trials aiming to the elimination of malaria, schistosomiasis, echinococcosis and clonorchiasis (2015a). For other tropical diseases,

the NIPD has initiated several pilot projects to control STH, FBT, vector-borne parasitic diseases; and carried out the research and diagnostics on viral infection, protozoa and ectoparasites in some projects.

3.2 Application and implementation: from validity to control schemes

The NIPD has been able to provide technical support to the national plan and policy making for parasite control. The institute formulated/drafted and publicised more than 20 national plans and 43 criteria. In addition, surveillance methods, technical guidance and standardization rules were formulated and publicised. Particular examples are the development of the China National Schistosomiasis Elimination Work Plan (2016–2025), the China National Work Plan for Malaria Elimination (2010–2020) and the 13th 5-year Control Plan for Major Parasitic Disease in China (2016–2020). Furthermore, the NIPD organised the implementation of community-based interventions for disease control at field stations, including the promotion of pilot experience in national control programmes.

3.3. Information dissemination: from pamphlets to scientific publications

Relying on the available resource, the NIPD carries out health education for the prevention of parasite diseases. It produces pamphlets of various kinds for dissemination, and produces TV programmes or video for broadcasting across the country. As the Popular Science Education Base of Huangpu District, Shanghai, the Human Parasites and Vector Specimen Museum of NIPD has served for more than 37,000 people since 2011. As for the On-Topic Service of Parasitic Disease, the institute has launched 5 times of publicity about the knowledge of parasite disease prevention through popular television programmes, such as in CCTV10 “Approaching to Science”, CCTV7, Hunan Satellite TV News.

From 1950s, the NIPD has continued to increase the number and quality of its research and review articles in Chinese and English peer-reviewed journals. It has published 62 books and a total of 3,087 journal articles, mainly in the field of malaria and schistosomiasis (Figure 3). While the average annual number of papers published in Science Citation Index journals reached 72 during the most recent ten years. Most of these articles were published in parasitology-specific journals, or in the high-impact journals (Table 2), such as *New England Journal of Medicine*, *The Lancet*, *Lancet Infectious Diseases*, *Emerging Infectious Diseases*, and some others. Beside high impact factor papers, the institute also released high impact papers, for example, staff in the NIPD published related papers rapidly after Tu Youyou achieving the Nobel Prize in Physiology or Medicine in 2015 for her discoveries concerning a novel therapy against malaria (Tambo et al., 2015).

Table 2 NIPD's Publications in journals with high impact*

Title	Journal title	Publication year
A strategy to control transmission of <i>Schistosoma japonicum</i> in China.	New England Journal of Medicine	2009
China's sustained drive to eliminate neglected tropical diseases.	Lancet Infectious Diseases	2014
Communicating and monitoring surveillance and response activities for malaria elimination: China's "1-3-7" strategy.	PLoS Medicine	2014
Chinese action towards global malaria eradication.	The Lancet	2016
Clonorchiasis.	The Lancet	2016
Redefining the invertebrate RNA virosphere.	Nature	2016
Enhancing collaboration between China and African countries for schistosomiasis control.	Lancet Infectious Diseases	2016
Dynamic transcriptomes identify biogenic amines and insect-like hormonal regulation for mediating reproduction in <i>Schistosoma japonicum</i>.	Nature Communications	2017
Schistosomiasis.	Nature Reviews Disease Primers	2018
Inhibition of CRTH2-mediated Th2 activation attenuates pulmonary hypertension in mice.	The Journal of Experimental Medicine	2018
The dynamics of forming a triplex in an artificial telomere inferred by DNA mechanics.	Nucleic Acids Research	2019

* Science Citation Index Impact Factor > 10

The NIPD has launched its own open-access journal in 2012, *Infectious Diseases of Poverty* (IDP - <https://idpjournal.biomedcentral.com/>), cooperated with BioMed Central (BMC). IDP aims to identify and assess research and information gaps that hinder progress towards new interventions for specific and particular public health problems in the developing world. Moreover, it provides a platform for discussion of the issues raised in order to advance research and evidence building for improved public health interventions in poor settings. This journal has solicited substantial interest in health-related research and attracted more than one million accesses from 100 countries. The five-year Journal Impact Factor of IDP is 3.126 with peak of 4.11, while the citespace is around 2.9, which is unparalleled for a specialized international journal. As of March, 2019, 574 articles in seven volumes have been published and accessed by more than one million times.

Another journal, *Chinese Journal of Parasitic Diseases and Parasitology*, published by NIPD since 1983, serve as a stage for promoting innovative researches and scientific exchange, encouraging application of newly developed tools, updating the progress of disease control and providing evidence for policy-makers to develop/improve disease control programmes. The journal has published 6,827 papers, ranking first among the 27 preclinical medicine journals in China.

3.4 Technical Platforms: from establishing to sharing

The NIPD has fostered seven basic platforms: (i) bio-banking platform for parasite germplasm (genetic) resource collection, appraisal, and preservation, formulation of technical regulations on preservation, resource utilization and health education; (ii) diagnosis and detection platform for serum bank construction, diagnostic testing technology research, external testing services and etc.; (iii) infection monitoring and EWS by surveillance, video conferencing, emergency management; (iv) biotechnology for basic research and parasitic diseases, technical methods research; (v) platforms for drug research and development, (vi) vector control, and (vii) information services. These approaches have provided useful support to carry out experimental research and technology innovation (2015a).

