Review

Major trends in human parasitic diseases in China

Ting Li[1], Shenyi He[1], Hong Zhao[1], Guanghui Zhao[1] and Xing-Quan Zhu[2,3]

[1] Department of Parasitology, Shandong University School of Medicine, 44 Wenhua Xi Road, Jinan 250012, Shandong Province, People's Republic of China
[2] State Key Laboratory of Veterinary Etiological Biology, Key Laboratory of Veterinary Parasitology of Gansu Province, Lanzhou Veterinary Research Institute, Chinese Academy of Agricultural Sciences, Lanzhou, Gansu Province, People's Republic of China
[3] Laboratory of Parasitology, College of Veterinary Medicine, South China Agricultural University, 483 Wushan Street, Tianhe District, Guangzhou 510642, Guangdong Province, People's Republic of China

Tremendous progress has been made in the control and prevention of human parasitic diseases in mainland China in the past 30 years because of China's Reform and Opening to the Outside Policies initiated in 1978. However, parasitic diseases remain a major human health problem, with significant morbidity and mortality as well as adverse socioeconomic consequences. Although soil-transmitted parasitic diseases are in the process of being gradually controlled, food-borne parasitic diseases and emerging parasitic diseases are becoming the focus of new campaigns for control and prevention. This article reviews major trends in human parasitic diseases in mainland China, with perspectives for control.

Current status of human parasitic diseases in China

From 2001 to 2004, a national survey of the prevalence of parasitic diseases was carried out in China (not including Taiwan, Hong Kong and Macau) sponsored by the Ministry of Health, China, and involving stratified, random, and mass sampling [1]. The data of that survey revealed two major trends in the epidemiology of parasitic diseases in China. First, the prevalence of the intestinal parasites such as *Entamoeba histolytica*, *Fasciolopis buski* and soil-transmitted helminths has declined markedly in comparison to the rates recorded in the first national survey conducted in 1990 [2,3]. In 2003 the prevalence of hookworms, *Ascaris* and *Trichuris* had reduced by 60.7%, 71.3% and 73.6%, respectively (Figure 1), and the number of people infected by soil-transmitted nematodes declined from 536 million in 1990 to 129 million in 2003, of which 85.9, 39.3, and 29.1 million represent infections with *Ascaris lumbricoides*, hookworms, and *Trichuris trichiura*, respectively [1,4]. However, the infection rate with soil-transmitted helminths in China is still unacceptably high in comparison to economically developed countries such as Japan and South Korea [5,6].

In remarkable contrast, the prevalence of food-transmitted parasitic diseases (e.g. trichinellosis, clonorchiasis, paragonimiasis, cysticercosis, and echinococcosis) has increased significantly [7]. The most striking example is clonorchiasis, for which the national average prevalence has increased by 75% compared to the results of the first national survey, with an estimated 12.49 million people (0.58%) being infected in 2003 [1], compared with 4.7 million (0.36%) in 1990 [8]. The prevalence of *Taenia* has increased by 52.49% nationwide, with Sichuan and Tibet having the highest increases of 98% and 97%, respectively (Box 1) [1,7].

Sixty years ago China had ~31 million cases of lymphatic filariasis and ~330 million people were at risk of infection. By the year 1994, all of the 864 endemic counties/cities in 15 provinces/autonomous regions/municipalities (P/A/M) had achieved the criteria for effective control of filariasis (taking a village as a unit of reckoning, the microfilaria rate was less than 1%), and filariasis was almost eliminated in the entire country [9]. Elimination of infection sources has been adopted as a major intervention measure in filariasis control. Because diethylcarbamazine (DEC) was safe and effective for treating microfilaremia, mass treatment of the whole population was undertaken, and all inhabitants above 5 years with or without microfilaremia received DEC. In severe endemic areas, DEC-fortified table salt was supplied to inhabitants [9,10]. The strategies used to interrupt the spread of lymphatic filariasis in China were recognized by the World Health Organization (WHO) and recommended to other countries [10].

Demographics of the distribution features of parasitic diseases in China

The geographical distribution of parasitic infections in China has some distinct features. For example, tapeworm infections are correlated to hypsography. The elevation of the land in China generally declines from west to east. The Qinghai–Tibet Plateau in southwest China is 4000 m above sea level (on average), and taeniasis saginata, echinococcosis and alveococcosis are most common in these areas. From the Qinghai–Tibet Plateau to the Greater Higgnan Mountains in the northeast of China, most plateaus and basins are between 1000 and 2000 m, and the altitude of the central and east regions is generally below 500 m. Taeniasis solium and cysticercosis are common in these regions, whereas they are seldom detected in the Qinghai–Tibet Plateau region [11].

The distribution of soil-transmitted helminthiasis varies with the temperature zones and humidities. The highest infection rates of *A. lumbricoides*, *T. trichiura*, and

Corresponding authors: He, S. (shenyihe2007@163.com); Zhu, X.-Q. (xingquanzh@scau.edu.cn).

