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A Nationwide Survey on the Prevalence of Intestinal Parasitic Infections in the Republic of Korea, 2004

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Abstract: National surveys on the prevalence of intestinal parasitic infections have been carried out every 5-7 years since 1971 in the Republic of Korea in order to establish control measures. The present nationwide survey was conducted from June to December 2004. The 10% population sampling data of Population and Housing Census by the Korean government in 2000 was used as the survey population. One sample was selected randomly from each of the 22,858 registered subjects, and a total of 20,541 people were ultimately included in this survey. Fecal examinations were performed by the cellophane thick smear and saturated brine flotation techniques. Pinworm infection was examined by cello-tape anal swab method. This survey also included a questionnaire study for a socioeconomic analysis. The total helminth egg positive rate was 3.7%, and the estimated total positive number among nationwide people was 1,780,000. The rates in urban and rural areas were 3.1% and 6.8%, respectively. As the total egg positive rate in the 6th survey in 1997 was 2.4%, the present survey showed that there was a considerable degree of increase in the prevalence rate of intestinal parasitic infections over the 7-year period following the 6th survey. The largest increases occurred in the egg positive rates of *Clonorchis sinensis* and heterophyids including *Metagonimus yokogawai*.

Key words: *Clonorchis sinensis*, *Metagonimus yokogawai*, human, intestinal parasites, fecal examination, nationwide statistical data, Republic of Korea

INTRODUCTION

Until the 1970s, many Koreans had intestinal parasitic infections, mostly soil-transmitted helminths such as *Ascaris lumbricoides*, *Trichuris trichiura*, hookworms (*Ancylostoma duodenale* and *Necator americanus*), and *Trichostrongylus orientalis* [1,2]. National surveys of these intestinal parasitic infections have been carried out in the Republic of Korea (= Korea) every 5-7 years since 1971 to acquire national level statistical data according to the statistics plan by the National Statistical Office of Korea. The 2nd survey was conducted in 1976, followed by the 3rd in 1981, the 4th in 1986, the 5th in 1992, the 6th in 1997, and the 7th in 2004.

Korea has become a new member of Economic Cooperation and Development (OECD) countries and has shown a remarkable economic growth in the early 21st century [3]. In this respect, the results of the 7th survey conducted 7 years after the 6th are very important since the data can show the transition of intestinal parasitic infections in Korea. At the first survey conducted in 1971, Korea was a traditional agricultural society using human manure and had a poor sanitary and living standard with a variety of conditions that can cause intestinal parasitic infections. The data in 1971 showed an overall helminth egg positive rate of 84.3% and an accumulated egg positive rate of 147.1% indicating that Korean people had at least one or more kinds of intestinal parasitic infections. However, during the subsequent 30 years, Korea showed very high economic growth with a dramatic decrease of the helminth egg positive rate down to 2.4% in 1997. In particular, *A. lumbriocoides*, a representative

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intestinal helminth parasite and an index of soil-transmitted helminths, showed a dramatic decrease from 54.9% in the 1st survey in 1971 to 0.06% in the 6th survey in 1997. Other soil-transmitted helminths also showed dramatic decreases in the prevalence; 0.007% for hookworms, 0.04% for *T. trichiura*, and 0% for *T. orientalis* in 1997. By comparison, the prevalence of *Clonorchis sinensis* and heterophyids, mostly *Metagonimus yokogawai*, were 1.4% and 0.3%, respectively, showing comparatively higher prevalences than soil-transmitted nematodes [4-9]. In addition, about 15 species of trematodes transmitted by fresh- or brackishwater fish, including *Heterophyes* and *Pygidiopsis*, have been reported to cause human infections in Korea [10,11].

In the present study, the current status of intestinal helminth infections, i.e., egg positive rate and number of infected people as well as errors of the values, has been estimated using the results of the 7th survey conducted in 2004. Also, a basic statistical analysis was conducted using various characteristics including the region, gender, age, and urban versus rural areas. Then, the results were compared with those of the previous 6 surveys and association analyses were performed among various characteristics. To do this, a contingency table was prepared and an independence test was conducted. Also adapted was a logistic regression model to conduct more in-depth analysis based on analysis of the effect of explanatory variables on response variables to acquire more specific statistical data.

