Infect Chemother. 2020 Sep;52(3):427-440
https://doi.org/10.3947/ic.2020.52.3.427
pISSN 2093-2340·eISSN 2092-6448

Infection & Chemotherapy

Special Article

Check for updates

Review of Successful Control of Parasitic Infections in Korea

Sung-Tae Hong [1] **and Tai-Soon Yong** [2]

[1]Department of Tropical Medicine and Parasitology, Seoul National University College of Medicine, Seoul, Korea
[2]Department of Environmental Medical Biology, Yonsei University College of Medicine, Seoul, Korea

OPEN ACCESS

Received: Aug 1, 2020

Corresponding Author:
Sung-Tae Hong, MD, PhD
Department of Tropical Medicine and Parasitology, Seoul National University College of Medicine, 103 Daehak-ro, Jongno-gu, Seoul 03080, Korea.
Tel: +82-10-3734-0938
E-mail: hst@snu.ac.kr

Copyright © 2020 by The Korean Society of Infectious Diseases, Korean Society for Antimicrobial Therapy, and The Korean Society for AIDS
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ORCID iDs
Sung-Tae Hong
https://orcid.org/0000-0002-0300-1944
Tai-Soon Yong
https://orcid.org/0000-0002-3445-0769

Conflict of Interest
No conflicts of interest.

Author Contributions
Conceptualization: STH, TSY. Data curation: STH, TSY. Formal analysis: STH, TSY. Writing - original draft: STH, TSY. Writing - review & editing: STH, TSY.

ABSTRACT

Korea had been one of hyperendemic countries of human parasitic infections until 1970s. In 1966, the Law for the Prevention of Parasitic Diseases was enacted, and the nationwide anti-parasitic control program began in 1969. The initiation of the national program was supported financially by Japan. The program included screening of whole students in Korea and treatment of all egg positive cases twice a year, and ended in 1995. In addition to student program, deworming campaign was run in the community, and 8 national status surveys were implemented from 1971 to 2012. Whole helminth egg positive rate was 84.3% in 1971 and decreased to 2.6% in 2012. *Ascaris* and other intestinal nematodes, *Paragonimus*, *Taenia*, and intestinal protozoa had decreased significantly throughout the country, but *Clonorchis sinensis* and intestinal trematodes are still prevalent locally in endemic areas. Lymphatic filariasis had been endemic in Jeju-do and other southern islands but elimination was endorsed in 2008. The control of parasitic infection in Korea was successful with statistical prevalence data, which can be a benchmarking model. In conclusion, the successful control in Korea could be achieved by social agreement of the priority, professional guidelines and systematic approach with good anthelminthics supply, and simultaneous economic growth.

Keywords: Korea; Intestinal helminths; Lymphatic filariasis; Elimination; National status

Parasitic infections are largely classified as infections by helminths, protozoa, and arthropods. Organisms belonging to all the three taxa have been prevalent in Korea since a long time, among which infections caused by intestinal helminths have received substantial attention with respect to their control and management measures. Direct sampling from mummies by archaeological excavation or examination of eggs in the ruins of residential areas have revealed that intestinal parasites including *Ascaris* have existed for thousands of years [1]. Academic records by Japanese scholars on this issue are available since the times of Japanese occupation. According to the records of the Korean History of Infectious Diseases, almost all of the people were infected with parasites during the Japanese occupation [2]. This high rate of prevalence was a common phenomenon as the nation's economy was majorly agrarian in the earlier times wherein there was a frequent use of human feces as

Generated by xmlinkpress

Infection & Chemotherapy

This secondary publication is based on 'Korean Society of Infectious Diseases (KSID). Korean History of Infectious Diseases II. Seoul: Koonja; 2018 (ISBN 979-11-5955-379-0)'.

fertilizer for agricultural produce. Additionally, since parasitic infections were mostly chronic cases with low mortality rates and bereft of clinical symptoms, such cases rarely received enough attention for mitigation as compared to acute infectious ailments. Thus, parasites were excluded from the management regimen of infectious diseases, thereby making their prevalence inevitable. The high rates of incidence continued even after the country attained independence and was under a new government. The Korean War further aggravated the scenario. Subsequent to the war, a large consignment of anthelminthics was brought in from foreign countries. However, this did not translate into an effective deworming as it suffered from a non-uniform distribution system. It was only in 1969, after the enactment of the Law for the Prevention of Parasitic Diseases in 1966, that there was a systematic nationwide antiparasitic program with domestic legal grounds and financial support from Japanese government [3]. Since 1970, the government has conducted necessary mass screening and anthelminthic-administrations twice a year to all students across the country and the national survey of intestinal parasitic infection was started in 1971. Accordingly, the infection of soil-transmitted intestinal helminths began to decrease steadily, reaching the threshold point (R-rate of less than 1), especially for *Ascaris*, in the 1980s [4]. In the late 1980s, schools with no incidence of *Ascaris* egg positive cases began to suspend the deworming program, thereby ending the nationwide inspections and administrations by 1995.

The main goal of the management program, which was implemented in all Korean schools was to manage the soil-transmitted intestinal helminths (*Ascaris lumbricoides, Trichuris trichiura*, hookworm). While a focused intestinal parasite management was conducted among the students, a national survey was conducted every 5 to 8 years from 1971 to obtain the national picture on the issue. The last national statistical survey that is available is the 8th one conducted in 2012 [5]. As per this survey, intestinal parasitic infection rate in Korea (synonymously egg positive rate) was 2.6%. Since there is a great variety in the infection rate of diverse parasitic infections, the following sections have been segregated based on individual parasitic infection.

1. SOIL-TRANSMITTED HELMINTHS

Soil-transmitted nematodes or soil-transmitted helminths (STH) are constituted by *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale* (hookworm), and *Strongyloides stercoralis* that majorly infect the small intestine. These species can be discussed together as they are majorly found together in the endemic regions.

