# Enhancing collaboration between China and African countries for schistosomiasis control

*Jing Xu, Qing Yu, Louis-Albert Tchuem Tchuenté, Robert Bergquist, Moussa Sacko, Jürg Utzinger, Dan-Dan Lin, Kun Yang, Li-Juan Zhang, Qiang Wang, Shi-Zhu Li, Jia-Gang Guo, Xiao-Nong Zhou*

**Schistosomiasis remains an important public health issue, with a large number of cases reported across sub-Saharan Africa, and parts of Asia and Latin America. China was once highly endemic, but has made substantial progress and is moving towards elimination of schistosomiasis. Meanwhile, despite long-term, repeated, school-based chemotherapy in many African countries, more than 90% of all schistosomiasis cases are concentrated in Africa, and hence, this continent constitutes the key challenge for schistosomiasis control. Opportunities and issues for international collaboration in the fight against schistosomiasis are outlined with a focus on China's experiences, including the role of public health authorities and intersectoral collaboration, use of new and effective snail control approaches and diagnostic tools adapted to the specific stage of control, as well as the strengthening of risk mapping and surveillance-response mechanisms. Training courses targeting African governmental officials and professionals, coupled with field visits of African scientists and control programme managers to China, and vice versa, are considered important for improved schistosomiasis control and elimination. The crucial question remains whether the Chinese experience can be translated and applied in African countries to improve the effectiveness of health interventions and scale-up.**

## Introduction

More than 250 million people worldwide are estimated to be infected by blood flukes of the genus *Schistosoma* and nearly 800 million people are at risk of schistosomiasis.[1,2] More than 90% of all cases are concentrated in sub-Saharan Africa where people live in settings characterised by scarce sanitation and limited access to clean water.[3] The infection is usually transmitted by the free-swimming cercaria of *Schistosoma*, which penetrate the skin of people that are in contact with infested water. Urogenital schistosomiasis, the infection of *Schistosoma haematobium*, can lead to fibrosis, stricturing, and calcification of the urinary tract, and bladder cancer is a late stage consequence. Infections with *Schistosoma japonicum*, *Schistosoma mansoni*, *Schistosoma mekongi*, and *Schistosoma intercalatum* can cause progressive liver fibrosis, portal hypertension, and ascites.[1,4] Several improvements in schistosomiasis control are urgently needed, including high-resolution mapping of schistosomiasis; improved diagnostics; widened drug coverage; implementation of integrated approaches to improve sanitation, effective information, education, and communication; and re-institution of snail control.[3,5] In the authors' view, schistosomiasis has to be controlled on a continent-wide scale; strengthened intercountry communication and cooperation would save time and allow limited resources to be allocated appropriately to explore suitable and effective approaches and strategies for national control programmes.

China has a history of successful schistosomiasis control.[6,7] An uninterrupted national control programme has been in place since the early 1950s and has resulted in a substantial reduction of schistosome-related morbidity and mortality. By the end of 2013, the transmission of schistosomiasis has been interrupted in five of the 12 originally endemic Chinese provinces, whereas four have reached the transmission control criteria (<1% prevalence in human beings and livestock; figure 1).[8] Over the past decades, China has accumulated a large amount of experience in schistosomiasis control in various settings.[9,10] Supported by the UK's Department for International Development, and in collaboration with African, European, and Chinese scientists and institutes, the China–UK Global Health Support Programme was initiated in 2013, aiming to distil, synthesise, and disseminate the Chinese schistosomiasis experience to endemic countries in Africa.

The key differences between African and Chinese schistosomiasis are related to the snail intermediate hosts and animal reservoirs (table). By contrast with all the different aquatic snail intermediate hosts in Africa (eg, *Biomphalaria* spp and *Bulinus* spp),[11,12] the only snail capable of transmitting schistosomiasis in China (*Oncomelania hupensis*) is amphibious. Although human beings are essentially the only end host for *S mansoni* and *S haematobium* in Africa, at least 40 domestic and wild animal reservoir hosts are associated with the transmission of *S japonicum* in China, and as such it is considered a zoonotic disease.[13] If anything, control and elimination of schistosomiasis would seem to be more challenging in China than in Africa. Nonetheless, Africa and China have many similarities with respect to disease control—eg, risk mapping and prediction, diagnostics, prevention, treatment, surveillance, and management. These similarities justify attempting to translate China's experience with schistosomiasis control and elimination to the African scene—facilitating and strengthening control activities there.