The parasite germplasm platform stores living genetic resources maintained for breeding of the pool of the parasite diseases in 15 study bases in China. It collects and integrates 1115 kinds/117,814 pieces of germplasm resources physical stocks, 23 classes, 11 phylums, and data stocks with three living body preservation bases of parasite germplasm resources, its preservation volumes 39% of the same kind in China. The platform consists of including the repository of human and animal parasites and vectors, botany nematode featuring specimen, medical insect featuring specimen, fluke pattern, and vector snails pattern specimen. The institute has 38,000 pieces of parasite and vector specimens in its specimen bank. The platform has shared 16,720 pieces of these items to other institutes and projects since 2008.

3.5 Capacity-building: from degree education to diverse professional training

NIPD was authorized to deliver master and doctoral degree education since 1978. Since

then, a total of 206 Masters of Science, 56 PhDs and 32 post-doctoral fellows has graduated. In 2008, the NIPD started to enrol international post-doctoral fellows. As of 2018, a total of 9 post-doctoral fellows (from Cameroon, Egypt, Nigeria, Singapore, Switzerland, Tanzania and Togo) completed research projects at the NIPD.

The NIPD has also made efforts to technical training for the control of parasitic diseases, carrying out more than 140 course sessions, including 25 international courses with more than 500 Asian-Pacific and African participants. The topics covered malaria surveillance and evaluation, malacology, diagnostics, modelling, global health and medical writing. Regarding academic exchange, a total of 415 staff received training in 242 groups or attended conferences overseas, while a total of 319 international visitors were invited to China. Increasingly, intense international exchange underpins the capacity-building effort at the NIPD. The institute has made a substantial efforts to expose its staff to the international scientific and tropical disease research and control environment. This in turn has reinforced the capabilities of the NIPD as a WHO Collaborating Centre.

4. International engagement

4.1 International cooperation: from project-driven to active participation

Early collaboration and support for the control of schistosomiasis and malaria provided experience and prepared NIPD for further work with international partners. In the early 1980s, NIPD started to receive international recognition in the form of assistance on technical support, capacity building and funding, mainly from the World Bank, the Global Fund to Fight AIDS, Tuberculosis and Malaria (GF), WHO and the UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR). An important part of this recognition was the 10-year World Bank Loan Project (WBLP) obtained by the Chinese Government for the national schistosomiasis control programme. The World Bank committed US\$ 71 million in the form of loan to China and the Chinese Government provided a complementary US\$ 82 million as counterpart funds for control activities (Yuan et al., 2000). The WBLP was launched in 1992 with the aim of improving morbidity control through large-scale administration of praziquantel both to humans and bovines, with the NIPD appointed to be responsible for technical guidance, surveillance and project supervision (Yu and Zhou, 2014). MDA based on praziquantel was carried out complemented with health education, chemical control of snails and environmental modification. By the end of 2001, the estimated number of people with schistosomiasis had decreased by more than 50%, while the prevalence rates in humans and livestock were reduced by the similar percentage (Xianyi et al., 2005).

Malaria control in China was supported by the GF through five programme rounds between 2003 and 2012. Commissioned by the Ministry of Health (now named the National Health Committee) of China, the NIPD supervised the implementation of programmes as Principal Receipt (Yu and Zhou, 2014). During the ten years, approximately 1.1 million infected people received treatment and 1.8 million long-lasting insecticide-treated nets were distributed (Wang et al., 2014). The number of provinces reporting indigenous malaria cases fell from 24 in 2003 to five in 2011, and the number of

reported malaria cases plummeted from 100, 106 cases in 2005 to 4,498 in 2011. Integrated with the national malaria control programme, the specific Malaria Control Programme granted by the GF significantly reduced the burden of malaria, particularly in the highly prevalent regions and border areas with large migrant populations, facilitating the progress towards malaria elimination in China (Minghui et al., 2015).

4.2 International engagement: from cooperation to contribution

NIPD's extensive experience in tropical diseases control allowed the institute to be proactively involved in the international arena of disease control initiatives. The China/UK/Tanzania pilot project on malaria control followed by the China/UK/Global Health Support Programme (GHSP), funded by the Department for International Development (DFID) of UK, conducted in the Rufiji District in southern Tanzania reduced the parasite prevalence with around two-thirds after intervention for three years (Wang et al., 2019). The intervention strategy will be verified for scale-up with support of Gates Foundation. Another example is represented by the improved malaria diagnostic capacity in Papua New Guinea that started in 2016 in cooperation with the Australian Government. The other overseas project supported by International Development Research Centre aiming to develop the control strategy for solving the local tropical diseases problems were also implemented, such as the strategy of schistosomiasis and liver fluke control Cambodia, Laos and Thailand, countries belonging to the Greater Mekong sub-region. Control and elimination of other helminth zoonoses are also taking place in this sub-region, as well as investigation of new surveillance tools for malaria elimination along the China-Myanmar borders.

4.3 Global partnerships: from bilateral to multilateral

NIPD broadened its international partnerships and established networks for multilateral collaboration during the last decade. It signed a Memorandum of Understanding (MOU) on mid/long term cooperation with 13 international institutions from 2010 to 2018, half of which in the form of network partnerships. In parallel with the Regional Network on Asian Schistosomiasis and Other Helminth Zoonosis (RNAS⁺), which was set up in 1998 to promote research on schistosomiasis and other helminths in Asia, NIPD established four international networks during 2015-2018, covering the field of malaria, schistosomiasis, echinococcosis, cysticercosis and also drug and diagnostics. These partnerships and networks have common goals that foster joint projects, strengthen capacities on research, and foster collaboration of information dissemination. Detailed information is listed in Tables 3 and 4.