1471-4922/$ – see front matter doi:10.1016/j.pt.2010.02.007

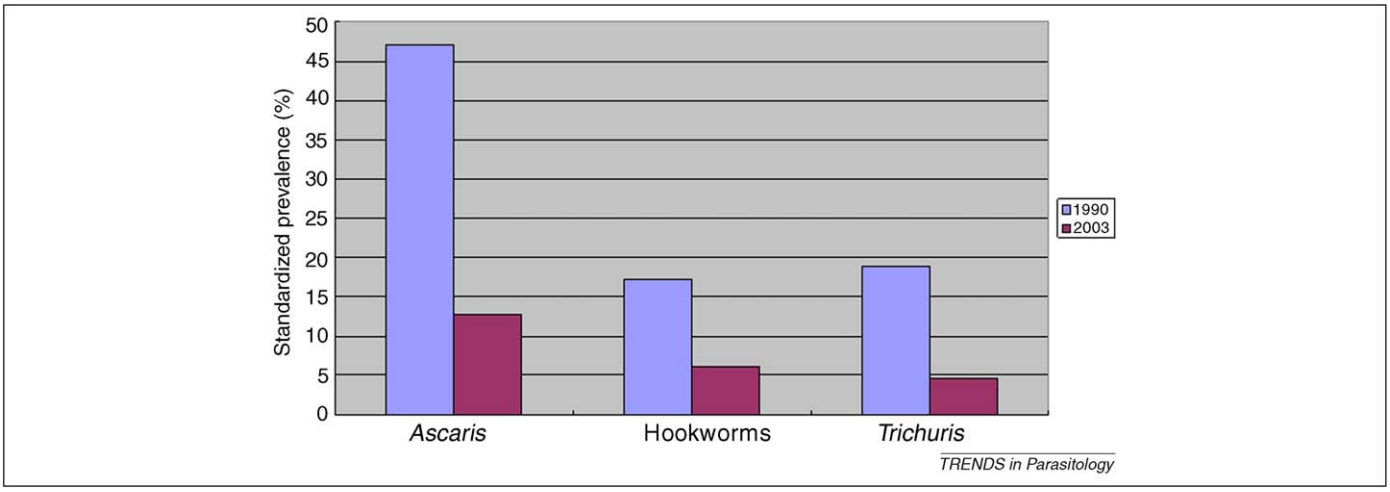

Figure 1. Comparison of prevalence rates of human infection with *Ascaris*, hookworms, and *Trichuris* in 1990 (blue) and 2003 (magenta) in China, showing a significant decrease of the prevalence of geohelminths in 2003 versus 1990.

hookworms are detected in tropical and subtropical zones [12].

The latest national survey showed that the prevalence of most parasites is higher in women and children [1,2], and the highest prevalence rates for soil-transmitted helminthiasis were found in the 5–9 year and 10–14 year age groups [1].

Emerging parasitic diseases in China

A total of 25 helminth species were recorded in the last nationwide survey [1], including eight nematodes, 12 trematodes, and five tapeworms [1]. Of these helminths, human infections with *Metorchis orientalis* and *Echinostoma aegypti* were detected in Fujian province, the first report in the world [13]. Human infection with *Haplorchis taichui* in Guangxi was noted for the first time in China, before which only animals were infected with this parasite [14].

A total of 63 parasite species causing emerging parasitic diseases were documented in China between 1950 and 2006 [13–19] (Table 1). Some of these are related to lifestyle changes including the consumption of raw or undercooked fish and meat, and the pursuit of eating exotic and delicate

Box 1. Major trends in human parasitic diseases in China

(i) Due to a natural increase in population and socioeconomic development of upland areas, some parasitic diseases have emerged in natural reserves in these remote regions. For example, visceral leishmaniasis has been primarily reported in Western China, and nematodiasis is still endemic in impoverished areas.

(ii) Opportunistic parasitic diseases are increasing due to the rise of diseases involving abnormal immune system function, exemplified by the increases in toxoplasmosis and cryptosporidiosis incidence rates that have accompanied the spread of HIV infection in China.

(iii) An increase in the rates of imported parasitic diseases, including imported malaria and onchocerciasis.

(iv) An increase in food-borne parasitic diseases associated with improved income and living standards and with a rise in the consumption of exotic and delicate foods.

Table 1. The first case(s) of human parasitic diseases in China during 1950–2006 [13–19].