## Conditions are favourable for cooperation between African countries and China

### Extending present cooperation to schistosomiasis control

Cooperation between China and Africa around health promotion has a long history. Aid has been provided

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**National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, WHO Collaborating Center for Tropical Diseases, Shanghai, China** (Prof J Xu PhD, Q Yu MPH, L-J Zhang MSc, Q Wang MPH, S-Z Li PhD, Prof X-N Zhou PhD); **WHO African Region, Intercountry Support Team for Central Africa, Libreville, Gabon** (Prof L-A Tchuem Tchuenté MD); **Ingerod, Brastad, Sweden** (Prof R Bergquist PhD*); **National Institute for Research in Public Health, Ministry of Health, Bamako, Mali** (Prof M Sacko PhD); **Swiss Tropical and Public Health Institute, Basel, Switzerland** (Prof J Utzinger PhD); **University of Basel, Basel, Switzerland** (Prof J Utzinger); **Jiangxi Provincial Institute of Parasitic Disease, Nanchang, China** (Prof D-D Lin PhD); **Jiangsu Provincial Institute of Schistosomiasis Control, Wuxi, China** (K Yang PhD); **and Department of Control of Neglected Tropical Diseases, WHO, Geneva, Switzerland** (Prof J-G Guo PhD)

*Prof R Bergquist is now retired from WHO

Correspondence to:
Prof Xiao-Nong Zhou, National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai 200025, China
**ipdzhouxn@sh163.net**

For **UK's Department for International Development** see https://www.gov.uk/government/organisations/department-for-international-development