MATERIALS AND METHODS

Survey period

The 7th national survey of the prevalence of intestinal parasitic infections was carried out from June to December, 2004 as a part of Scientific Research Project of National Institute of Health, Republic of Korea (Fig. 1). The statistical analysis of the results was carried out from 30 December 2004 to 29 April 2005.

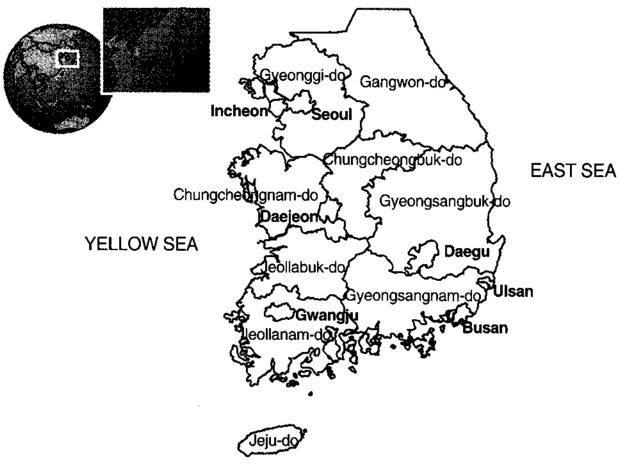

Fig. 1. Surveyed areas in the Korean peninsula.

Survey population

The 10% sample survey data of Population and Housing Census (2000) was used as the survey population which consisted of 23,536 enumeration districts (EDs) excluding those EDs that were used for various other researches such as economically active population, household income, and expenditure surveys. In addition, 153 EDs such as islands, dormitory facilities, social welfare facilities, and rural communities were also excluded because of practically difficult conduction of the survey. Finally we used 23,364 EDs as the population EDs which took up 99.3% of the total EDs of survey population. Also, the number of households and population took up 99.4% and 99.5%, respectively [12].

Sample size and sample allocation

A total of 300 EDs were selected as a sample from 23,364 population EDs which consisted of 8,178 apartment EDs and 15,186 house EDs. In order to allocate samples to strata, we used the compromise of Neyman allocation which is the average of 3 Neyman allocations using 3 variables (*C. sinensis*, heterophyids, and pinworm infection rate) [12]. Since the infection rates of intestinal parasites were very low, we applied the relative risk and odds ratio instead of ordinary methods such as t-test to study the characteristics in 16 cities and provinces (7 metropolitan cities and 9 megalopolis areas) as in the 6th survey in 1997 [13,14].

Fecal examinations and cello-tape anal swabs

Fecal examinations were performed by the Kato-Katz thick smear and saturated salty water flotation techniques, as these were used in the 3rd, 4th, and 5th surveys [3]. For the Kato-Katz technique, only 1 smear was examined for each person. The results from the 2 examinations were put together. The prevalence of pinworm (*Enterobius vermicularis*) infections was estimated by the cello-tape anal swab method.

Socio-medical analysis of egg positive rate

This study conducted socio-medical analysis which was started from the third survey along with helminthological examination. Survey questions include 1) type of housing, 2) monthly income, 3) eating habit, 4) education, and 5) occupation and the trend of helminthic egg positive rate was analyzed according to the answers to the questions [15].

Statistical handling of socio-medical analysis

This study used specialized statistical software programs including the Statistical Analysis Software (SAS) and Statistical Package for the Social Sciences (SPSS) to analyze the collected data. It made a contingency table on infection path and an association analysis was conducted. The relative risk and odds ratio were used to analyze the data. Let raw freshwater fish eater's and non-eater's *Clonorchis* trematode egg positive rate be π_1 and π_2, respectively, at 2 × 2 contingency table. Then, the infection rate $\gamma=\pi_1/\pi_2$ is the relative risk, and $\theta=\frac{\pi_1/(1-\pi_1)}{\pi_2/(1-\pi_2)}$ is the odds ratio. The large sample 100 (1-α) % confidence interval of the relative risk is as follows. If 1 is not included in the confidence interval of the relative risk, it can be considered that there is a significant difference between the 2 groups.