1) Domestic outbreak and prevalence

When an adult worm spawns in the small intestine, the eggs are discharged to the environment along with the feces, thereby contaminating the soil. The egg develops to a larva in the soil and infects new people. *A. lumbricoides* and *T. trichiura* infect the human body when embryonated eggs that have larvae in their eggshells enter the mouth via mainly vegetables. On the other hand, *A. duodenale* and *S. stercoralis* larvae enter the body through the skin of a person upon coming in contact with the human body. In the case of *A. lumbricoides* and the hookworm, the larva performs hematogenous pulmonary migration at the initial stage of infection and then descends into the small intestine to grow into an adult. According to the investigation and excavation of archaeological sites in Korea, eggs belonging to *Ascaris* and *Trichuris* have been found in the remains from the 5th century period [1]. It is presumed that these species have settled and distributed on the land since the beginning of human

Table 1. National surveys of intestinal parasitic infections in Korea

Year	Number of examinees (persons)	Egg positive rate of intestinal helminths (%)			
		Total eggs	*Ascaris lumbricoides*	Hookworm	*Trichuris trichiura*
1971	24,887	84.3	54.9	10.7	65.4
1976	27,178	63.2	41	2.2	42
1981	35,018	41.1	13	0.5	23.4
1986	43,590	12.9	2.1	0.1	4.8
1992	46,912	3.8	0.3	0.01	0.2
1997	45,832	2.4	0.06	0.007	0.04
2004	20,541	4.3	0.05	0	0.3
2012	23,956	2.6	0.03	0	0.4

Source: National survey of intestinal parasitic infections in Korea, 8th Report [5].

settlement in Korea. The records of egg positive rates through academic examination of feces dated to reports from 1913. These reports accounted 80% of cases to *A. lumbricoides*, 93% to *T. trichiura*, and 65% to hookworms among the population of Hwanghae-do. In 1925, a nationwide fecal examination by the Japanese Government-General of Korea showed 54.9% of *A. lumbricoides* egg positive rate [6]. Going by the sensitivity of egg detection in feces, it can be estimated that the entire population might have been infected. The natural lifespan of adult *Ascaris* inside the human body is about 1 to 1.5 years, and the *Ascaris* eggs buried in the soil may survive for about 3 years in the natural environment of Korea. Earlier projects or surveys were mainly focused on *Ascaris*, and the egg positive rate in the 1950s - 60s was reported to be 50% or higher and sometimes even escalated to 90%. In the past, there was a widespread public awareness that human body with *Ascaris* is healthy. However in the 1960s, with the death of a heavily infected girl, the recurrence of the international problem of parasitic infections of dispatched miners, and the efforts of foreign doctors and domestic parasitologists in Korea, the prevalence of infection emerged as a national concern of public health that had to be eradicated nationally [7]. Nationwide surveys (**Table 1**) showed the decreasing pattern of past intestinal parasitic infections [5].

Based on these data, it was deduced that the reinfection power of *Ascaris* decreased in Korea in the early 1980s, and thereafter, it has gradually declined even in the absence of dedicated management projects [4].

2) Domestic disease patterns

STHs are usually parasitic in the small intestine and have no symptoms in the event of minor infections. However, in the event of an increase in the number of infected bodies, nonspecific digestive symptoms such as abdominal pain, diarrhea, vomiting, and nausea might manifest along with concomitant malnutrition. *A. lumbricoides* adult worms have strong body mobility and sometimes cause heterotopic parasitism, which might cause its transfer to the stomach and subsequent discharge by vomiting. If the worms enter the bile ducts, individuals might develop jaundice and might require surgical treatment. Among hookworms, one American hooker (*Necator americanus*) sucks up 0.03 mL of blood per day; while the Dubini hooker (*A. duodenale*) sucks up 0.15 mL, resulting in anemia and degenerative lesions of the small intestine villi when the number of parasites is large. *T. trichiura* are parasitic in the large intestine, including the appendix with most of them showing no symptoms. Severe infections cause diarrhea, anal prolapse, and anemia, but no such cases have been reported yet in Korea. *Strongyloides* and the *Trichostrongylus orientalis* also belong to this category, but cases of infections from these worms were low and are no longer reported any more.

Infection & Chemotherapy

3) Prevention and management

In the wake of the Japanese occupation and the Korean War, domestic intestinal parasitic infections were almost naturally saturated, infecting the entire population except newborns and infants. Nevertheless, there was a pile of anthelminthics (mainly piperazine) that were brought into the country through foreign aid after the Korean War; but they could not be distributed efficiently. The Korea Veterinary Sanitation Association, which was established in 1958 to remove harmful animals and rats, was responsible for distributing the donated anthelminthics. The association was disbanded later, and in 1964, the Korea Association for Parasite Eradication (KAPE) was founded for the deworming program. Furthermore, the 'Law for the Prevention of Parasitic Diseases' (Act No. 1789, promulgated on April 25, 1966) was enacted in 1966, and the law enforced nationwide feces screening of students. However, the deworming program was not actively engaged in activities due to lack of funds in the early stage. With the Japanese government's support, the KAPE began to conduct full-scale examinations and distributed anthelminthics in September 1969. The deworming program covering whole students was actively carried out throughout the nation with the primary aim of administering anthelminthics for all egg positive ones. In addition to this school program, community anthelminthic program was conducted alongside the family planning project and the Saemaeul Movement (New Village Campaign).