Species of parasite	Provinces/autonomous regions/municipalities	Year of report
Protozoa		
Acanthamoeba polyphage	Taiwan	1989
Acanthamoeba rhysodes	Jilin	1985
Blastocystis hominis	Guangdong	1990
Cyclospora cayetanensis	Fujian	1995
Cryptosporidium hominis	Jiangsu	1987
Entamoeba hartmanni	Taiwan	1966
Entamoeba polecki	Guangdong	1964
Lophomonas blattarum	Anhui	1992
Naegleria sp.	Taiwan	1975
Plasmodium knowlesi	Yunnan	2006
Plasmodium vivax multinucleatum	Guangdong	1965
Pneumocystis jiroveci	Beijing	1959
Sarcocystis hominis	Yunnan	1989
Sarcocystis suihominis	Yunnan	1983
Toxoplasma gondii	Jiangxi	1964
Trichomonas tenax (syn. *Trichomonas elongata*)	Sichuan	1952
Helminths		
Achillurbainia nouveli	Guangdong	1964
Ascaris suum	Zhejiang	1960
Bertiella studeri	Anhui	2006
Bunostomum trigonocephalum	Guizhou	1979
Capillaria hepatica	Guangdong	1979
Capillaria philippinensis	Taiwan	1989
Centrocestus cuspidatus	Fujian	1991
Centrocestus formosanus	Guangdong	1979
Cotylurus japonicus	Hunan	1985
Dioctophyma renale	Hubei	1981
Dirofilaria immitis	Shangdong	1975
Dirofilaria repens	Heilongjiang	1980
Dracunculus medinensis	Anhui	1995
Echinochasmus japonicus	Fujian	1982
Echinochasmus jiufoensis	Guangdong	1988
Echinochasmus liliputanus	Anhui	1992
Echinochasmus perfoliatus	Hubei	1979
Echinococcus multilocularis	Xinjiang	1965
Echinostoma aegypti	Fujian	2002
Echinostoma angustitestis	Fujian	1992
Echinostoma hortense	Heilongjiang	1989
Echinostoma paraulum	Yunnan	1979
Euparyphium ilocanum	Yunnan	1964

Table 1 (*Continued*)

Species of parasite	Provinces/autonomous regions/municipalities	Year of report
Eurytrema pancreaticum	Shanghai	1964
Fasciola gigantica	Anhui	1984
Fischoederius elongatus	Guangdong	1990
Gnathostoma spinigerum	Zhejiang	1957
Gongylonema pulchrum	Hunan	1955
Haplorchis pumilio	Guangdong	1964
Haplorchis taichui	Guangxi	2004
Haplorchis yokogawai	Guangdong	1979
Heterophyes heterophyes	Guangdong	1979
Mammomonogamus laryngeus	Shanghai	1997
Mesocestoides lineatus	Heilongjiang	1988
Metastrongylus elongatus	Jilin	1982
Metorchis orientalis	Guangdong	2001
Paragonimus heterotremus	Yunnan	1965
Paragonimus skrjabini	Sichuan	1957
Philophthalmus sp.	Hainan	1993
Pseudanoplocephala crawfordi	Shanxi	1980
Rhabditella axei	Tianjin	1950
Taenia hydatigena	Guizhou	1981
Tetrameres fissispina	Henan	1988
Trichostrongylus axei	Jiangsu	2000
Acanthocephales		
Macracanthorhynchus hirudinaceus	Liaoning	1964
Neosentis celatus liuanensis	Anhui	1965
Pentastomids		
Armillifer agkistrodontis	Zhejiang	1996

foods. An increasingly large transient population has also contributed.

Cryptosporidiosis is one of the emerging parasitic zoonoses in China, and is considered by the 'WHO Neglected Diseases Initiative' as an important infectious disease [20]. *Cryptosporidium hominis* is the causative agent for human cryptosporidiosis in China, and the first case occurred in Nanjing in 1987 [21]. Subsequently, many cases were reported from more than ten provinces [22]. The prevalence of cryptosporidiosis in diarrhea patients ranged between 1.4% and 13.3%, and was most commonly found in children [22]. A recent survey of cryptosporidiosis revealed a prevalence of 3% in children with diarrhea, and children of one to four years old had the highest prevalence at 5.5% [23].

Re-emerging parasitic diseases in China

Poor conditions for health care during the 1950s to 1960s caused ~70 million people to suffer from malaria, schistosomiasis and filariasis [24]. In 1956 the State Council adopted a policy of fighting schistosomiasis, malaria, leishmaniasis, filariasis and hookworm diseases, and a number of important parasitic diseases have been controlled or eradicated in the past 50 years. However, several factors have a bearing on parasitic diseases in China, including climate warming and the South–North Water Diversion Project that could transform the environment, and schistosomiasis, malaria, and some food-borne parasitic diseases have re-emerged in recent years.

Schistosomiasis

Although significant progress has been made since the 1950s in the control and prevention of human schistosomiasis caused by *Schistosoma japonicum*, schistosomiasis is still listed as China's most important parasitic disease, and remains endemic in seven southern provinces of China, paralleling the distribution of the intermediate host snail *Oncomelania hupensis*. In 1989 the transformation of agriculture production modes made it more difficult to eradicate snails, and in some areas many acute outbreaks (defined by a specified number of cases within a given time period) have occurred [25]. In 1989, ~54 million people were at risk of infection, and the number of infections was ~1.5 million [26].