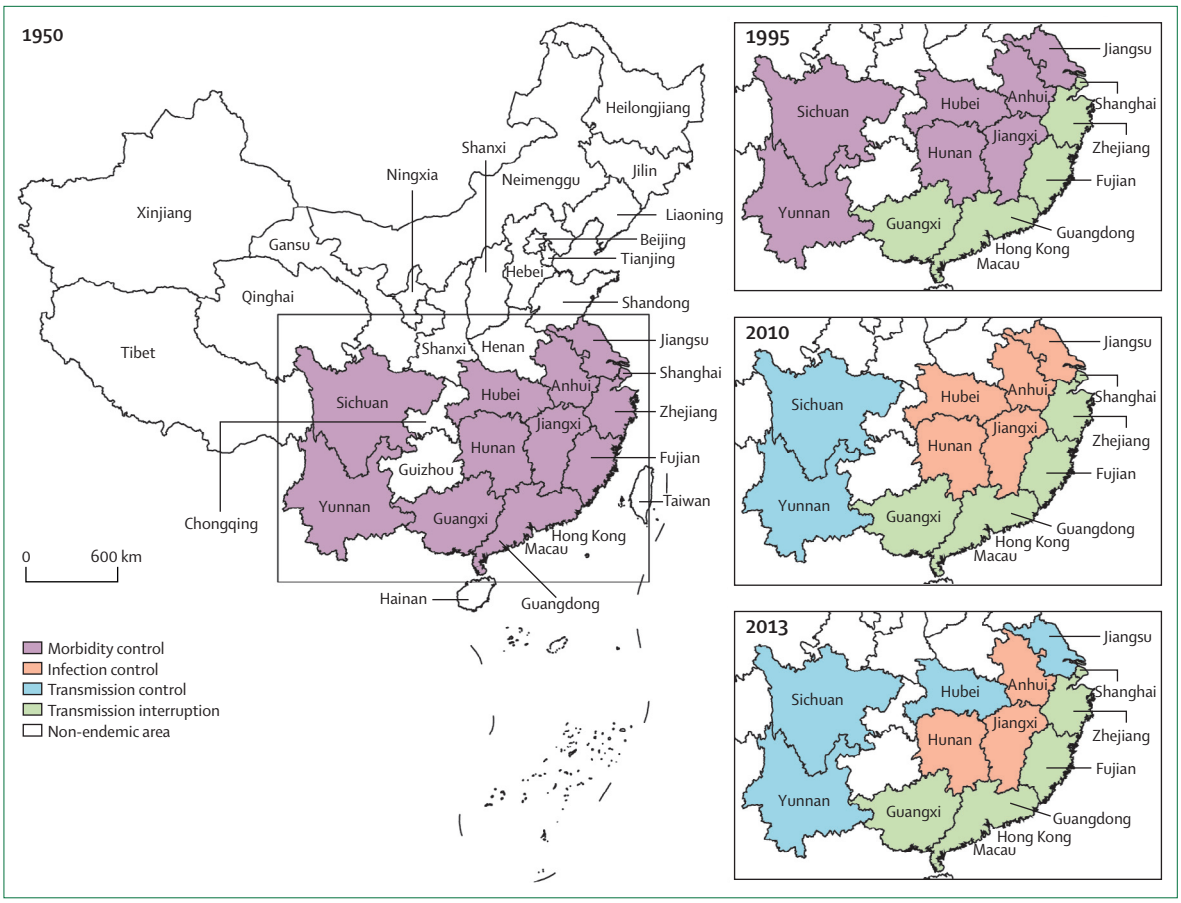


*Figure 1:* **Changes of schistosomiasis endemicity in China in the past 65 years**

through medical teams, establishment of health-care facilities, training of staff, support of malaria control, and donation of medicines.[14] In consideration of the wish by some African countries and WHO that China support schistosomiasis control in Africa, the Beijing Declaration of the Ministerial Forum of China–Africa Health Development, passed in 2013, agreed to joint pilot projects with African countries for schistosomiasis prevention, control, and elimination.[15] Collaboration between African countries and China through specific training courses and exchange visits by senior scientists sharing Chinese experience has been done through two existing networks: the Regional Network on Asian Schistosomiasis and other Helminth Zoonoses, and the Research Network on Schistosomiasis in Africa.[16] Technical support to help draft national plans and strategies, train staff, and guide control activities is planned to begin in the near future.

For the **Regional Network on Asian Schistosomiasis and other Helminth Zoonoses** see http://www.rnas.org.cn

## Commitments and achievements

Achievements for schistosomiasis control in previously highly endemic countries, such as China, Brazil, and Egypt, suggest that elimination is eminently feasible in countries with low prevalence, adequate resources, and sustained political commitment.[7] With the plummeting price of praziquantel and the increasing advocacy and provision of resources, a new regional strategic plan for neglected tropical diseases in the African region for the period 2014–2020 envisions the elimination of schistosomiasis as a public health problem by 2020 in target countries.[17] Some African endemic areas, such as Tanzania's partly self-governed province Zanzibar, have given voice to a willingness to attempt reaching this goal.[18] Meanwhile, supported by key funding and donor agencies, such as the US Agency for International Development, the UK Department for International Development, the World Bank, World Vision International, and Merck KGaA, many African countries are now implementing national schistosomiasis control programmes, either as a vertical programme or integrated with some of the other neglected tropical diseases. The number of people receiving preventive chemotherapy with praziquantel increased from 12·4 million in 2006 to 39·5 million in 2013, and several countries, such as Burkina Faso, Burundi, Malawi, Mali, Liberia, and Togo, have already achieved the 75% treatment coverage target for children aged 5–14 years.[19,20] In January, 2012, Merck KGaA increased its pledged

donation of praziquantel to 250 million tablets per year until schistosomiasis is eliminated.[21] Additionally, mapping of the national schistosomiasis distribution has been completed in many places or is in progress in many African countries, which will be beneficial for the development of control strategies and effective allocation of the limited resources available.[22–26]

### New instruments and improved capacity are driving control and elimination activities

To ensure the effectiveness of schistosomiasis control in Africa, functional instruments and efficient control approaches are necessary. With the unravelling of the schistosome genome in 2009,[27–29] new immunological diagnostic instruments—based on recombinant and purified antigen, monoclonal antibodies against such antigens, and extraordinarily sensitive and specific direct techniques based on DNA detection—have been explored for the assessment of ongoing control programmes, targeting chemotherapy and being applied for the surveillance of snail infection.[30–32] Techniques such as geographical information systems, global positioning systems, and remote sensing, along with mathematical or statistical modelling, have been used for mapping the risk for transmission or reintroduction of schistosomiasis.[33–35] Additionally, several African scientists specialised in schistosomiasis control and operational research have now been trained through existing and productive research partnerships with European institutions (eg, UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases, Swiss Tropical and Public Health Institute, University of Copenhagen, and London School of Hygiene and Tropical Medicine) and international cooperation projects (eg, the Schistosomiasis Control Initiative, the Schistosomiasis Consortium for Operational Research and Evaluation, and CONTRAST, a multidisciplinary alliance to optimise schistosomiasis control and transmission surveillance in sub-Saharan Africa).[36–38]