$$\hat{r}\times exp\,(-Z_{\alpha/2}ASE[\log\hat{r}]),\ \hat{r}\times exp\,(Z_{\alpha/2}ASE[\log\hat{r}]),$$
$$ASE\,(\log\hat{r})=\sqrt{\frac{1\text{-}n11/n1}{n11}+\frac{1\text{-}n21/n2}{n21}}$$

The large sample 100(1-α)% confidence interval of the odds ratio is calculated using log θ which is the equivalent of θ.

$$\log\hat{\theta}\pm Z_{\alpha/2}ASE(\log\hat{\theta}),\ ASE(\log\hat{\theta})=\sqrt{\frac{1}{n11}+\frac{1}{n22}+\frac{1}{n21}+\frac{1}{n22}}$$

Therefore, the large sample 100(1-α)% confidence interval of the odds ratio θ is as follows [16,17].

$$exp\times(\log\hat{\theta}\text{-}Z_{\alpha/2}ASE[\log\hat{\theta}]),\ exp\,(\log\hat{\theta}+Z_{\alpha/2}ASE[\log\hat{\theta}])$$

Basic statistical analysis

SAS statistical software was used to analyze the data based on the survey results of 2004. The weighted average of estimates of the egg positive rate and the number of egg positive were used. Also, this study used SAS calculation methods for convenience since there were insignificant differences between the correct calculation methods (both primary sampling unit, PSU, and secondary sampling unit, SSU) and SAS calculation method (only PSU) to calculate the error of the estimates [18].

RESULTS

Helminth egg positive rates in 2004 survey

The total helminth egg positive rate was 3.7% and the estimated positive number of infected people was 1,780,000. According to the regional analysis, Gyeongsangnam-do showed the high-

Table 1. Estimated numbers of egg positive cases among the whole population of the Republic of Korea according to administrative districts, 2004

	Egg positive rate (%)	Estimated total no. of egg positive cases	Al		Hw	Tt	To	Cs	Pw	Het	Ts	Hd	Hn	Unident	Ev
			U	F											
Total	3.7	1,783,550	17,781[a]	6,625	0	129,061	0	1,174,224	1,135	228,253	0	0	0	1,492	290,310
Seoul	0.9	115,961	5,954	0	0	8,386	0	38,787	0	8,370	0	0	0	0	54,565
Busan	3.4	130,625	0	0	0	1,241	0	112,774	0	10,422	0	0	0	0	6,405
Daegu	2.3	69,200	0	0	0	3,076	0	50,507	0	0	0	0	0	0	15,810
Incheon	2.2	60,354	3,844	0	0	5,942	0	37,884	0	0	0	0	0	0	12,618
Gwangju	6.5	99,112	0	0	0	0	0	72,724	0	6,373	0	0	0	0	20,147
Daejeon	13.3	155,313	0	0	0	18,958	0	80,331	0	20,242	0	0	0	0	47,183
Ulsan	5.8	80,175	3,919	0	0	2,570	0	73,656	0	0	0	0	0	0	4,299
Gyeonggi-do	0.9	78,166	2,362	0	0	14,710	0	52,432	0	0	0	0	0	0	8,906
Gangwon-do	1.4	21,040	0	0	0	0	0	8,127	0	11,111	0	0	0	0	9,920
Chungcheong buk-do	3.0	30,982	0	0	0	0	0	24,898	0	0	0	0	0	0	6,242
Chungcheong nam-do	10.9	162,842	1,702	5,347	0	38,123	0	102,542	1,135	11,732	0	0	0	0	13,432
Jeollabuk-do	3.4	55,435	0	1,278	0	1,462	0	24,700	0	10,075	0	0	0	1,492	17,797
Jeollanam-do	8.4	179,114	0	0	0	2,631	0	132,871	0	10,450	0	0	0	0	36,334
Gyeongsang buk-do	4.6	93,178	0	0	0	7,878	0	51,316	0	11,110	0	0	0	0	26,948
Gyeongsang nam-do	16.3	446,855	0	0	0	20,682	0	310,675	0	126,530	0	0	0	0	9,704
Jeju-do	0.1	5,196	0	0	0	3,402	0	0	0	1,838	0	0	0	0	0