Given the high prevalence and severe consequences of schistosomiasis, a national campaign for control of this disease was officially launched in 1991, with partial financial support by a loan from the World Bank. In the 1990s, morbidity control was the backbone of disease control, helped by the administration of praziquantel, that had been introduced for large-scale use in the previous decade, coupled with health education [27,28]. By the end of 1995 the number of infected people had significantly decreased, from 1.6 million in 1989 to 865000 in 1995, and the snail habitat area was much reduced [29].

In 2002 the State Council undertook to strengthen schistosomiasis control [30]. By the end of 2006 schistosomiasis was still endemic in 448 counties, of which 271 reached the status of transmission interruption [31], and a further 72 counties where prevalence rates were very low achieved the status of transmission control. Jiangsu, Anhui, Jiangxi, Hubei, Hunan (five provinces along the Yangtze River) and Sichuan, Yunnan (two upland provinces in southwestern China) had not yet reached the standard of epidemic control [31].

In 2006 the number of schistosomiasis cases was 671265, including 207 acute cases. The total area of snail habitats decreased from 14 billion m^2 in the early 1950s to 3.8 billion m^2 in 2006 [31]. Up to 2007, counted at the county level, only Sichuan province achieved control status, and presently schistosomiasis remains endemic in 90 counties (cities, districts) distributed across five provinces (Hunan, Hubei, Jiangxi, Anhui, Jiangsu provinces), principally in lake districts or in upland areas such as Yunnan province [32].

In the 1960s and 1970s, eradication of snails was considered as the focal point of the schistosomiasis control campaign, despite concerns that the molluscicides might lead to environmental pollution. Since the 1980s the use of praziquantel for mass chemotherapy has become the chief means to control schistosomiasis. In 2004 the State Council established two targets for the National Schistosomiasis Control Program. First, by 2008, the goal was to reduce the prevalence rate in humans to less than 5% in all counties in which *S. japonicum* is endemic, including 110 counties with a prevalence exceeding 5%. Second, by 2015, the program aims to reduce the prevalence in humans to less than 1%. To reach these targets the Ministry of Health recognized an urgent need to develop a new schistosomiasis control strategy for China [33]. A comprehensive integrated approach is being taken to tackle schistosomiasis in the new era, with a focus on the elimination of infection sources in major endemic regions [28,33]. This strengthened national control program has been implemented effectively since 2005, significantly reducing acute infections [34].

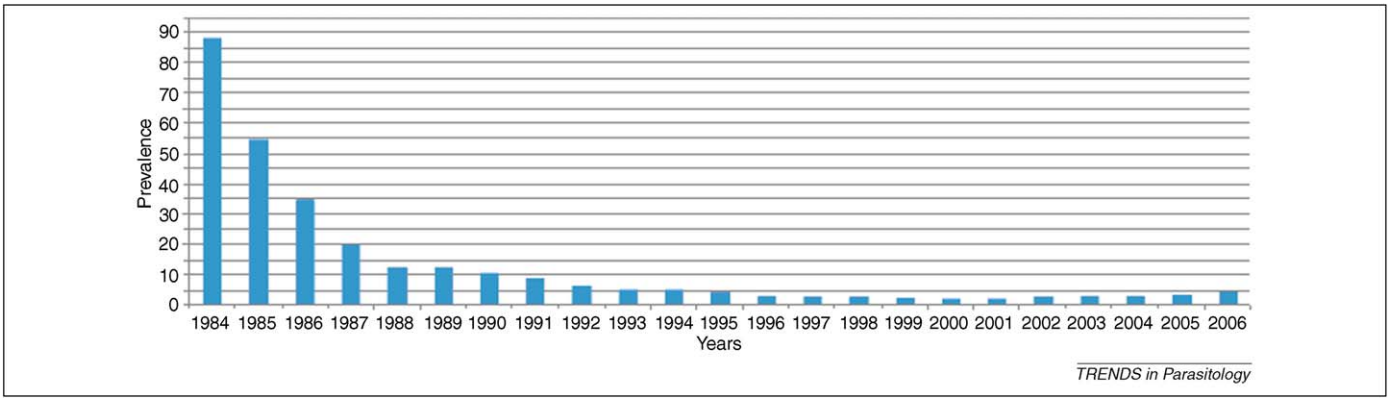

Figure 2. The prevalence of malaria in China (per 100000 population) from 1984 to 2006, showing a significant and continued decline of prevalence between 1984 and 1993 but a slight rise since 2001.

Malaria

The most common type of malaria in China is caused by *Plasmodium vivax*. Quartan malaria caused by *Plasmodium malariae*, that was sporadic in the 1950, is now very rare. Since 1982, however, there have been increasing numbers of reports of transfusion-induced quartan malaria in several provinces such as Guangdong and Hubei [35].