The NIPD launched several regular international symposia and bilateral workshops, i.e. the Symposium on Surveillance and Response System on Tropical Diseases Elimination (hosted every two years since 2012), the International Symposium for Cestode Zoonoses Control hosted every two years since 2017, and the China-Myanmar Cross Border Meeting on Malaria Elimination (hosted every year since 2014). During the symposia, participants reviewed the research progress on surveillance and response together discussing the impact of surveillance and response system on promoting disease elimination and exploring the possibility of bilateral and multilateral cooperation aiming at

corresponding mechanism for elimination of all tropical diseases.

Journal Pre-proof

Table 3. Global networks initiated by the NIPD

Network	Year of establishment	Number of partners*	Activities
The Regional Network on Asian Schistosomiasis and Other Helminth Zoonosis	1998	12 member countries	Research and control of schistosomiasis and soil-transmitted helminth diseases in southeast Asia
Institutional-based Network of Cooperation between Africa and China on Schistosomiasis	2015	10 member countries	Share experiences on schistosomiasis control and elimination; Establish research collaboration network between Africa and China on schistosomiasis control and elimination.
Chinese Society of Global Health, Chinese Preventive Medicine Association	2016	102 Chinese members	Provide intellectual and human resources support
Asia-Pacific Network on Drug and Diagnostics Innovation	2017	24 member countries/regions/territories	Share experiences and promote research collaboration between African and Chinese research institutions
The Belt and Road Network for the Elimination and Control of Echinococcosis and Cysticercosis	2017	11 members from 6 countries	Mobilize available resources and involve more multiple stakeholders for cestode zoonoses control

Institutional-based Network of Cooperation between Africa and China on Malaria	2018	7 institutions from 7 countries	Establish a cooperation network and mechanism; provide a platform for communication on malaria elimination
Malaria Elimination Network in Lancang Mekong Region	2018	3 institutions from 3 countries	Cooperation in elimination of malaria across border; experience sharing

* For list of partners, please see Appendix 1

Table 4. International NIPD partners (signed as mid- and long-term Memorandum of Understanding)

Partners	Year	Main contents
Swiss Tropical and Public Health Institute, Switzerland	2010/2016	Training, academic exchange, information sharing, scientific research
London School of Hygiene and Tropical Medicine, United Kingdom	2013	Training, academic exchange
Global Health Institute of Duke University, United States of America	2014	Academic exchange, information sharing, scientific research
Ifakara Health Institute of Tanzania, Tanzania	2014	Training, academic exchange, information sharing, scientific research
Theodor Bilharz Research Institute of Egypt, Egypt	2014	Training, academic exchange, information sharing, scientific research

Universite des Montagnes, Cameroon	2015	Training, academic exchange
Centre for Sustainable Malaria Control, University of Pretoria, South Africa	2015	Training, academic exchange
Blue Nile National Institute for Communicable Diseases, University of Gezira-Wad Medani, Sudan	2015	Training, academic exchange, information sharing
Health Poverty Action, Non-governmental Organisation	2016	Training, academic exchange, information sharing
National Center for Zoonotic Diseases, Ministry of Health, Mongolia	2018	Training
University of Montpellier, France	2018	Training, academic exchange, information sharing, scientific research
The University of Namibia, The Republic of Namibia	2018	Information sharing

5. Future perspectives

5.1 Institutional vision and strategy

For close to 70 years, the NIPD has been working on parasitic diseases control and research to improve human health in China. The institute is in the process of adding a new mandate of high-level research on tropical diseases. The NIPD/CTDR is expanding the original NIPD focus on parasitic diseases into the wider area of tropical diseases, and moving from disease control to elimination. Also other activities are changing, e.g., biological research to policy evidences accumulation and public health to global health. The new responsibilities for improving public health should no longer exclusively concern national goals but also play a role at the global level. China's increasing involvement in global health, and the augmented risk for expanded (re)emerging tropical diseases, emphasizes the need to scale up the global health agenda (Chen et al., 2019), which means that NIPD/CTDR will participate in the global developments in the new era towards a community with a new vision and a shared future for all mankind.

- **Vision** - to develop leading platforms on control and elimination of tropical diseases, providing research underpinnings and also engaging in managerial approaches from a global health perspective;
- **Mission** - to control tropical diseases effectively towards elimination through intervention, research, innovation, training and fostering, together with support services for local and international agencies as well as the public;
- **Core Value** – with shared health as its premise, all staff in NIPD/CTDR shall be rigorous in regular work, committed to diseases control, innovative in research, devoted to global health;
- **Strategy** - to further improve NIPD/CTDR's international standing in the control of tropical diseases, with summarising experiences, integrating various resources and expanding cooperation to engage in global health

5.2 Business line and work plan

5.2.1 Disease control

China has recently embarked on a national echinococcosis control programme in line with that done for LF, malaria and schistosomiasis in the country. Based on its vision, the institute is continuing to expand its technical support for control or elimination of the parasitic diseases that are still endemic in China (Qian and Zhou, 2019). For parasitic disease prevention and control, NIPD/CTDR will continue to scale up the key technology, promote the construction of support service, and improve the emergency response systems; meanwhile, the institute will carry out the control and prevention programmes

and research on imported and emerging tropical diseases. In details, the institute will formulate the strategy of eliminating parasitic diseases for scale-up, with the experiences summarised from pilot sites; establish the sensitive and efficient surveillance and early warning network depends on the data from monitoring sites; set up the diagnostic reference laboratory for schistosomiasis, malaria, and echinococcosis. The exemplary on-going projects are the studies on parasitic diseases and climate, epidemiology of severe parasitic diseases, such as malaria and schistosomiasis.