The majorly used anthelminthics were santonin and kainic acid (extract of *Digenea simplex*) from 1969 to the early 1970s, piperazine between1971 and 1981, pyrantel pamoate between 1973 and 1988, mebendazole between 1983 and 1993, and albendazole since 1988 [4]. In the 1980s, the egg positive rate was sharply reduced, and from the mid 80s, schools with no *Ascaris* egg-positives began to appear, resulting in suspension of the program and subsequent termination of the school deworming program in 1995 (**Table 2**) [8]. As a result of these changes, the KAPE, which oversaw the parasite management business, was later merged with the Korea Association of Health Promotion, that was established in 1982. Since then, the Korea Association of Health Promotion has been supervising the parasite management business in Korea till today. The school deworming program was discontinued, but the survey of the entire population has been continuing every five to seven years, and the 8th survey was conducted in 2012 to identify the current status (**Table 1**) [5]. Based on the national data, it was judged that the intestinal nematode, which was prevalent at a high rate in the past, is no longer a health problem in Korea and has little possibility of recurrence. In 2001, Korea was certified as a nation which has achieved total eradication of intestinal nematode infection by the World Health Organization (WHO).

2. LYMPHATIC FILARIA

1) Domestic outbreak and prevalence

In Korea, *Brugia malayi* was prevalent causing lymphatic filariasis. The records showed that it had already been in existence since a thousand years, but academic records first appeared in 1927. There have been sporadic reports, but the full-scale epidemiological survey started in the 1960s and a survey on 24,816 people nationwide from 1964 to 1967 reported a 0.63% of microfilaria positive rate [9]. Based on this data, surveys focused on Gyeongsangbuk-do, Jeollanam-do, and Jeju-do, and confirmed highly endemic areas with a larva positive rate of 10% or more. As human infection is mediated by mosquitoes, *Anopheles sinensis* in the inland Gyeongsangbuk-do and *Aedes togoi* in the Jeollanam-do coast and Jeju-do were confirmed to be major vectors. In these endemic areas, infected patients were treated with

Infection & Chemotherapy

Table 2. Results of national student fecal examinations

Year	No. of examinees (coverage rate %)	No. of egg positive (%)	No. of *Ascaris lumbricoides* egg positive (%)
1969	6,551,926 (44.9)	5,046,216 (77.0)	3,631,699 (55.4)
1970	10,871,280 (74.3)	8,095,911 (74.5)	6,042,588 (55.6)
1971	11,813,868 (77.3)	8,429,031 (71.3)	6,100,187 (51.6)
1972	11,243,033 (70.4)	7,179,521 (63.9)	5,148,951 (45.8)
1973	12,116,892 (78.3)	7,903,665 (65.2)	5,830,227 (48.1)
1974	11,901,236 (77.3)	6,360,121 (53.4)	4,545,509 (38.2)
1975	12,480,942 (80.5)	6,459,819 (51.8)	4,835,409 (38.7)
1976	13,423,636 (85.5)	6,104,644 (45.5)	4,519,433 (33.7)
1977	14,160,212 (89.0)	5,601,692 (39.6)	4,211,724 (29.7)
1978	15,030,061 (102.4)	4,200,218 (27.9)	2,914,865 (19.4)
1979	15,682,977 (96.5)	3,620,058 (23.1)	2,347,664 (14.9)
1980	15,495,361 (91.9)	3,050,527 (19.7)	1,883,010 (12.1)
1981	16,229,764 (92.7)	2,589,943 (16.0)	1,657,760 (10.2)
1982	16,216,136 (92.5)	1,947,871 (12.0)	1,122,911 (6.9)
1983	16,220,369 (93.2)	1,356,812 (8.4)	760,903 (4.7)
1984	16,091,005 (92.8)	889,495 (5.5)	492,474 (3.1)
1985	15,812,300 (91.2)	622,285 (3.9)	319,798 (2.0)
1986	14,861,006 (88.2)	403,015 (2.7)	199,925 (1.4)
1987	13,206,807 (92.1)	241,584 (1.9)	112,693 (0.9)
1988	12,703,799 (91.9)	148,261 (1.2)	70,209 (0.6)
1989	9,594,316 (88.3)	76,640 (0.8)	33,256 (0.3)
1990	9,146,913 (87.0)	50,579 (0.6)	21,788 (0.2)
1991	8,212,776 (87.2)	24,058 (0.3)	9,290 (0.1)
1992	4,294,499 (91.3)	8,310 (0.2)	2,892 (0.07)
1993	1,699,141 (91.8)	4,121 (0.2)	1,105 (0.07)
1994	1,531,706 (87.6)	3,576 (0.2)	668 (0.04)
1995	1,334,517 (90.5)	2,245 (0.2)	241 (0.02)
Total	307,926,478 (85.8)		

Source: Korea Association of Health Promotion, 『1995 Student Parasite Inspection Statistics』 (1996).

diethylcarbamazine (DEC) and the positivity rate gradually decreased. Eventually, in 2002, the last two positive cases in Sinan-gun, Jeollanam-do were identified and there were no further reports from these places. Consequently, in 2007, the elimination of *Brugia malayi* infection in Korea was declared through an epidemiological survey following the standards set by the WHO [10].

2) Domestic disease patterns

In lymphatic filariasis, symptoms such as high fever and systemic muscle aches accompanied by lymphangitis, lymphadenitis, and swelling on the arms and legs are manifested. The affected arm or leg gradually thickens. As the collagen increases in the affected arm and leg tissue, the skin becomes chapped repeatedly, turning into thick skin and thick legs or arms so-called elephantiasis. With repeated infections and healing, about 15% of infected people develop the symptoms of elephantiasis. Because elephantiasis usually develops after a long period of time from the onset of infection, it usually shows negative for the larva test. This is irreversible and leaves life-long sequelae that interfere with everyday life.

3) Prevention and management

There are two main methods of management. First, it is important to find and administer requisite anthelminthic to an infected person to lower the burden of disease and reduce reinfection. In addition, because the vector for the infection is a mosquito, it is effective to use various methods (mosquito net, insect screen, insecticide, etc.) to protect from mosquito bites. Korea has been endorsed the eradication of this ailment by WHO in 2008.