### Social and economic development is beneficial for schistosomiasis control

In addition to biological factors, the endemicity of schistosomiasis is governed by other contextual factors, such as social and economic status. China has witnessed more than 30 years of sustained economic growth, and over the past few years, the public health infrastructure has been strengthened, access to clean water improved, and lavatories and latrines have been constructed.[39] Moreover, resources were mobilised on the basis of multisectoral collaboration in an effort to construct a new socialist countryside. African economies grew in the past decade, with exports rising at an annual rate of 5·2% in real terms, compared with a mean of 4·8% for the world in 2011, and the per person gross domestic product of African countries reached US$1000 for the first time in history in 2013.[40] Correspondingly, the living conditions of African people improved with the population coverage of safe water reaching 64% in sub-Saharan Africa in 2012, while the total sanitation coverage (proportion of people who have access to improved sanitation) increased at a slower, though still impressive pace, from 25% in 1990 to 30% in 2012.[41] Additionally, health system reform was strengthened in several countries, including new legislation for national health, construction or improvement of clinics providing primary health care, desegregated medical services, and nationalisation of health laboratories, resulting in improved access to health services.[42–45]

| | *Schistosoma haematobium* | *Schistosoma mansoni* | *Schistosoma japonicum* |
|---|---|---|---|
| Intermediate host | *Bulinus* spp | *Biomphalaria* spp | *Oncomelania hupensis* |
| Definitive host | Human beings, primates | Human beings, primates, rodents | Human beings, ruminants, carnivores |
| Site of infection | Veins of urogenital system | Intestinal mesenteric veins | Intestinal mesenteric veins |
| Egg excretion | Urine | Faeces | Faeces |
| Major pathogenic stage | Tissue eggs | Tissue eggs | Tissue eggs |
| Distribution | Africa, Middle East | Africa, Middle East, Caribbean, Brazil, Venezuela, Suriname | China, Philippines, Indonesia |

*Table:* **Comparison of major schistosome species endemic in African countries and China**

## Challenges for cooperation between African countries and China

### Low coverage of preventive chemotherapy

Schistosomiasis and other neglected tropical diseases are endemic and often co-exist in sub-Saharan Africa, where most people live on less than $2 per day.[46] In Africa, schistosomiasis control programmes mainly depend on external funds, often receiving donated drugs. If funding ceases, consolidation of achievements made is generally impossible, with rapid re-emergence of schistosomiasis as a result. Although sub-Saharan Africa harbours most schistosomiasis cases and the disease burden at present is estimated to be 1·6–4·2 million disability-adjusted life years, coverage with preventive chemotherapy in 2012 was only 13·6% because of the existing gap between drug donation and need, and the poor capability of drug delivery, leaving a substantial number of people at risk of schistosomiasis without treatment.[19,21,47] Children aged 5–14 years, who are the main target group of preventive chemotherapy because they often present with high-intensity infections, are relatively easy to reach, but other high-risk populations (eg, fishermen, irrigation workers, and housewives) are difficult to gain access to. Urogenital schistosomiasis is a risk factor for infection by HIV in women,[48] who therefore require treatment with praziquantel in areas endemic for *S haematobium* more often than in non-endemic areas. A treatment gap also exists for children aged less than 5 years, who become

For **UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases** see http://www.who.int/tdr

infected through passive water contact; however, at present, they are not targeted by national chemotherapy campaigns because of a scarcity of formal legislation and suitable paediatric formulations of praziquantel.[49] In 2015, Lai and colleagues[26] completed a predictive risk map of schistosomiasis and analysed the treatment needs for sub-Saharan Africa on the basis of a systematic review and Bayesian-based geostatistical analysis, providing a scientific basis to guide chemotherapy and allocation of limited resources (figure 2).