NIPD/CTDR's comparative advantages resides in its extensive expertise in parasitic disease control in combination with an aptitude to provide innovative, high-technology solutions that consistently move from control to elimination. For example, the integration of modern high-tech approaches with firm expertise in parasitology provides an appropriate approach for parasitic disease control programmes in low- and middle-income endemic countries.

5.2.2 Research

The progress of genomics and other expression of bioinformatics provide more opportunities for the NIPD/CTDR to promote technical support for rapid 'translation' of discoveries in basic research to field-applicable tools, such as novel therapeutics, diagnostics or preventative agents that would greatly shorten the process to bring products based on new scientific discovery to market. The NIPD/CTDR has a strong comparative advantage with respect to initial development and innovation of novel products and diagnostics. The innovative research already under way on tropical diseases at an updated level is expected to trigger the move of more translational researches to field applications. Therefore, the concept of translational research from bench to field is becoming the new milestone when NIPD/CTDR embarks on the new era of integration of implementation, evaluation and validation in scientific research.

In 2019, the Key Laboratory of Parasite and Vector Biology, Ministry of Health was jointly built by CTDR and Shanghai Jiao Tong University School of Medicine. The institute shall innovate prevention strategies with modern biological science theories and technologies, establish new standards, develop new technologies, and invent products. In such way the laboratory is to enhance key scientific support for achieving the overall elimination of parasitic diseases in China. In addition, some major research have been in process, such as those on diagnostics and reference bank, pathogen spectrum of parasites, and vector organisms carrying pathogens.

5.2.3 Global health

Since 2014, the NIPD has actively engaged in global health activities. NIPD/CTDR will need to update the priority settings not only making them suitable for national goals but also to streamlining them to fit the new engagement in global health (Wei D., 2019).

A survey among the senior staff and staff of NIPD's Global Health Center identified five challenges and seven opportunities with respect to global health engagement as follows

Challenges:

- **funding and policies** - scary financial support; lack of national strategy on global health, financial and taxation policies;
- **globalization and localization** - scarcity of experience and expertise on global health; seldom approach to transfer and tailor Chinese expertise and products to the local demands;
- **human resource** - lack of human resources equipped with comprehensive knowledge of disease control and global health, poor communication with local people;
- **partnering mechanism** - lack of unified and effective mechanism, insufficient incentive measures; and
- **international cooperation** – lack of cooperation with other governments and NGOs, and other global health teams.

Opportunities:

- **China's engagement in global development** - Belt and Road Initiative, China-Africa cooperation, South-South cooperation;
- **collaborative platforms** - WHO collaborative centres, other cooperative platforms, Memoranda of Understanding;
- **low endemicity of parasitic diseases in China** - surplus experts, experiences accumulated from control to elimination of above mentioned diseases.
- **accomplishment in overseas pilot studies**
- **funding** from Gate Foundation, International Development and Research Center, UBS Optimus Foundation;
- **Global Health Institute jointly built*** - disciplines establishment, professional training.

* by NIPD/CTDR and Shanghai Jiao Tong University School of Medicine

Priorities:

Based on the partnership and principals of the Belt and Road Initiative, the priority regions for cooperation are Africa, Southeast Asia, Central Asia, and Europe. In addition, combining the current efforts that the NIPD/CTDR engaged in global health, the priority activities will be to:

- perform research and control activities on tropical diseases;
- conduct multilateral implementation programmes or demonstration projects on

malaria, schistosomiasis and other NTDs control with the aim of achieving elimination in the near future;

- improve and apply surveillance-response system, information system, GIS mapping technologies in low- and middle-income countries;
- implement capacity building in multi-focus, e.g., training on diagnosis, vector control, project management, training of post-doctoral fellows, etc.;
- provide services for experience sharing, e.g. dissemination through journals, publications, workshops, conferences, symposia, etc.

6. Conclusions

China has extensively shown its capacity to successfully lead the research and control of tropical and parasitic disease. The NIPD is an important national resource contributing to such programmes having transition from control to elimination. The institute, after adding new tasks through the newly designated CTDR, is at a crucial stage of its development, at which the institute needs to respond to the domestic challenge of elimination programmes and to be on the forefront in accompanying China's increasing contribution to global health leadership in tropical diseases control.

Engaging in global health is a long way to go for the NIPD/CTDR. To address the challenges ahead, the NIPD/CTDR shall mobilise all resources to fight control, innovate diagnosis and treatment in research, thus to combat infectious diseases epidemics in China and where necessary, such as some countries in Africa. Lack of professionals calls for multi-level training to foster global health capability and build an echelon of global health team and relevant systems and policies, perhaps which can be promoted by the newly established Global Health Institute. The NIPD/CTDR shall also enhance global health cooperation through, for example, more actively communicate with partners, obtain more projects and favourable national policies.

The implementation of the "Healthy China 2030 Plan" and contribution to ending the infectious diseases epidemics worldwide according to the United Nations' Sustainable Development Goal 3.3 will require increased global engagement. China is devoted to achieving this goal and has the expertise in tropical diseases and parasitic diseases control/elimination required. The elimination of filariasis from the country in 2007 and now closing in on malaria and schistosomiasis through a large-scale combination of clinical care and social protection, China has proven, at the national level, that the Sustainable Development Goal central principles of equitable development can be achieved for the tropical and parasitic diseases. It can therefore set the example guiding other developing regions in the world in this respect. Global health will be the endogenous growth point of the NIPD/CTDR, creating a shared future for all with its new vision.