3. *CLONORCHIS SINENSIS*

1) Domestic outbreak and prevalence

The eggs of *Clonorchis sinensis*, along with *Ascaris* eggs, were observed in the early ruins of the Three Kingdoms period, indicating that it is a parasite distributed since the beginning of human life. Academic records on this worm have been shown from the Japanese occupation era. In 1948, a public health official from the Ministry of Health and Social Affairs noticed that there were an unusually large number of patients with cholangiocarcinoma in Busan and Gyeongsangnam-do. He recorded that 50% to 70% of residents in the area were positive for *C. sinensis* and underscored its significance in human health improvement [11]. Since then, several examinations have recorded the distribution of *C. sinensis*-positive people almost all over the country. Between 1979 and 1980, 13,373 residents of the five major river basins nationwide were surveyed, wherein a 21.5% egg positive rate was recorded [12]. According to the eight surveys of intestinal parasitic infections in Korea since 1971, the positive rate of *C. sinensis* eggs has shown the national average of 4.6% in 1971, 1.8% in 1976, 2.6% in 1981, 2.7% in 1986, 2.2% in 1992, 1.4 in 1997%, 2.4% in 2004, and 1.9% in 2012 respectively (**Table 3**). As this positive rate is the result of a nationwide population-based sample survey, the data allude to the average infection rate of the total population living in Korea at that time. In 1981, the national average positive rate was 2.6%, while it was 21.5% in the four major river basins nationwide, showing very high positive rate. *C. sinensis* was not distributed evenly but was rather concentrated in the endemic areas around the river basin. The national average positive rate slowly declined overall, and recent data remain at 1%. *C. sinensis* is a typical food-borne parasite and is widely distributed in Far East Siberia, China, Korea, Taiwan, and Vietnam.

2) Domestic disease patterns

When a person consumes raw freshwater fish, he/she is infected with *C. sinensis* by ingesting metacercariae in fish flesh. The larvae that have excysted from the duodenum directly reach the intrahepatic bile duct through the common bile duct and grow into adult flukes. As its life expectancy is estimated to be 20 to 30 years in the human body, infections accumulate almost for a lifetime. Since the infection rate is high and the amount of infection is high in endemic areas, many people show clinical symptoms. A small proportion of infection rarely shows detectable symptoms, while a larger share of infection shows the symptoms such as clogging in the epigastric tip and the feeling that something stuffy hangs around the stomach. Also, pain occurs pain after eating. Diluted stool excretion occurs and if infection persists for a longer time, bile duct expansion and fibrosis progress, leading to cirrhosis. Occasionally, cholangitis causes pain with fever. Pyogenic cholangitis might also occur, and gallstones and cholangiocarcinoma increase. Based on the results of previous research in Korea, it is estimated that the risk of developing cholangiocarcinoma increases by 4.7 times

Table 3. Nationwide status survey of trematode egg positive rate

Year	No. of examinees (persons)	Trematode egg positive rate by fecal examination (%)			
		Total egg positive rates	*Clonorchis sinensis*	*Paragonimus westermani*	Intestinal trematodes
1971	24,887	84.3	4.6	0.09	-
1976	27,178	63.2	1.8	0.07	-
1981	35,018	41.1	2.6	0	1.2
1986	43,590	12.9	2.7	0.002	1
1992	46,912	3.8	2.2	0	0.3
1997	45,832	2.4	1.4	0	0.3
2004	20,541	4.3	2.4	0.002	0.5
2012	23,956	2.6	1.9	0	0.26

Source: National survey of intestinal parasitic infections in Korea, 8th Report [5].

https://doi.org/10.3947/ic.2020.52.3.427

due to *C. sinensis* infection and that about 10% of all cholangiocarcinoma in Korea were caused by *C. sinensis* [13].

3) Prevention and management

Management of *C. sinensis* has been possible since the 1980s, when an effective anthelminthics, praziquantel, was developed and marketed. Following the supply of BILTRICIDE® from Bayer, Germany, which first entered the country, a localized DISTOCIDE® by Shin Poong Pharmaceutical, Korea was supplied and many untreated patients were treated. In the 1980s, the Army launched a project to find and treat infected soldiers, but it did not last long, and no records from that trial remain. After the Korea Association of Health Promotion partially spotted and treated infected people around the endemic areas, and confirmed in the 7th survey in 2004 that the nationwide average infection rate was 2.4% and heavy endemic areas still remained in Korea, the Korea Centers for Disease Control and Prevention (KCDC) has been conducting treatment of infected people nationwide, specially focused on the endemic areas since 2005. According to the results, about 50,000 people were tested annually and positive people were treated, and the egg positive rate in the endemic area decreased from 15.1% in 2005 to 5.2% in 2016 (survey data by KCDC, unannounced). *C. sinensis* management business was planned to proceed further that was concentrated on administering positive people for that period time, with special focus on the endemic area.

4. *PARAGONIMUS WESTERMANI*

1) Domestic outbreak and prevalence

According to the earlier parasitology data, there was a record of infection with *Paragonimus westermani* in the 16th and 17th centuries during the Joseon Dynasty [14]. The major agents responsible for causing *P. westermani* infection in humans are freshwater crabs and crayfish, the second intermediate host. Soybean sauce marinated freshwater crab was a favorite side dish of people, and freshwater crabs were consumed extensively throughout the country. People were infected while being subjected to traditional remedies against measles or other respiratory diseases that entailed catching live crayfish and squeezing juice out of them [16]. The Japanese occupation records showed more than 5,000 infections each year and about 1,000 deaths [2]. People all over the country were infected, however, the areas in which the outbreak remained until the 1970s were around Jeju and Haenam. As the number of freshwater crabs and crayfish decreased significantly in the nature due to development activities, the number of infected people also decreased significantly since the 1980s. Moreover, in most cases, there has been no infection in feces tests (**Table 3**). It means that there are less than 1,000 infected people nationwide in the national survey, rather than no one at all. Fecal examination data should be understood as the minimum number of confirmed infections, considering that sensitivity of the test is so low that even 20% of infected persons are found. Off late, serological tests are widely used for diagnosis instead of stool test and it is estimated that about less than 100 people get the infection each year [15].