### Insufficient water supply, hygiene, and poor sanitation

Access to clean water would reduce the need to use and be in contact with water from natural sources such as lakes, impoundments, streams and rivers, which is the key risk factor for schistosomiasis.[24,50,51] Although 89% of the global population had access to improved sources of drinking water by 2012, more than 700 million people still did not have access to safe water, 50% of them in sub-Saharan Africa. As such, the Millennium Development Goal for safe water is far from being met. Additionally, because of the inequity of economic development and funds donated, inequalities exist within countries or regions with regard to access to drinking water, which negatively affects the control of schistosomiasis.[41] In China, resources were mainly allocated to areas highly endemic for schistosomiasis, fostering multisectorial collaboration and promoting interventions such as supplying safe water and construction of lavatories and latrines to prevent and control schistosomiasis.

### Fragile health systems

Although the funds donated by developed countries for the improvement of the health situation have increased nearly three times between 1990 and 2011 (from $1·5 billion to $4·2 billion),[52] African health systems are still fragile—the Ebola virus outbreak in western Africa in 2014 fully proving this point. Absence of health insurance, funds, health staff, and a functioning health information system are key problems for the health care in most African countries, many of which do not have the public health infrastructure or the necessary resources to implement schistosomiasis control. The vicious cycle of disease and poverty is easily and rapidly established when people who cannot avoid infection, cannot afford their own treatment, further exacerbating their poverty.

### Poor coordination at the government level

As the transmission of schistosomiasis is governed by various natural, social, and biological factors, integrated approaches based on intersectoral collaboration are crucial for sustainable schistosomiasis control. However, most African countries do not have this kind of mechanism. Additionally, scarce information about people's knowledge, attitudes, beliefs, and practices regarding water contact, the effect of treatment-seeking behaviours, and sanitation habits, with respect to schistosomiasis, has been documented across Africa.[50,53,54] Another reason for the difficulty in controlling schistosomiasis in Africa is the little consideration for the potential effect on schistosomiasis in the design and construction of water conservancy and irrigation projects.[1,54–56] With political commitment assured, a leading group composed of decision makers at the national government level, including key people at the ministry level, particularly those dealing with health, education, agriculture, and water conservancy, would

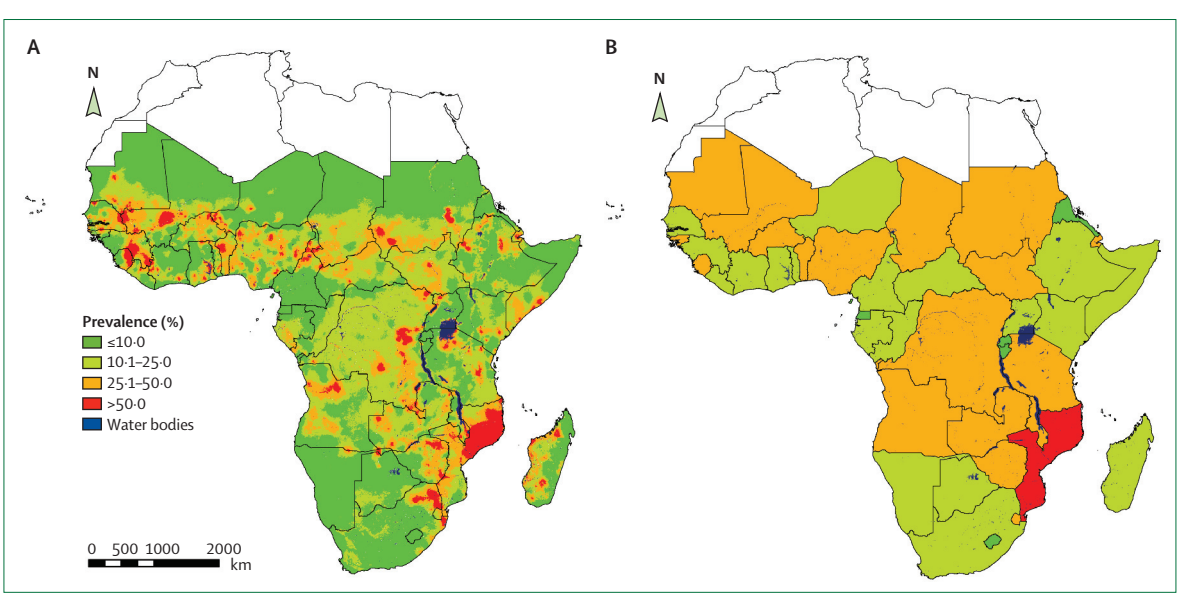


*Figure 2:* **Predicted prevalence of schistosomiasis in WHO's Africa region**
(A) Based on the median of the posterior predictive distribution at pixel level (5 × 5 km spatial resolution). (B) Based on population-adjusted estimation at country level for school-aged children (5–14 years old) from 2000 onwards.