7. Declarations of interest: none

8. Funding information: The fourth round of Three-Year Public Health Action Plan (2015-2017) No.: GWIV-29

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Figure 1

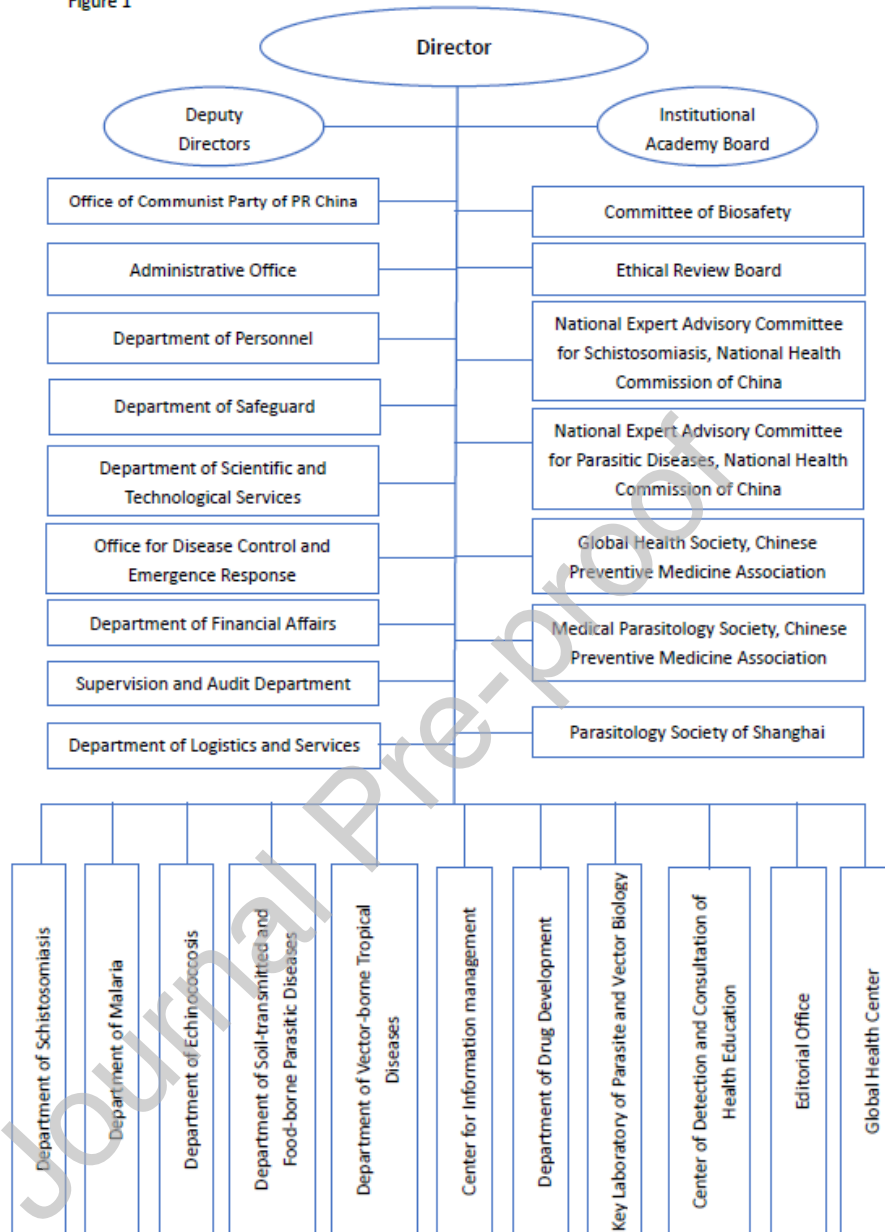


Figure 1 Organizational structure of the National Institute of Parasitic Diseases, China CDC