2) Domestic disease patterns

P. westermani forms worm capsules of 3 to 5 cm in diameter in the lung tissue and appear as nodules in radiological images. Usually two worms nest one capsule and eggs are mixed in necrotic tissue, blood, and pus, forming a worm capsule. When the pressure inside the worm capsule increases, necrotic tissue and pus are discharged along with the eggs to the nearby bronchial tubes, which cause blood phlegm symptoms. Some of *P. westermani* worms

https://doi.org/10.3947/ic.2020.52.3.427

that infect the human body cause extrapulmonary infections and most often occur in the abdominal cavity, such as the intraperitoneal omentum, mesentery, uterus or ovaries, and abdominal wall. The liver and spleen infections have also been reported and may cause pleurisy due to intrathoracic infection. In such infections, brain attack is clinically serious. Cerebral paragonimiasis can cause various neurological symptoms depending on the affected area along with headache and lead to epilepsy.

3) Prevention and management

For the mitigation of *P. westermani* infection, individuals were treated with bithionol before introduction of praziquantel. In the 1960s, many endemic areas in Jeju-do were surveyed and paragonimiasis was controlled with a group therapy using bithionol [16]. After the introduction of praziquantel, treatment was carried out more effectively with less toxicity. Instead of managing it as an actual public health target, it is focused on treating individual infected patients. In the 1980s and 1990s, the number of the first intermediate host, marsh snails, and the second intermediate host, crayfish and crab, was reduced due to environmental pollution caused mainly by pesticides and polluted water. The environmental change decreased the number of infected people steeply. Moreover, the continuous treatment of infected individuals contributed to the overall decrease in the number of infected people.

5. INTESTINAL TREMATODES

1) Domestic outbreak and prevalence

There are diverse species of intestinal trematodes that inhabit different regions of Korea. There are over 16 species that have been recorded. Among them, *Metagonimus yokogawai* has been reported to infect the largest number of people. According to the survey of the national intestinal parasitic infections, it was first recorded at 1.2% in the 3rd survey in 1981, and 0.26% in the 8th survey in 2012 (**Table 3**) [5]. Based on this number, it is estimated that there were about 300,000 people nationwide. Until the 1970s, fecal examinations could not distinguish *Metagonimus* eggs from *C. sinensis* eggs, and all were identified as eggs of *C. sinensis*. These were recorded separately from the late 1980s. Currently, intestinal parasite, which has the second highest rate of egg positive rates in Korea, is *M. yokogawai*. This intestinal trematode is mainly transmitted by sweetfish and yellowfish, and heterophyid trematodes are also prevalent locally with high rates mostly transmitted by raw brackish water fish depending on the region. Because it is difficult to distinguish several types of heterophyid trematodes with only eggs, all are diagnosed as *M. yokogawai* [17]. In addition to heterophyid, intestinal trematodes such as *Echinostoma* spp., *Neodiplostomum seoulense,* and *Gymnophalloides seoi* cause human infection with local endemicity have been confirmed. The *N. seoulense* and *G. seoi* are intestinal trematodes newly recorded as novel species in Korea.

2) Domestic disease patterns

If any of the species is infected with intestinal trematode, the intestinal epithelial cells undergo degenerative changes and cause inflammation of the mucosal layer. As a result, shortening and fusion of villi, proliferation of the crypts, immature epithelial cells, and inflammation of the submucosal layer will clinically result in diarrhea and subsequent abdominal pain. The echinostomiasis causes large scale infections and infiltrates the mucosal layer using the head crown and collar spines, causing tissue defects and bleeding. Intestinal tissues secrete more mucus due to increased goblet cells and show eosinophilic inflammation. The lesions of intestinal trematode disappear after treatment, and the tissue is completely restored to normal.

 https://doi.org/10.3947/ic.2020.52.3.427

3) Prevention and management

Because intestinal trematode is directly killed by praziquantel in the intestine, dead bodies are easily discharged to the outside along with feces. Therefore, the anthelminthic effect is excellent with single low dose and easy to manage. The intestinal trematodes have never been a target of deworming on public health stance, but countermeasures such as public notifying the dangers of eating raw fish or praziquantel therapy of egg positive people have been undertaken.

6. *TAENIA*

1) Domestic outbreak and prevalence

In Korea, the cestodes that infect human include *Taenia asiatica*, *Taenia saginata,* and *Taenia solium* (taeniasis), *Hymenolepis nana*, and *Diphyllobothrium nihonkaiensis* (including *D. yonagoensis*). Among them, taeniasis is the most important in terms of distribution and the number of infected people. Because three types of human infections are difficult to be discriminated by only eggs, it was recorded as taeniasis by fecal examination. Egg positive rates were 1.9% in 1971, 0.7% in 1976, 1.1% in 1981, 0.3% in 1986, 0.06% in 1992, 0.02% in 1997, and 0.04% in 2012. The data from 2012 estimated that there are about 20,000 people with taeniasis in Korea. Although it has not been confirmed by domestic archaeological data, in China, instances of taeniasis were found in the mummy of the Han Dynasty in the 3rd century BC, thereby identifying cestodes as old human parasites along with *A. lumbricoides, C. sinensis, and T. trichiura* [5]. More than 90% of taeniasis in Korea were identified as *T. asiatica*. The health-critical taeniasis is caused by *T. solium*, which causes human cysticercosis in addition to taeniasis. The intermediate host of *T. solium* is the pig which carries cysticercus, and humans are infected by ingestion of cysticercus in pork. Pigs with cysticercus in Korea have not been observed so far since they were identified in the mid-1990s. *H. nana* can be used as a hygiene indicator since it infects humans through contamination by rat feces. It accounted 0.2% cases in 1969 and 0.07% in 1981 and has not been detected since the 1990s [12, 18].

