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Current status of human parasitic infections in Taiwan

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The eradication of the 2 mosquito-borne parasitic diseases, malaria and lymphatic filariasis, is one of the greatest achievements of the parasite control campaigns in Taiwan. Most of the soil-transmitted nematode infections, with the exception of pinworm infection, are currently well controlled and limited to some aboriginal areas. Food-borne parasitic zoonosis such as infections with *Angiostrongylus cantonensis*, *Clonorchis sinensis*, and *Taenia saginata asiatica* are not rare, but the former is seasonal and the latter 2 are ethnically and geographically associated. Intestinal protozoal infections with *Giardia lamblia* and *Cryptosporidium parvum* are at low levels but may be widely distributed. Opportunistic protozoal infections among patients with acquired immunodeficiency syndrome, which included amebic colitis, *Pneumocystis carinii* pneumonia, and cerebral toxoplasmosis, are becoming increasingly important. The rapid increase in international travel and the introduction of large numbers of foreign workers from other countries in Southeast Asia may change the epidemiological patterns of parasitic infections in Taiwan.

Key words: AIDS-related protozoal infection, parasitic infection, Taiwan, zoonosis

Malaria was eradicated from Taiwan by 1965 [1], followed by the eradication of lymphatic filariasis in the 1980s [2,3]. The overall infection rate of soil-transmitted intestinal nematodes in Taiwanese school children was as high as 70% in 1950s, but this rate has been reduced to less than 2% in the 1990s [4]. Intestinal nematode infections with roundworm, whipworm, and hookworm are currently under control, but enterobiasis is still prevalent among primary school children [4,5]. Food-borne parasitic zoonosis such as clonorchiasis and taeniasis are confined to some ethnic groups [6-8], whereas angiostrongyliasis is associated with the rainy season [9,10]. Intestinal protozoal infections with *Giardia lamblia* and *Cryptosporidium parvum* are not rare, but their exact prevalence is difficult to assess because of a lack of epidemiological surveys [11,12]. Opportunistic-related protozoal diseases, such as *Pneumocystis carinii* [13-15], *Entamoeba histolytica* [16,17], and *Toxoplasma gondii* [18-20] are the leading parasitic pathogens among patients with human immunodeficiency virus (HIV) infections in Taiwan.

Despite major achievements in the parasite control campaigns during the past 4 decades (Table 1), the popularity of quick and affordable international travel and the introduction of foreign workers may reintroduce or import eradicated or controlled parasitic infections into Taiwan. Regulatory steps may be needed to identify the possibility of imported foods being contaminated with parasites. Moreover, the subtropical climate and suitable environmental conditions in Taiwan may help sustain a considerable number of potential vectors and intermediate hosts for various parasites. These factors may together result in outbreaks of mosquito-borne and snail-transmitted parasitic infections in Taiwan if the surveillance system for parasite control fails. Thus, the impact of human parasitic infections on public health in Taiwan needs to be reevaluated.

Vector-borne Parasitic Infections

In the 1950s, 2 major mosquito-borne parasitic infections were prevalent in Taiwan. Malaria was endemic throughout the country [1], whereas lymphatic filariasis caused by *Wuchereria bancrofti* was mainly localized in some offshore islets [2,3]. To eradicate malaria, other malaria control measures in addition to chemotherapy were introduced, which include house

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Table 1. Achievements of parasite control campaigns in Taiwan

Parasite control campaign	Location	Result
Malaria	Countrywide	Eradicated in 1965
Filariasis	Kinmen islands	Eradicated in 1978
Intestinal nematode infections	Urban areas	Controlled in 1985
	Aboriginal remote areas	Controlled in 1995

spraying of dichloro-diphenyl-trichloroethane (DDT) in particular [1]. After an 8-year DDT-spraying campaign, the number of indigenous transmission malaria cases, conservatively estimated in 1952 as 1.2 million, was significantly reduced by the early 1960s [1]. On December 4, 1965, Taiwan was officially registered on the World Health Organization list of countries where malaria had been eradicated. Since then, less than 50 imported cases of malaria are reported each year in Taiwan [1].

Babesiosis, a tick-borne protozoal infection, is rare–until today, only 2 cases have been reported in Taiwan [21-23]. In the 1960s, bancroftian filariasis was prevalent in the Kinmen Island, with overall infection rates of 19.1% and 5.8% in native Kinmenese and military personnel assigned to the area, respectively [2, 3]. To control bancroftian filariasis and to promote public health of the Kinmen Island, chemotherapy and vector control were combined with the use of common salt medicated with diethylcarbamazine (DEC). Control campaigns to eliminate lymphatic filariasis using DEC in cooking salt commenced in Little Kinmen in 1974 and in Kinmen Proper in 1977 [2,3]. Filarial infection on Little Kinmen and Kinmen Proper was eliminated in 1975 and 1978, respectively [2,3]. This campaign was successful, particularly for patients with acute manifestations who received a low dose of DEC-enriched salt for a period of 6 months [24].