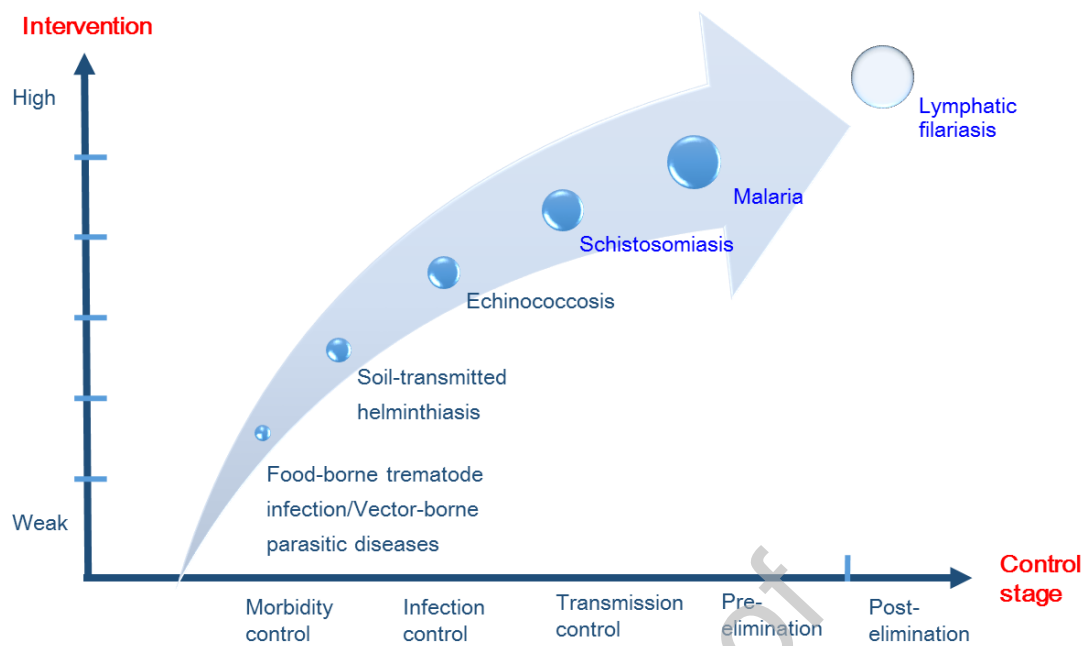


Figure 2 Progress of parasitic diseases control in China

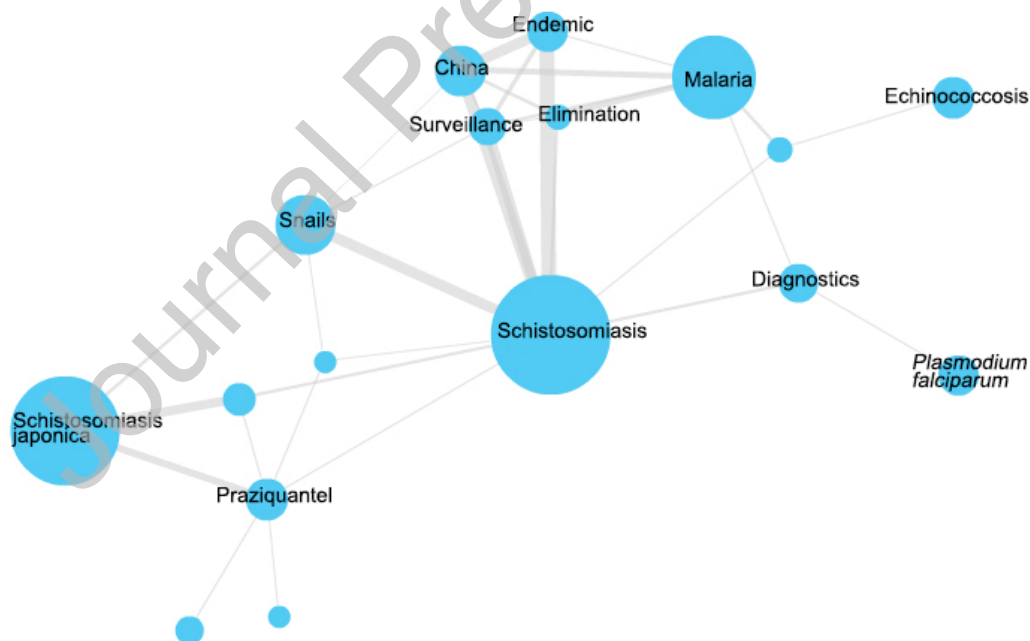


Figure 3 Keyword co-occurrence network in NIPD's Chinese publications

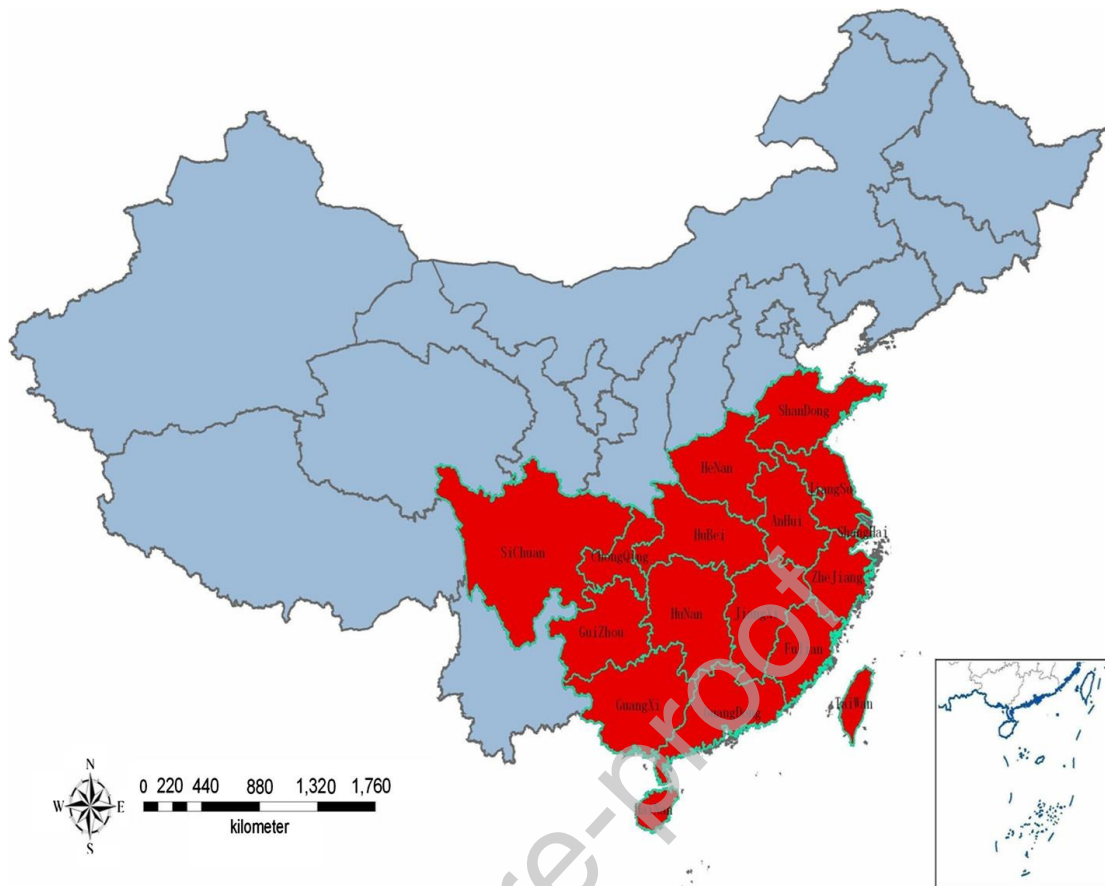


Figure A.1 Distribution of endemic areas for lymphatic filariasis in China (in red) (De-Jian et al., 2013)

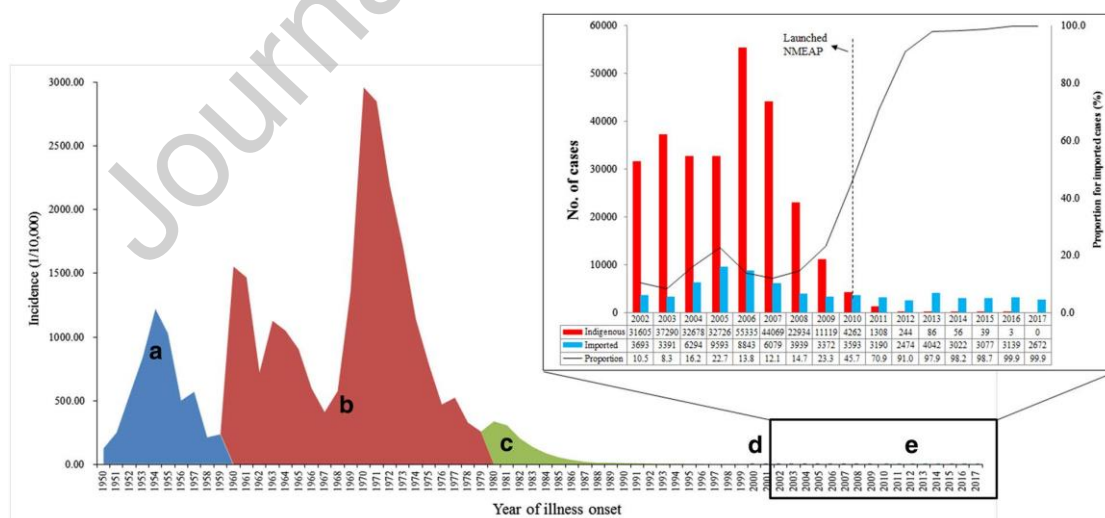


Figure A.2 Incidence of malaria in China, 1950–2017. The different control and elimination phases