2) Domestic disease patterns

The definitive host of taeniasis is human, and the adult worm is parasitic in the small intestine. Most cases show no clinical symptoms, while the most common symptom is discharge of proglottids of the in *T. saginata* or *T. asiatica* infection. It can often cause abdominal pain or diarrhea, and in rare cases it might lead to mechanical bowel obstruction. A person infected with *T. solium* may develops various symptoms, from asymptomatic to epilepsy, depending on the affected area. Cysticercosis of the central nervous system is more clinically important than that of any other area, and most of them develop symptoms with calcification or decomposition of worms in the brain after several years of infection. The domestic infection cases of *D. nihonkaiensis, D. yonagoense,* or *H. nana* showed no clinical characteristics.

3) Prevention and management

The countermeasure against taeniasis is to ensure proper sanitation in the breeding procedure of cattle and pigs. Furthermore, proper cooking of meat should reduce incidence of taeniasis cases. Besides, employing the use of praziquantel to the infected would further reduce the disease burden. Although there was no specific management program in Korea for taeniasis, all of the egg positive cases identified in medical examinations were treated with praziquantel. In addition, there was little possibility that domestic beef or pork can spread the worm because most of cattle or pigs are bred with commercial diet at hygienic livestock pen. Currently, the

https://doi.org/10.3947/ic.2020.52.3.427

infection is more likely to be introduced from foreign endemic areas, so educating people not to eat raw meat in endemic countries would be the principal countermeasure.

7. INTESTINAL PROTOZOA

1) Domestic outbreak and prevalence

In Korea, for decades since the 1960s, the government has made efforts to control intestinal parasitic infections continuously. However, no collective control of intestinal infections caused by protozoan parasites has been implemented. Because the cysts and oöcysts of the protozoa are relatively smaller compared to the helminth eggs, identification of infections and confirmation of the species are relatively difficult. Not being easy to applying an anti-protozoan agent administration made it difficult to control protozoan infections in groups. Therefore, it was not possible to find national statistics on intestinal protozoan infections or any statistical data that could represent the national prevalence. The status could only be estimated based on the results of fragmented papers published by researchers interested in parasitic protozoan infections. Meanwhile, it was possible to indirectly infer the water-borne intestinal protozoan infection status on the basis of investigations of the surrounding environment or the water source for a supply of tap water [19].

Entamoeba histolytica, a pathogenic intestinal protozoan, has been known since the introduction of Western medicine [20]. Non-pathogenic *Entamoeba coli*, *Endolimax nana* and *Giardia lamblia* were also detected on stool examination by microscopy. Before and after the Korean War, when hygiene was poor, intestinal protozoa were commonly detected. A survey recorded the cyst-positive rate of 33.4% in 1949. The cyst positive rate of *E. histolytica* was estimated to be around 10% nationwide and 4.3% in Seoul in the 1960s [21]. In the 1980s, it was about 1%, and less than 1% in recent years nationwide. *E. histolytica* was regarded as relatively more important since it caused diseases such as amoebic dysentery or liver abscess [22]. The HK-9 strain has a history of isolation and cultivation from a prisoner of war at the concentration camp in Geoje Island after the Korean War. The strain is still used in experiments for research on amoebiasis. Although the data on intestinal protozoa were rare, the infection rate showed higher than 30% even in the 2000s in special occasions [23]. Since the 1990s, the existence of *E. histolytica*, which had been earlier indistinguishable with *Entamoeba dispar*, was confirmed by molecular techniques. In Korea, most of the asymptomatic cyst passers were identified infected with *E. dispar* [24]. It is thought that *G. lamblia* has the highest infection rate among the pathogenic intestinal protozoa until now. Among gastroenteritis patients at a Gyeonggi-do Provincial Hospital, 2.5% had been reported to be infected with *G. lamblia* [25]. *G. lamblia* cysts were found in river water samples (4.5 cysts/10 L), of which 21% were confirmed alive [26]. Existence of *Cryptosporidium parvum* has been known since it was found in immunosuppressed mice and cattle [27, 28]. It has been identified as a causative agent of diarrhea in people with immunosuppression [29]. An imported case of *Cyclospora* was reported [30].

2) Domestic disease patterns

E. histolytica spreads via water and food, causing digestive tract infections, while sexual contact has been known as the main route of infection in developed countries. An ulcer is made in the mucous membrane of the large intestine and progresses to amebic dysentery, which includes symptoms such as diarrhea, abdominal pain, and bloody and mucous stools. It moves through blood vessels to other organs, resulting in extraintestinal amebiasis such as hepatitis, hepatic and lung abscess etc.

Infection & Chemotherapy

G. lamblia also causes water-borne infections. It is a parasite in the small intestine and does not invade tissues, however, multiplies in large numbers that result in damage to the brushborder membrane and atrophy of the villi, thereby causing chronic diarrhea, abdominal pain, and steatorrhea. Although *C. parvum* can develop mild diarrhea in people with normal immune function, acquired immune deficiency syndrome or immunocompromised patients with decreased immune function may develop severe diarrhea and die. In fact, intestinal protozoan infections are often asymptomatic or show only minor digestive symptoms.

3) Prevention and management

Antiprotozoal agents (*e.g.* metronidazole, ornidazole) that require a doctor's prescription should be administered for several days or more to be cured. In Korea, *G. lamblia* and *C. parvum* cysts are monitored during the water intake process for supply of tap water and are managed to be completely removed during the purification process. It is necessary to boil untreated or unsafe water before drinking.