need to be established to enhance leadership. In China, with the resurgence of schistosomiasis at the beginning of the 2000s, the leading group on schistosomiasis at the State Council level was set up and a notice to further strengthen schistosomiasis control and improve collaboration between sectors was issued by the State Council in 2004. The establishment of the leading group accelerated the implementation of the integrated control strategy in endemic areas, making resource mobilisation easier. National schistosomiasis control programmes should be supported through drafting of strategic national plans and establishment of long-term collaboration mechanisms, which would benefit and mobilise internal and external social resources and intensify integrated schistosomiasis control interventions.

## China's experience can be transferred to Africa

During the six decades of uninterrupted schistosomiasis control in China, the strategies and approaches used have varied with technological development and social–economic changes. The experience and lessons present many aspects, some of which are possible and appropriate for implementation in African countries to accelerate the control process.

### The administrative situation

Since the founding of the People's Republic of China, the central Government and its departments at different levels have given schistosomiasis control a high priority.[13] A national leading group for schistosomiasis control was set up in 1955 and the national control programme was established in 1956. When a temporary rebound of the disease occurred in 2004, schistosomiasis control was given top priority together with HIV, tuberculosis, and hepatitis B.[9] Achievements gained in the area of schistosomiasis control in China were attributed to close collaboration between different ministries and departments.[57,58] The medium-term and long-term national programme on schistosomiasis control was initiated in 2004 and implemented in collaboration with institutions, such as the National Health and Family Planning Commission, Ministry of Agriculture, Ministry of Water Resources, and State Forestry Administration.[59] The State Council is responsible for the coordination between different governmental departments to improve the integrated efforts. Professional institutions, such as the Chinese Center for Disease Control and Prevention, health bureaus, and hospitals, collaborate at all levels to manage and implement disease control activities to control and eliminate schistosomiasis.

### Scientific control strategies adapted to local conditions

The verbatim translation of the general principle for schistosomiasis control in China is "prevention first, scientific control", which means that effective intervention measures need to be integrated with a focus on prevention. The control strategies have shifted according to the economic situation and technology—the strategy emphasised snail control in the years before praziquantel was discovered and released for large-scale use (1950s to early 1980s) and then morbidity control based on chemotherapy supplemented by health education and snail control (mid-1980s to 2003); since 2004, China has adopted an integrated control strategy giving priority to control of infection sources.[10,60] In view of the differences with regard to epidemiological factors of the disease and ecological characteristics of the intermediate snail host across China, one or more measures were strengthened in different endemic areas to achieve the expected objectives as soon as possible with the limited health resources available.

### Professional control agencies

The involvement of a professional workforce in control activities ensured the success of schistosomiasis control in China. Anti-schistosomiasis institutions at all levels—national, provincial, prefectural, county, and township—were set up in the 1950s and were well funded to take the main responsibility for disease control and treatment. The number of staff specialised in prevention and clinical care and those working in these specialised organisations reached 17 000 by the mid-1960s.[61] Although the small-scale vertical programmes consisting of many anti-schistosomiasis control stations in areas where the transmission of schistosomiasis had been interrupted were integrated into the general Chinese Center for Disease Control and Prevention network, professional teams are still kept in many places to do surveillance, while institutions and technicians are retained in the regions that are still seriously endemic.[62] Because of the substantial public health burden caused by schistosomiasis and other neglected tropical diseases in African countries, a professional workforce is needed to ensure the implementation of national control programmes and to take the main responsibility for disease control, treatment, and prevention.

### New and effective snail control approaches

Since schistosomes have to complete their lifecycle through an intermediated snail host, elimination of the host would theoretically interrupt the transmission of schistosomiasis. In China, various synthesised molluscicides, such as 50% niclosamide ethanolamine salt powder and other formulations (eg, granules, suspension concentrate, retarder, etc), and plant molluscicides with low toxicity to fish (eg, tea seed distilled saponins) were developed and adapted to the local situation in snail-infested areas.[63–65] Environmental modification—ie, alteration of the ecological environments of the snails' habitats to make their survival difficult—was implemented in combination with agriculture production, water conservation, and forestry projects, resulting in transmission interruption in many endemic areas.[66] These interventions might be

adapted for the control of intermediate host snails in Africa, but will require specific tailoring to existing social–ecological settings.