Over the past 50 years the Chinese government has made consistent efforts to control and prevent malaria, and has made great achievements. In 1984 the incidence of malaria dropped to 100 cases per 100000 population; however, the incidence rate has risen slightly since 2001 (Figure 2) [36]. An increase in the transient population has been accompanied by local outbreaks of malaria in some regions where malaria had previously disappeared. In 2006, a total of 64178 malaria cases and 52082 suspected cases, with 38 deaths among the suspected cases, were reported in 917 counties of 23 P/A/M, and the annual incidence was 5 cases per 100000 population [37]. In 2007, 50148 malaria cases and 83551 suspected cases with 18 deaths were reported in 1182 counties of 23 P/A/M, and the annual incidence was 3.9 cases per 100000 population [38].

Yunnan and Hainan provinces still face a severe situation of endemic malaria because of the spread of *P. falciparum* and imported cases of malaria in 25 border counties in Yunnan province [39]. According to the data from the National Malaria Survey in 2006, the number of fatal malaria cases in Yunnan province was 32, the highest rate in China, and accounted for 84.2% of total fatal malaria cases (32/38); subtertian malaria imported from abroad accounted for 60.4% of these cases [37]. Thus, malaria cases from abroad still have a significant impact on malaria prevalence in China.

However, with regard to the malaria situation in Hainan province, the prevalence was 4.65 cases per 10000 people in 2006, and this represents a marked fall, being 14.8% less than in the previous year [37]. All subtertian malaria cases came from indigenous infections, and there were no fatal cases. This indicates that the 'Global Fund Program' has achieved significant results in Hainan province [37].

Leishmaniasis

Visceral leishmaniasis (kala-azar) caused by *Leishmania donovani* is one of the important parasitic diseases in China. It was once prevalent in rural areas north of the Yangtze River, such as Shandong, Jiangsu, Henan and Hubei provinces that were epidemic areas at one time with high prevalence rates. As a result of effective measures taken to control leishmaniasis, including the eradication of sandflies and the culling of infected dogs, the disease was almost completely eliminated in China between 1958–1960 [40]. The number of cases of kala-azar fell from 530000 in 1951 to 10000 in 1959, and the prevalence rate decreased from 0.5 to 0.2/100000 during the period from 1959 to 1968, with only a few sporadic cases occurring thereafter [40].

Nevertheless, sporadic and imported cases have been reported in six Northern provinces. In the 2004 national survey there were 85 cases in Xinjiang, six cases in Sichuan, and five cases in Gansu, and 80 of these 96 (i.e. 83%) occurred in the 0–19 year age group [1]. The occurrence of kala-azar is beginning to rise as a result of ecological changes [41]. More than 300 cases of visceral leishmaniasis are reported each year across the whole country, and about half of these cases originate from Kashi city in Xinjiang province [41,42].

Food-borne parasitic diseases

Over the past 20 years, with increased income and standards of living, and a rise in the consumption of exotic and delicate foods, food-borne parasitic diseases have become one of the main factors that impact upon national food safety and public health. The fastest growing food-borne parasitic diseases in China include clonorchiasis, angiostrongyliasis, echinococcosis, trichinellosis and cysticercosis [43,44].

Clonorchiasis caused by *Clonorchis sinensis* is mainly distributed in Asian countries, with an estimated 35 million people infected worldwide [45]. In China, clonorchiasis is endemic in 27 P/A/M [44] and is listed by the Ministry of Health as one of the most important parasitic diseases [46].

Angiostrongylus cantonensis, the causative agent for angiostrongyliasis, was first discovered in rat lung in Guangzhou in 1933 [47]. Approximately 400 angiostrongyliasis cases have been reported in China since 1984 [44,48,49], and these occurred predominantly between 1979 and 2008 [48,49].

Echinococcosis caused by *Echinococcus granulosus* and *Echinococcus multilocularis* is considered to be the most severe parasitic disease in the seven western provinces or

autonomous regions (Xinjiang, Ningxia, Gansu, Qinghai, Sichuan, Tibet and Inner Mongolia) [1,44,50]. Nationwide, there were ~380000 cases of echinococcosis and ~50 million people were at risk of infection [1,44]

Human trichinellosis is caused by *Trichinella spiralis* and *Trichinella nativa*. The first trichinellosis case was found in Tibet in 1964, and the disease was epidemic in a number of provinces where ~20 million people were infected [1,51–53]. In the 1980s, when the food market in China was first opened, many outbreaks of trichinellosis occurred as a result of an inadequate and incomplete system of detection and quarantine. Since the 1990s government departments have implemented strict measures for the detection and quarantine of contaminated meat and food, and the prevention of trichinellosis has become more effective. However, in areas inhabited by minor nationalities (in China, the Han people comprise ~92% of the total population, with the other 55 nationalities representing only ~8%, and these minorities reside principally in the northwest and southwest of China), a number of outbreaks of trichinellosis have occurred, mainly due to the lifestyle of eating raw or undercooked meat [51,52,54,55]. Although pork is the major source of infection, the meat of herbivores can also be a source of infection, and several trichinellosis outbreaks attributed to the consumption of roast mutton or instant-boiled mutton were reported over the period from 1979 to 1999 [51,52].