8. *TRICHOMONAS VAGINALIS* & FREE-LIVING AMOEBA

Trichomonas vaginalis is infected by sexual contact, causing trichomoniasis. *T. vaginalis* is commonly observed in sexually active adults worldwide. In Korea, an available research indicated that the prevalence or infection rate of *T. vaginalis* is relatively lower than in other countries, however, it had been found in 10.4% of patients with vaginitis [31]. *T. vaginalis* causes vaginitis mainly in women, including genital pruritus and increased vaginal discharge. It is considered that there may be many infected males but most of them are asymptomatic. Such males mainly act as a silent parasite transmitter. It can be prevented by healthy sex life and use of condoms. *Trichomonas* vaginitis is treated with antiprotozoal agents such as metronidazole.

A free-living amoeba is an amoeba that exists in water or soil in the surrounding environment. It is known that *Naegleria* and various *Acanthamoeba* exist in Korea. Occasionally human infections in the eyes have been reported with *Acanthamoeba* spp. [32]. Once the amoeba multiplies in the cornea, it causes serious symptoms such as keratitis and corneal perforation. Most infected people die when amebic meningoencephalitis develops because there is no effective treatment.

9. TISSUE PARASITIC PROTOZOA

1) Domestic outbreak and prevalence

Toxoplasma gondii is a coccidian protozoan parasite which lives in a cell. Its prevalence is estimated mainly by serology, but the first record in Korea used an intradermal test [33]. *T. gondii* infects various livestock or wild animals, however, has been rarely identified parasitologically in Korea. In 2003, *T. gondii* was isolated and cultured from a patient with eye disease [34]. Later, a group of cases were reported after eating uncooked pork. Serum antibody test is the main screening of toxoplasmosis and has been reported low in Korea compared to that in Europe. Meanwhile, there was a report of two outbreaks [35], and that of 5.5% and 12.9% of IgG positive rates in students and residents, respectively in Jeju-do [36].

Although *Leishmania* is not distributed in Korea, there have been reports of imported infections among overseas workers who have been to the Middle East or other endemic areas.

https://doi.org/10.3947/ic.2020.52.3.427

Infection & Chemotherapy

The sand fly transmits leishmaniasis, thereby showing different clinical symptoms depending on the species of *Leishmania*. More than 20 imported cases of cutaneous leishmaniasis have been reported since 1978 [37], and visceral leishmaniasis has been identified in five cases by 2010 in Korea [38].

2) Domestic disease patterns

Toxoplasmosis can cause lymphadenitis, meningitis, chorioretinitis, etc. [39]. Congenital infections can also cause stillbirth, abortion, or premature delivery, and there might be manifestation of calcification, hydrocephalus, microcephaly, psychomotor disorder, chorioretinitis, or epilepsy [40]. Myocarditis or mental development disorders in children may appear and can lead to systemic infection and death.

Cutaneous leishmaniasis develops papules and ulcers on the exposed parts of the face or limbs, and usually heals itself over several months. Individuals who develop visceral leishmaniasis may die from fever, hepatosplenomegaly, systemic weakness, bloating, diarrhea, abdominal pain, leukopenia, anemia, and sepsis. It may also leave sequelae on the skin after recovery.

3) Prevention and management

There is no more special preventive method for *T. gondii* than thorough personal hygiene, such as eating well-cooked pork and not eating raw meat of wild animals. While the stray cat plays the role of a definitive host, there is no special means to manage it. In the case of *Leishmania*, care must be taken not to be bitten by sand flies in endemic areas. The Korea Center for Disease Control and Prevention is running a report system of imported parasitic diseases for noticed cases.

REFERENCES

1. Seo M, Chai JY, Kim MJ, Shim SY, Ki HC, Shin DH. Detection trend of helminths eggs in the strata soil samples from ancient historic places of Korea. Korean J Parasitol 2016;54:555-63.
PUBMED | CROSSREF
2. The Korean Society of Infectious Diseases. Korean history of infectious diseases. Seoul: Koonja Publishing; 2009.
3. Lee SH. Transition of parasitic diseases in Korea. J Korean Med Assoc 2007;50:937-45.
CROSSREF
4. Hong ST, Chai JY, Choi MH, Huh S, Rim HJ, Lee SH. A successful experience of soil-transmitted helminth control in the Republic of Korea. Korean J Parasitol 2006;44:177-85.
PUBMED | CROSSREF
5. Korea Center for Disease Control and Prevention (KCDC). National survey of intestinal parasitic infections in Korea, 8th Report. Osong: KCDC; 2013.
6. Seo HG, Hwang SI, Chae JI. [Study on the transition of intestinal parasites in Korea from 1913 to 1989]. Uisahak 1992;1:45-63.
PUBMED
7. Jung J, Park Y, Kim OJ. A social history of ascariasis in the 1960s Korea: from a norm to a shameful disease. Uisahak 2016;25:167-204.
PUBMED | CROSSREF
8. Korea Association of Health Promotion (KAHP). 1995 student parasite inspection statistics. Seoul: KAHP; 1996.
9. Seo BS. Malayan filariasis in Korea. Korean J Parasitol 1978;16 Suppl:5-108.
PUBMED | CROSSREF

10. Korean Center for Disease Control and Prevention (KCDC). Elimination of lymphatic filariasis in Korea. Osong: KCDC; 2007.

11. Korea Association of Health Promotion (KAHP). 40-Years History of Korea Association of Health Promotion. Seoul: KAHP; 2005.