are shown in different colours. a Transmission not known (1949–1959); b outbreak and pandemic transmission (1960–1979); c decline with sporadic distribution (1980–1999); d low transmission with re-emergence in central China

(2000–2009); and e the elimination phase (2010–2020). The indigenous and imported cases from 2002 to 2017 are shown in the right-hand column (Feng et al., 2018)

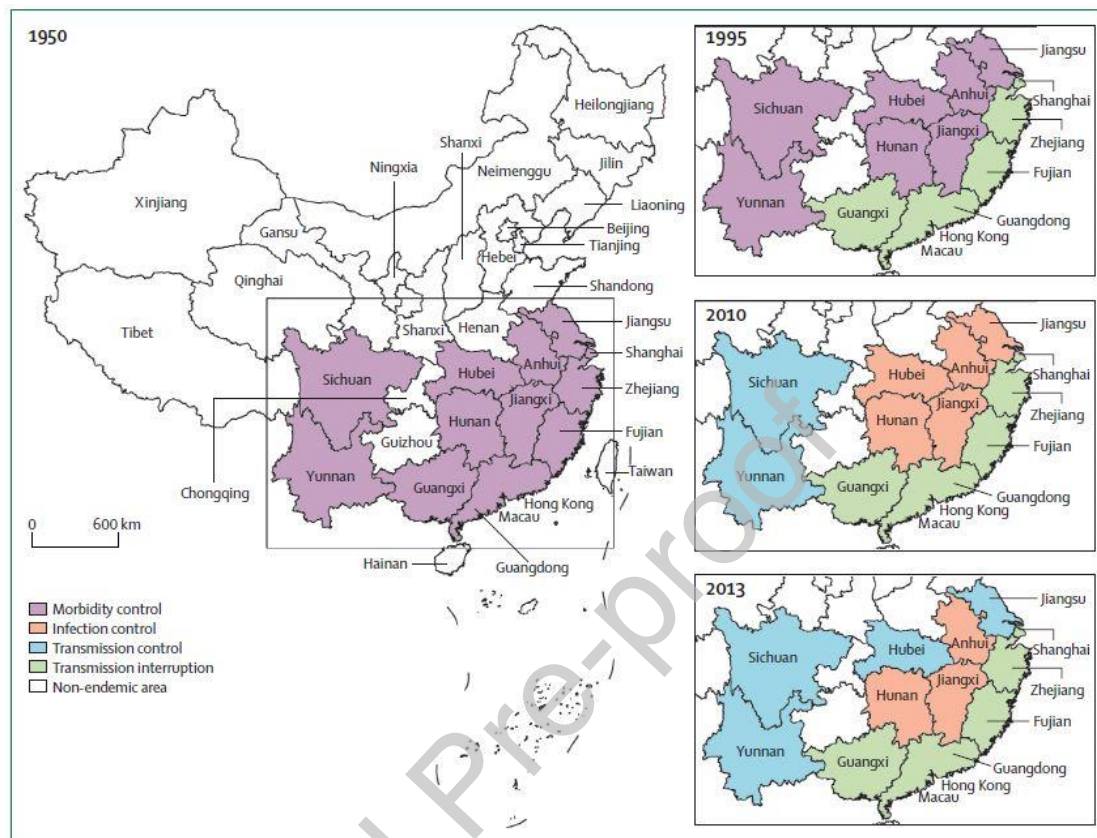


Figure A.3 Changes of schistosomiasis endemicity in China (Xu et al., 2016)