Human cysticercosis caused by the larval stage of *Taenia solium* occurred in 29 P/A/M, and ~7 million people were infected [1]. As with trichinellosis, some minor nationalities prefer to eat raw pork and hence are at high risk of cysticercosis [1].

Perspectives for control

The major trends in parasitic diseases in China are as follows. First, biohelminths will replace geohelminths as the focus for future control programs against helminthiasis. Second, the prevalence of food-borne parasitic zoonoses has increased significantly. In the recent national survey, prevalence rates of *T. solium* and *Clonorchis sinensis* infection increased by 52.5% and 75%, respectively, compared to the rates reported in the 1990 survey. By contrast, the prevalence of soil-transmitted hookworms, *Ascaris* and *Trichuris*, has dropped significantly [1]. Finally, the control focus for parasitic diseases is moving from the southeast coastal area to Western China. To cope with the new trends of parasitic diseases, in 2006 the Ministry of Health established the 'Prevention and Control Programs for National Important Parasitic Diseases between 2006 and 2015', that includes a program of publicity and education regarding the scientific basis for the prevention and control of parasitic diseases, in addition to the implementation of appropriate prevention and control measures against different parasitic diseases (Box 2) [56].

Nonetheless, parasitic diseases previously under control can re-emerge if control measures are discontinued. For example, the ten-year turmoil of the 'Cultural Revolution' caused the interruption of prevention and control work for leishmaniasis, and this resulted in a significant rise in the number of leishmaniasis cases [40]. It is therefore imperative that control measures are not relaxed.

Box 2. Measures to target different parasitic diseases in China

(i) **Geohelminthiasis**: all persons aged three years and upwards should receive anthelmintic treatment in the areas where prevalence is more than 50%, and also in areas where prevalence is between 10% and 50%. Some high-risk groups, including people living in rural areas and children, should also be treated with anthelmintics.

(ii) **Echinococcosis**: in areas where echinococcosis is prevalent, dogs should periodically be given anthelmintics. Relevant governmental departments should also strengthen quarantine measures, and internal organs of infected animals should be disinfected by government-certified methods including incineration and deep burial.

(iii) **Clonorchiasis**: in areas where prevalence is greater than 40%, and in areas where prevalence is between 10% and 40%, all persons aged three years and above should receive anthelmintic therapy. Some high-risk groups, such as young adults, should also be treated with anthelmintics. Relevant governmental departments should collaborate to reinforce food-processing safety measures.

(iv) **Leishmaniasis**: in areas where leishmaniasis is prevalent, children less than 15 years of age should be screened annually. In these regions, appropriate environmental pesticides should be applied to eradicate sandfly vectors prior to the vector reproductive season (May to August).

The distribution of water resources in China is extremely uneven. Southern China is rich in water, accounting for ~80% of the water resource, and yet about 65% of the arable land is located in northern China [57]. The South–North Water Diversion Project was therefore implemented in order to improve the water-shortage situation in the north, and was mainly aimed at providing water for the North China Plain and the Jiaodong Peninsula Region. This project was designed with three supply routes: the west, middle and east routes. According to the plan, the three routes will transfer water to north China from the upper, middle and lower reaches of the Yangtze River, respectively.

There is continued concern regarding the potential impact of this project on the transmission of diseases including schistosomiasis [58,59]. The predominant paths of disease transmission are anticipated to be via the east route through the Lixia River basin in Jiangsu Province and through Chaohu areas of Anhui Province, and via the middle route through the Sihu areas of Hubei Province. Northward snail transmission will be affected both by this project and by global warming. As a result, future endemic areas of schistosomiasis will probably extend to the Hongzehu and Chaohu regions, and this could severely constrain socioeconomic development [58,59].

Furthermore, in order to control emerging and re-emerging parasitic diseases, techniques for detection, surveillance and infection source-tracking must be further improved.

Concluding remarks

Significant socioeconomic advances have been made in China over the last three decades, and these have been accompanied by control of major infectious diseases caused by viruses, bacteria, and soil-transmitted helminths. However, due to the complexity and difficulty encountered in the control of helminthiasis caused by biohelminths (such

as *S. japonicum*) in view of the involvement of intermediate hosts in their lifecycles, biohelminths will remain the focus of current and future national control programs. In addition, with increasing public awareness and food-safety concerns, food-borne parasitic zoonoses are increasingly receiving attention from central and local governments, and have been listed by the Ministry of Health as among the most important human diseases to be controlled in the near future. Although facing many challenges, such as the detrimental impact of global warming and accompanying ecological changes on the transmission of parasitic diseases, and further issues including the uneven economic development of urban versus rural regions, and between the east and west of China, parasitic diseases will be well under control in the near future in China.