12. Seo BS, Lee SH, Cho SY, Chai JY, Hong ST, Han IS, Sohn JS, Cho BH, Ahn SR, Lee SK, Chung SC, Kang KS, Shim HS, Hwang IS. An epidemiologic study on clonorchiasis and metagonimiasis in riverside areas in Korea. Korean J Parasitol 1981;19:137-50.
PUBMED | CROSSREF

13. Shin HR, Oh JK, Lim MK, Shin A, Kong HJ, Jung KW, Won YJ, Park S, Park SJ, Hong ST. Descriptive epidemiology of cholangiocarcinoma and clonorchiasis in Korea. J Korean Med Sci 2010;25:1011-6.
PUBMED | CROSSREF

14. Ki HC, Shin DH, Seo M, Chai JY. Infection patterns of trematode parasites among Joseon people. J Korean Med Assoc 2014;57:866-75.
CROSSREF

15. Jin Y, Kim EM, Choi MH, Oh MD, Hong ST. Significance of serology by multi-antigen ELISA for tissue helminthiases in Korea. J Korean Med Sci 2017;32:1118-23.
PUBMED | CROSSREF

16. Kim JS. Mass chemotherapy in the control of paragonimiasis. Korean J Parasitol 1969;7:6-14.
PUBMED | CROSSREF

17. Chai JY, Lee SH. Intestinal trematodes of humans in Korea: *Metagonimus*, heterophyids and echinostomes. Korean J Parasitol 1990;28 Suppl:103-22.
PUBMED | CROSSREF

18. Yeh HY, Mitchell PD. Ancient human parasites in ethnic Chinese populations. Korean J Parasitol 2016;54:565-72.
PUBMED | CROSSREF

19. Lee MY, Kim DY, Cho EJ, Lee EK, Oh SJ, Lee CK, Ha YC. Detection of *Giardia* and *Cryptosporidium* in water supplies in Seoul using method 1623. J Korean Soc Water Qual 2000;16:595-608.

20. Ludlow AI. Amebic liver abscess. China Med J 1926;40:1165-88.

21. Soh CT. Parasitic amebae in Korea. Korean J Parasitol 1981;19 Suppl:5-93.
PUBMED | CROSSREF

22. Hong SO, Cho KM, Chung PR, So CT. Parasitological studies on liver abscess in Cheju Island. Yonsei Med J 1968;9:127-38.
PUBMED | CROSSREF

23. Lee J, Park GM, Lee DH, Park SJ, Yong TS. Intestinal parasite infections at an institution for the handicapped in Korea. Korean J Parasitol 2000;38:179-81.
PUBMED | CROSSREF

24. Choe SC, Lee M, Lee SK, Im K, Tannich E, Lee SH, Hong ST. Differentiation of Korean isolates of *Entamoeba histolytica* from *Entamoeba dispar*. Korean J Parasitol 1996;34:15-20.
PUBMED | CROSSREF

25. Huh JW, Moon SG, Lim YH. A survey of intestinal protozoan infections among gastroenteritis patients during a 3-year period (2004-2006) in Gyeonggi-do (province), South Korea. Korean J Parasitol 2009;47:303-5.
PUBMED | CROSSREF

26. Cho EJ, Lee MY, Byun SH, Han SH, Ahn SK. Detection of *Giardia lamblia* in river water samples using PCR and RT-PCR. J Korean Soc Environ Eng 2007;29:904-8.

27. Chai JY, Shin SM, Yun CK, Yu JR, Lee SH. Experimental activation of cryptosporidiosis in mice by immunosuppression. Korean J Parasitol 1990;28:31-7.
PUBMED | CROSSREF

28. Rhee JK, Seu YS, Park BK. [Isolation and identification of *Cryptosporidium* from various animals in Korea. I. Prevalence of *Cryptosporidium* in various animals]. Korean J Parasitol 1991;29:139-48.
PUBMED | CROSSREF

29. Guk SM, Chai JY, Shin YO, Seo M. Antibody responses to *Cryptosporidium* antigen in HIV-positive patients in the Republic of Korea. Korean J Parasitol 2008;46:71-5.
PUBMED | CROSSREF

30. Yu JR, Sohn WM. A case of human cyclosporiasis causing traveler's diarrhea after visiting Indonesia. J Korean Med Sci 2003;18:738-41.
PUBMED | CROSSREF

31. Ryu JS, Min DY. *Trichomonas vaginalis* and trichomoniasis in the Republic of Korea. Korean J Parasitol 2006;44:101-16.
PUBMED | CROSSREF

32. Xuan YH, Chung BS, Hong YC, Kong HH, Hahn TW, Chung DI. Keratitis by *Acanthamoeba triangularis*: report of cases and characterization of isolates. Korean J Parasitol 2008;46:157-64.
PUBMED | CROSSREF

33. Soh CT, Lee SJ, Ahn YG. Latent infection by *Toxoplasma gondii* in Korea. Yonsei Med J 1960;1:52-4.
CROSSREF

34. Chai JY, Lin A, Shin EH, Oh MD, Han ET, Nan HW, Lee SH. Laboratory passage and characterization of an isolate of *Toxoplasma gondii* from an ocular patient in Korea. Korean J Parasitol 2003;41:147-54.
PUBMED | CROSSREF

35. Choi WY, Nam HW, Kwak NH, Huh W, Kim YR, Kang MW, Cho SY, Dubey JP. Foodborne outbreaks of human toxoplasmosis. J Infect Dis 1997;175:1280-2.
PUBMED | CROSSREF

36. Yang HJ, Jin KN, Park YK, Hong SC, Bae JM, Lee SH, Choi HS, Hwang HS, Chung YB, Lee NS, Nam HW. Seroprevalence of toxoplasmosis in the residents of Cheju island, Korea. Korean J Parasitol 2000;38:91-3.
PUBMED | CROSSREF

37. Ahn MH. Imported parasitic diseases in Korea. Infect Chemother 2010;42:271-9.
CROSSREF

38. Chi JG, Shong YK, Hong ST, Lee SH, Seo BS, Choe KW. An imported case of kala-azar in Korea. Korean J Parasitol 1983;21:87-94.
PUBMED | CROSSREF

39. Park YH, Han JH, Nam HW. Clinical features of ocular toxoplasmosis in Korean patients. Korean J Parasitol 2011;49:167-71.
PUBMED | CROSSREF

40. Jeong WK, Joo BE, Seo JH, Mun JK, Kim J, Seo DW. Mesial temporal lobe epilepsy in congenital toxoplasmosis: a case report. J Epilepsy Res 2015;5:25-8.
PUBMED | CROSSREF