### Diagnostic tools

Although the global strategy of schistosomiasis control emphasises preventive chemotherapy, diagnosis always played an important role in China. Indeed, Chinese scientists have contributed to the development of many diagnostic methods, especially immunodiagnostic assays.[67] In the past few decades, several quality-assured immunoassays have been approved by the China Food and Drug Administration and integrated into the national control programmes for use in chemotherapy targeting, epidemiological surveys, and the assessment of control strategies that are in progress.[68–70] Appropriate diagnostic methods were selected to help guide treatment strategies at different thresholds of schistosomiasis control in China.[69,71] A diagnostic network has been set up to monitor the quality of diagnostics and provide scientific evidence for schistosomiasis surveillance and response in areas of low endemicity or where the transmission of schistosomiasis has been interrupted.[72,73]

### Strengthening disease mapping and surveillance

Disease mapping, which supplies basic information when designing control programmes or doing such activities, is a high-priority when tackling schistosomiasis. National surveys have been conducted in China since the 1950s to deepen the understanding of the distribution of schistosomiasis in the country, and an updated *Atlas of Schistosomiasis Transmission in China* (2nd version)[74] was published in 2012 based on the data collected from the national control programme and the national surveillance system between 2002 and 2010. To ensure efficient management of schistosomiasis, attention must be paid to monitoring and surveillance based on fixed sentinel surveillance sites with particular emphasis along the border between the non-endemic areas and endemic areas.[70,75] Annual risk mapping of schistosomiasis with special focus on high-risk regions, including the geographical distribution mode of snails, has been analysed and implemented on the basis of new technologies. These new technologies include geographical information systems, remote sensing, predictive modelling, and xeno-monitoring instruments based on the loop-mediated isothermal amplification technique and similar sensitive and specific diagnostic techniques.[76–78]

### Transfer the Chinese experience to Africa

As China and African countries have many differences in terms of schistosomiasis control, the aspects of the Chinese experience that would be appropriate in the various African countries need to be demonstrated and verified. Research on how the social, political, economic, and health systems affect schistosomiasis is important, and, in selected African countries, retrospective data collection and field visits to understand the status of disease control and management models should be used to ascertain data on schistosomiasis control and the epidemic situation. Identification and closure of existing gaps in schistosomiasis control and elimination will help to establish a good foundation for pilot intervention programmes. Specific training courses and field visits to China should be targeted at governmental officials and professionals in African countries to improve their skills in schistosomiasis control and help them to better understand the Chinese experience. An assessment model, based on pilot studies that are rigorously implemented and monitored over time, should be developed to answer whether and how the experience and lessons learned in China will be able to help African countries improve the effectiveness in scaling up health interventions.[79]

## Conclusion

The joint schistosomiasis control cooperation aims to accelerate the process of schistosomiasis control in African countries, which should not only promote technical transfer of information, but also help strengthen international communication between China and the endemic African countries. This cooperation would be similar to the win–win model discussed previously,[80] but mechanisms are also needed to accelerate the dissemination and translation of China's experience to selected African countries.

Although China has accumulated much experience in cooperation with African countries in various health specialties, resulting in the development of a global health capacity in the past decade,[14] challenges remain when facing a different environment for a new cooperation, such as schistosomiasis control, including insufficient experience and experts involved in international activities. Agencies with supranational responsibilities and major donor organisations have already cooperated with African countries on schistosomiasis control, and experienced experts and organisations are expected to be able to provide guidance and support on China–Africa collaboration. Coordination with the WHO Regional Office for the Western Pacific and with that for Africa should be strengthened to facilitate the multi-partner cooperation. The precise form of coordination mechanism needs to be explored and agreed on by all stakeholders.

#### Contributors

JX, QY, and X-NZ participated in structuring this manuscript. JX and QY searched the scientific literature and wrote the first draft. L-ATT, RB, MS, JU, D-DL, KY, and X-NZ revised the manuscript, and provided important intellectual content. L-JZ, QW, S-ZL, and J-GG participated in the scientific literature search and assisted with the tables and figures. All authors have approved the final manuscript before submission for publication.

#### Declaration of interests

We declare no competing interests.

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