Acknowledgements

This work is supported, in part, by grants from the National Basic Research Program of China (Grant No. 2007CB513104), the National Special Research Program for Non–Profit Trades (Agriculture) (Grant No. 200803017), the Program for Changjiang Scholars and Innovative Research Team in University (Grant No. IRT0723), the National Natural Science Foundation of China (Grant No. 30371257), the Yunnan Provincial Program for Introducing High-level Scientists (Grant No. 2009CI125), and the State Key Laboratory of Veterinary Etiological Biology, Lanzhou Veterinary Research Institute, Chinese Academy of Agricultural Sciences.

References

1 Xu, L.Q. *et al.* (2005) A national survey on current status of important parasitic diseases in human population. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 23 (Suppl.), 332–340
2 Yu, S.H. *et al.* (1995) Special report of nationwide survey of human parasites in China. *Southeast Asian J. Trop. Med. Public Health* 25, 4–10
3 Xu, L.Q. *et al.* (1995) Soil-transmitted helminthiases: nationwide survey in China. *Bull. World Health Organ.* 73, 507–513
4 Chen, Y.D. *et al.* (2008) Current status of soil-transmitted nematode infection in China. *Biomed. Environ. Sci.* 21, 173–179
5 Takeuchi, T. *et al.* (2007) Past Japanese successes show the way to accomplish future goals. *Trends Parasitol.* 23, 260–267
6 Shin, E.H. *et al.* (2008) Trends in parasitic diseases in the Republic of Korea. *Trends Parasitol.* 24, 143–150
7 Lin, J.X. (2006) Control strategies and trends in food-borne parasitic diseases. *Strait J. Med.* 12, 1–3
8 Cao, Z.G. (2007) Prevalent status of clonorchiasis and its control in China. *China Trop. Med.* 7, 1455–1457
9 Chen, J. *et al.* (2007) The program of lymphatic filariasis epidemiologic study in China. *Di Fang Bing Tong Bao* 22, 77–79
10 Sun, D.J. (2005) Global significance of eliminating lymphatic filariasis in our country. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 23 (Suppl.), 329–331
11 Xia, L.Z. (1997) Epidemic situation of parasitic diseases in China. *J. Dis. Cont. Prevent.* 1, 169–172
12 Xu, L.Q. *et al.* (1995) Nationwide survey of parasites in China – the characteristics and geographic distribution of human helminth infections. *Chin. J. Parasitol. Parasit. Dis.* 13, 99–103
13 Cheng, Y.Z. *et al.* (2005) Survey on the current status of important human parasitic infections in Fujian province. *Chin. J. Parasitol. Parasit. Dis.* 23, 283–287
14 Li, X.M. *et al.* (2004) *Haplorchis taichui* was discovered in Guangxi. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 22, 61
15 Qu, F.Y. (2007) Historical review on the development of medical parasitology in China during the years of 1871–2006. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 25, 259–273
16 Zhang, Q.Y. *et al.* (1996) Disease caused by *Armillifer agkistrodontis*: report of a case. *Zhonghua Nei Ke Za Zhi* 35, 747–749
17 Zhang, B.X. (2000) A case with *Cyclospora cayetanensis* infection. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 18, 319
18 Cheng, Y.Z. *et al.* (1991) The first report of human infection with *Centrocestus cuspidatus*. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 9, 273
19 Xiao, X. *et al.* (1992) The first record of human natural infection with *Echinochasmus liliputanus*. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 10, 132–135
20 Xue, Y.P. (2006) Emerging parasitic disease: cryptosporidiosis. *J. Clin. Exp. Med.* 5, 1427–1428
21 Han, F. *et al.* (1987) Two cases of *cryptosporidiosis* in Nanjing. *Jiangsu Med. J.* 13, 692–693
22 Yang, X.Y. (2005) Epidemic characteristics of human cryptosporidiosis. *Parasit. Dis. Infect. Dis.* 3, 135–137
23 Zhang, Y.J. *et al.* (2001) Survey on cryptosporidiosis among children with diarrhea in Chengdu. *J. Practi. Parasit. Dis.* 9, 72–73
24 Wei, J. (2007) New features and variations of parasitic diseases in our country. *Chin. J. Pratic. Intern. Med.* 27, 1354–1355
25 Deng, Y. and Zhou, X.N. (2007) Social factors of schistosomiasis transmission in China. *Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi* 19, 393–397
26 Wang, X.W. *et al.* (1989) Analysis for epidemic situation of schistosomiasis in 1988. *Chin. Dis. Surveillance* 4, 94–95
27 Utzinger, J. *et al.* (2005) Conquering schistosomiasis in China: the long march. *Acta Trop.* 96, 69–96
28 Wang, L.D. *et al.* (2008) Schistosomiasis control: experiences and lessons from China. *Lancet* 372, 1793–1795
29 Guo, J.G. (2006) The history and present situation of comprehensive control on schistosomiasis in China. *Zhonghua Yu Fang Yi Xue Za Zhi* 40, 225–228
30 Yu, Q. *et al.* (2006) Evolution of comprehensive strategy for schistosomiasis control in various control phases in China. *Zhongguo Bing Yuan Sheng Wu Xue Za Zhi* 1, 470–473
31 Hao, Y. *et al.* (2007) Schistosomiasis situation in the People's Republic of China in 2006. *Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi* 19, 401–404
32 Hao, Y. *et al.* (2008) Schistosomiasis situation in the People's Republic of China in 2007. *Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi* 20, 401–408
33 Wang, L.D. *et al.* (2009) A strategy to control transmission of *Schistosoma japonicum* in China. *N. Engl. J. Med.* 360, 121–128
34 Li, S.Z. *et al.* (2009) Schistosomiasis in China: acute infections during 2005–2008. *Chin. Med. J (Engl).* 122, 1009–1014
35 Chen, B. (2001) Review of prevention and control of transfusion-induced quartan malaria. *Zhongguo Ji Sheng Chong Bing Fang Zhi Za Zhi* 14, 6–7
36 He, T.F. and Shen, Y.P. (2008) A study on three models for the prediction of malaria incidence trend in China. *Shanghai J. Prevent. Med.* 20, 57–60
37 Zhou, S.S. *et al.* (2007) The situation of malaria in the People's Republic of China in 2006. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 25, 439–441
38 Zhou, S.S. *et al.* (2008) The situation of malaria in the People's Republic of China in 2007. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 26, 401–403
39 Lu, Y.L. (2008) The status of malaria in transient population in China. *Prevent. Med. Trib.* 14, 632–634
40 Xiong, G.H. (1992) Current situation of leishmaniasis epidemiology in China. *Di Fang Bing Tong Bao* 7, 113–125
41 Gu, D.A. (2006) Present situation and perspective of leishmaniasis and its vector sandfly control. *Int. J. Med. Parasit. Dis.* 33, 236–238
42 Kai, S.R. *et al.* (2008) The consideration of leishmaniasis prevention and control in Kashi area of Xinjiang Autonomous Region. *Di Fang Bing Tong Bao* 23, 23–26
43 Yin, G.R. *et al.* (2006) Common food-borne parasitic diseases and their prevention and control in China. *Chin. J. Dis. Cont. Prevent.* 10, 400–402
44 Zhou, P. *et al.* (2008) Food-borne parasitic zoonoses in China: perspective for control. *Trends Parasitol.* 24, 190–196
45 Lun, Z.R. *et al.* (2005) Clonorchiasis: a key foodborne zoonosis in China. *Lancet Infect. Dis.* 5, 31–41
46 Cao, Z.G. (2007) Prevalence status of clonorchiasis and its control in China. *China Trop. Med.* 7, 1455–1457
47 Chen, H.T. (1933) A preliminary report on a survey of animal parasites of Canton China rats. *Lingnan Sci. J.* 12, 65–74