Dirofilaria immitis infection rate was as high as 55% in dogs from the north of Taiwan during the past 10 years [25,26], which is not only a veterinary issue but also zoonotic that threatens public health [27]. The large number of stray dogs and the unrestricted importation of dogs from endemic areas may have contributed to the high prevalence of canine *D. immitis* infection [25,26]. Although only a single human case of pulmonary dirofilariasis has been reported [28], the prevalence of human dirofilariasis in Taiwan is worthy of further investigation (Table 2).

Soil-transmitted Nematode Infections

In the 1970s, the overall rate of intestinal nematode infections in primary school children was over 70% [4].

Table 2. Underestimated human parasitic infections in Taiwan

Disease	Major animal reservoirs
Nematode infections	
Dirofilariasis	Dogs
Strongyloidiasis	Dogs[a]
Toxocariasis	Cats, dogs
Protozoal infections	
Cryptosporidiosis	Calves, lambs
Cyclosporiosis	Birds[a]
Giardiasis	Beavers
Microsporidiosis[a]	
Toxoplasmosis	Cats, pigs

[a]Major animal reservoirs are not certain.

A control campaign of intestinal nematode infections among primary school children thus commenced in 1972. A massive chemotherapy campaign with mebendazole was initiated, and regular surveys were conducted seasonally [4]. An epidemiological study performed in 1995 throughout the country revealed that the overall infection rate of *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms was less than 2%, though higher infection rates were noted in aboriginal children living in some mountainous areas and on the offshore islets [29,30]. The overall infection rate of *Enterobius vermicularis* was 16% among aboriginal school children in Taiwan [30]. In urban areas, the prevalence of enterobiasis in preschool children was noticeably higher (up to 14%) compared with school children [29].

The prevalence of soil-transmitted nematode infections with tissue invasion, such as *Strongyloides stercoralis* and *Toxocara* spp., has been underestimated in Taiwan (Table 2). *S. stercoralis* infection has been occasionally found in immunocompromised patients [31]. In addition, the general population may be at risk of contacting with *S. stercoralis*-contaminated soil during gardening. *Toxocara* spp., which is responsible for ocular larva migrans or visceral larva migrans, is mainly a pediatric disease. Children are more likely to encounter toxocarid eggs when playing outdoor, such as in grass areas, frequented by stray dogs and cats in Taiwan.

Food-borne Parasitic Infections

Several food-borne parasitic diseases have been reported in Taiwan, with *Angiostrongylus cantonensis*, *Clonorchis sinensis*, and *Taenia saginata asiatica* being the most important and common [6]. Eosinophilic meningitis (or meningoencephalitis) caused by *A. cantonensis* is a common parasitic disease in southern and eastern Taiwan, especially among children during

the summer rainy season when the intermediate host, the giant African snail, *Achatina fulica*, takes a major role in transmission [9,10,32]. Most cases of eosinophilic meningitis in other countries are reported in adults, and their clinical manifestations are different from those of children in Taiwan [10]. The incubation period (13 days) in Taiwanese children is shorter than that in adults, and meningoencephalitis is also more common in children [10,32]. Both albendazole and levamisole are effective treatments for meningoencephalitis [32,33].

Infection with *C. sinensis* is ethnically and geographically associated. Transmission is via the intake of raw or undercooked metacercaria-freshwater fish. Clonorchiasis is endemic to Miao-li in the north, Sun-moon Lake in central Taiwan, and Mei-nung in the south. A 1984-survey reported that the overall infection rates for these 3 areas were 57%, 52%, and 52%, respectively [7]. After the introduction of praziquantel as chemotherapy and the promotion of health education, the prevalence of clonorchiasis decreased significantly [6].

Taeniasis is highly prevalent among the aborigines in the mountainous areas of Taiwan. During the period from 1971 through 1995, a large-scale survey found the overall infection rate of taeniasis among aborigines was 11% [8]. This high prevalence was due to the aboriginal people eating raw meat and/or viscera of wild pigs infected with *T. saginata* [34]. A series of studies have shown that taeniasis in Asia is caused by a new subspecies of *T. saginata*, which is now named *T. saginata asiatica* [34]. After chemotherapeutic trials, praziquantel was found to be the most effective treatment [34].

Other food-borne parasitic infections, such as human paragonimiasis, used to be prevalent in Taiwan more than 40 years ago, but are now rarely seen. This is due to both a successful national public health program and a decrease in intermediate hosts such as freshwater crabs in polluted rivers [35,36].

Human intestinal capillariasis is an emerging food-borne parasitic disease [37]. Hwang [38] reported 7 patients in the southern and eastern parts of Taiwan who have intestinal capillariasis. It was proposed that human may become infected when they eat undercooked or raw fish, which are commonly consumed by birds [37]. Raw fish (sashimi) is a very popular food in Taiwan, but its link with intestinal capillariasis needs further investigations.