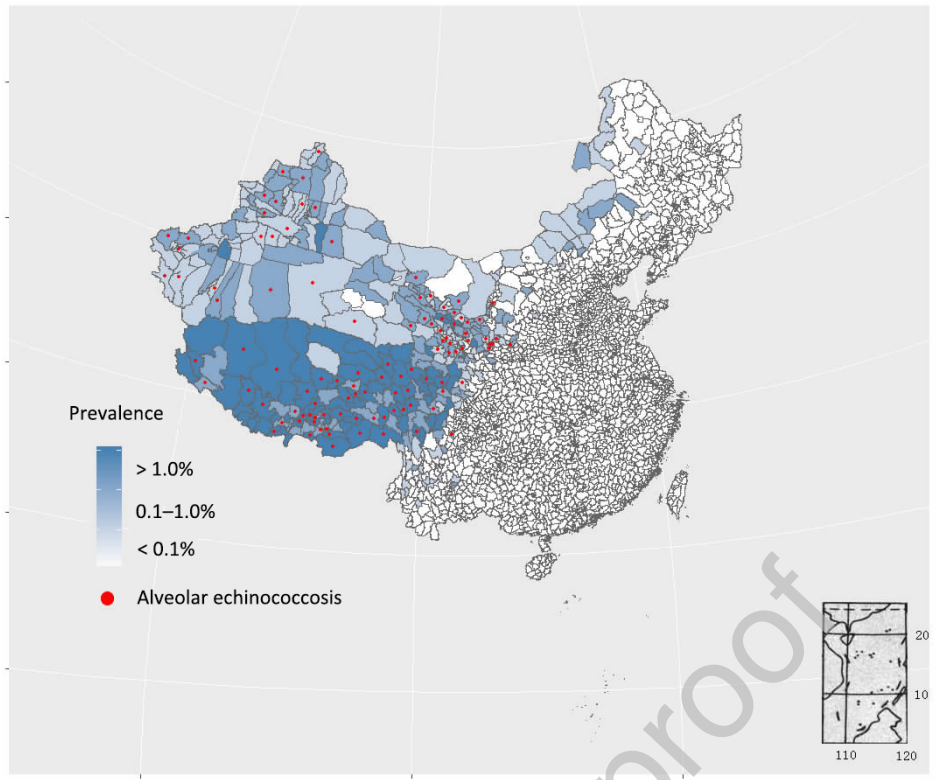


Figure A.4 The prevalence of echinococcosis during 2012–2016 (Wu et al., 2018)

Appendix 1

Table 2. Global networks initiated by the NIPD

Networks	Year of establishment		Partners
The Regional Network on Asian Schistosomiasis and Other Helminth Zoonosis (RNAS ⁺)	1998	12 country institutions	Australia, Cambodia, China, Indonesia, Japan, Laos, Malaysia, Myanmar, the Philippines, South Korea, Thailand, Vietnam
Institutional-based Network of Cooperation between Africa and China on Schistosomiasis (INCAS)	2015	6 institutions	National Institute of Parasitic Diseases, China CDC Universite des Montagnes, Cameroon Institut National de Recherche en Santé Publique, Mali University of Gezira-Wad Medani, Sudan National Institute for Medical Research, Mwanza Centre, Tanzania College of Health Sciences, University of Zimbabwe
Chinese Society of Global Health (CSGH), Chinese Preventive Medicine Association (CPMA)	2016	102 members(Chinese)	-
Asia-Pacific Network on Drug and Diagnostics	2017	24 member countries/regions/	Australia, Cambodia, Canada, China, Hongkong SAR China, India, Japan, Lao PDR, Macau SAR

Innovation (AP-NDI)		territories	China, New Zealand, Singapore, South Korea, Thailand, US
The B&R Network for the Elimination and Control of Echinococcosis and Cysticercosis (BR-NEC)	2017	11 member countries	Australia, China, France, Japan, Kazakhstan, Mongolia, Saint Kitts and Nevis, Tanzania, Turkey, UK, US
Institutional-based Network of Cooperation between Africa and China on Malaria (INCAM)	2018	7 institutions	National Institute of Parasitic Diseases, China CDC Ifakara Health Institute, Tanzania Universite des Montagnes, Cameroon National Malaria Elimination Centre, Ministry of Health, Zambia Disease Prevention and Control, Ministry of Health and Sanitation, Sierra Leone Institute for Research in Health Sciences/CRUN, Burkina Faso Malaria Research and Control Center, National Institute of Public Health, Cote d'Ivoire
Malaria Elimination Network in Lancang Mekong Region	2018	3 institutions	National Institute of Parasitic Diseases, China CDC National Center for Parasitology, Entomology

and Malaria Control, Cambodia
National Institute of Malaria, Parasitology &
Entomology, Vietnam