48 Lv, S. *et al.* (2008) Emerging angiostrongyliasis in Mainland China. *Emerg. Infect. Dis.* 14, 161–164
49 Lv, S. *et al.* (2009) Human angiostrongyliasis outbreak in Dali, China. *PLoS Negl. Trop. Dis.* 3, e520
50 Xu, L.Q. (2002) The consideration to the prevention and control work of important parasites in western China. *Zhongguo Ji Sheng Chong Bing Fang Zhi Za Zhi* 15, 1–3
51 Liu, M.Y. and Boireau, P. (2002) Trichinellosis in China: epidemiology and control. *Trends Parasitol.* 18, 553–556
52 Cui, J. and Wang, Z.Q. (2005) Epidemiological trends and control measures of trichinellosis in China. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi* 23 (Suppl.), 344–354
53 Cui, J. *et al.* (2006) The re-emergence of trichinellosis in China? *Trends Parasitol.* 22, 54–55
54 Yang, Y.C. *et al.* (2007) Survey on the outbreak and epidemic focus of trichinellosis in Guangxi. *Applied Prevent. Med.* 13, 139–141
55 Ma, G.Y. (2008) An outbreak of human acute trichinellosis in Dali Prefecture, Yunnan Province. *Parasit. Infect. Dis.* 6, 55–56
56 The Ministry of Health (2006) Prevention and control program for national important parasitic diseases during 2006 and 2015. *Chin. Practic. J. Rural Doctor.* 13, 1–3
57 Jia, S.F. *et al.* (2004) Problems and countermeasures of water resource security in China. *Bull. Chin. Acad. Sci.* 19, 347–351
58 Wang, W. *et al.* (2008) Impact of the construction of the South-North Water Diversion Project on distribution of *Oncomelania hupensis*, the intermediate host of *Schistosoma japonicum* in China. *Acta Ecol. Sinica* 28, 4235–4245
59 Zhou, X.N. *et al.* (2003) Potential impact of the South-North Water Diversion Project on transmission and distribution of schistosomiasis japonica. *Zhongguo Xue Xi Chong Bing Fang Zhi Za Zhi* 15, 294–297