Water-borne Protozoal Infections

The first case of giardiasis in Taiwan was reported in 1975 on an offshore island. Stool specimens revealed that about one third of the children residing on the island were infected with *Giardia* spp. [12]. Very few clinical cases of giardiasis in adults have been reported [11]. Presently, both *G. lamblia* and *C. parvum* have been largely ignored as water-borne pathogens of concern. A recent survey of protozoa in water supply systems found a high prevalence of *Giardia* and *Cryptosporidum* contamination [39,40]. Risk assessments of these parasitic infections suggest that tap water in Taiwan is unsuitable for drinking without first being boiled or going through point-of-use treatment [40].

Opportunistic-related Protozoal Infections

The prevalence of HIV infection and acquired immunodeficiency syndrome (AIDS) has increased rapidly in Taiwan during the past decade [41,42]. Among the opportunistic protozoal infections found in AIDS patients, *P. carinii* pneumonia was the most common parasitic infection that developed at an early stage of AIDS [13]; it was also the leading opportunistic infection in AIDS patients [14]. A recent report indicated that *P. carinii* pneumonia is also the most common pulmonary infection in HIV-infected patients [15]. Invasive amoebiasis is another emerging parasitic disease found in HIV-infected patients in Taiwan [16]. Amoebic colitis is responsible for prolonged diarrhea in patients with AIDS [17].

Despite the fact that it contributes to the neurologic complications in AIDS patients, cerebral toxoplasmosis is not common in Taiwan [18-20]. Only a few suspected cases of human toxoplasmosis have been reported in Taiwan [43-47], whereas a number of animals have been found to be infected with the parasite and also serologically positive [48-50]. Between 25% and 30% of pigs and cats tested were seropositive for *T. gondii* infection [48,49], but the seropositive rate was low among both urban and aboriginal residents of Taiwan [44,45]. The reason for the low prevalence of human *T. gondii* infection in Taiwan is unclear. Nevertheless, the frequency of seropositivity to *T. gondii* among humans in Taiwan suggests that nonimmune women of childbearing age are potentially highly susceptible to toxoplasma infection.

Since the recognition of HIV and AIDS in the late 1970s and early 1980s, several previously rare or unknown parasitic protozoa have been identified in immunocompromised patients [51]. Both microsporidial and *Cyclospora* infections in humans are now well documented, but in Taiwan the prevalence of both infections in immunocompromised or immunocompetent patients needs further study (Table 2).

Parasitic Infections among Southeast Asian Workers

Parasitic infections are relatively common among Southeast Asian workers employed in Taiwan [52]. In a survey conducted from 1991 through 1992, 18% of Thai laborers in Taiwan were infected with one or more species of intestinal parasites [52]. A long-term study also showed that the overall prevalence of intestinal parasitic infections was 10.3% [53]. The annual prevalence, however, decreased from 33.3% from 1992 through 1993 to 4.6% from 1995 through 1996. *Opisthorchis viverrini* was the most significant parasite in Thai workers and *T. trichiura* was common in other ethnic groups [53]. A strict policy of health check-ups for immigrant workers may have contributed to this decrease in the overall prevalence of intestinal parasitic infections.

Current Outlook of Parasitic Infections in Taiwan

The achievements of economic development and political stability in Taiwan have dramatically improved the living standard and public health of its inhabitants. Despite these improvements, however, some existing parasitic infections in Taiwan may worsen in the future. There may be a false belief that economic achievement automatically results in good public health and an end to parasite infections. This false belief may in turn result in parasite control and associated activities being neglected. Budgets for campaigns against parasitic infections are insufficient to support a continuous surveillance system. In fact, the problems of many parasitic infections, which include almost all zoonoses, have been neglected or underestimated; this could potentially become a serious public health problem in the near future (Table 2). Furthermore, both applied and basic research now focus mainly on molecular and immunological parasitology. There are fewer scientists interested in classical parasitology, which may lead to a lack of experienced traditional parasitologists in future. Inadequate teaching of parasitology in medical schools confounds the situation. Erroneous diagnosis and improper treatment often occurs, even in major teaching hospitals. Under such circumstances, it may not be possible to effectively screen all international visitors and workers from foreign countries for pathogens.

As HIV spreads in both Taiwan and the rest of the world, the potential risk for opportunistic parasitic infections also increases. Major parasitic diseases, such as malaria, filariasis, schistosomiasis, and soil-transmitted helminthiasis, are still highly endemic in some areas of China and in other parts of the world. The dramatic increase in the frequency of international travel may allow parasitic infections to spread more quickly. In the long-term, scientists, clinicians, and others who are interested in preventing and controlling parasitic diseases in Taiwan should work together to promote and improve public health. Health authorities should take the initiative in visualizing and spearheading this mission through education and research. The specific goals for this mission are the (1) education of health professionals and the public regarding parasitic infections; (2) stimulation of the advancement of basic and applied research in parasitic infections; (3) improvement of the health of people, especially those who are exposed to parasitic infections; (4) promotion of science-based policy-making concerning international health; (5) enhancement of international scientific collaboration in preventing parasitic infections; and (6) promotion of professional interest and career development in parasitology, and the recognition of exceptional achievements in parasitology and parasite control.

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