[a]Estimated number of egg positive cases for each parasite species among the whole population of the Republic of Korea.
Al, *Ascaris lumbricoides*; U, Unfertilized egg passers; F, Fertilized egg passers; Hw, hookworms; Tt, *Trichuris trichiura*; To, *Trichostrongylus orientalis*; Cs, *Clonorchis sinensis*; Pw, *Paragonimus westermani*; Het, heterophyids including *Metagonimus yokogawai*, Ts, *Taenia* spp.; Hd, *Hymenolepis diminuta*; Hn, *Hymenolepis nana*; Unident, unidentified; Ev, *Enterobius vermicularis*.

est prevalence of 16.3%, followed by 13.3% in Daejeon, 10.9% in Chungcheongnam-do, and 8.6% in Jeollanam-do. The estimated number of helminth egg positive cases was the highest in Gyeongsangnam-do as 450,000, and the second highest was observed in Jeollanam-do as 180,000 followed by the third highest in Chungcheongnam-do as 160,000 (Table 1).

Table 2. Estimation of the number of egg positive cases among the whole population of the Republic of Korea according to parasite species, 2004

		Estimated no. of egg positive cases			
		No. of egg positive	SD[a]	LB[b]	UB[c]
Total		1,783,550	94,160	1,598,210	1,968,889
Ascaris lumbricoides	U[d]	17,781	7,453	3,111	32,451
	F[e]	6,625	3,186	354	12,896
Hookworms		0	0	0	0
Trichuris trichiura		129,061	30,801	68,435	189,688
Trichostrongylus orientalis		0	0	0	0
Clonorchis sinensis		1,174,224	81,733	1,013,344	1,335,104
Paragonimus westermani		1,135	1,128	0	3,354
Heterophyids		228,253	27,907	173,323	283,184
Taenia spp.		0	0	0	0
Hymenolepis diminuta		0	0	0	0
Hymenolepis nana		0	0	0	0
Enterobius vermicularis		290,310	36,774	217,926	362,694
Unidenttified species		1,492	1,478	0	4,401

[a]SD, standard deviation; [b]LB, lower bound; [c]UB, upper bound; [d]U, unfertilized egg passers; [e]F, fertilized egg passers.

Table 3. Summarized results of the prevalence of intestinal helminths among the Korean people in total and by urban and rural areas during 1971-2004[a]

	Year	No. of people examined (%)	Egg positive rate	Al U	Al F	Al Total	Hw	Tt	To	Cs	Pw	Het	Ts	Hd	Hn	Unident	Ev
Total	1971	24,887 (95.8)	84.3	-	-	54.9	10.7	65.4	7.7	4.6	0.09	-	1.9	-	-	0.6	1.3
	1976	27,178 (89.9)	63.2	15.2	25.8	41.0	2.2	42.0	1.0	1.8	0.007	-	0.7	-	0.6	0.4	-
	1981	35,018 (87.3)	41.1	7.2	5.8	13.0	0.5	23.4	0.2	2.6	0.0	1.2	1.1	0.009	0.4	0.0	12.0
	1986	43,590 (91.4)	12.9	1.4	0.8	2.1	0.1	4.8	0.02	2.7	0.002	1.0	0.3	0.005	0.2	0.03	3.6
	1992	46,912 (91.0)	3.8	0.2	0.1	0.3	0.01	0.2	0.004	2.2	0.0	0.3	0.06	0.002	0.01	0.009	0.9
	1997	45,832 (91.7)	2.4	0.03	0.03	0.06	0.007	0.04	0.0	1.4	0.0	0.3	0.02	0.0	0.02	0.007	0.6
	2004	20,370 (89.1)	3.7	0.04	0.01	0.05	0.0	0.3	0.0	2.4	0.002	0.5*	0.0	0.0	0.0	0.003	0.6
Urban areas	1971	8,911 (91.3)	83.5	-	-	46.4	8.3	69.7	10.9	3.4	0.01	-	1.4	-	-	0.5	0.8
	1976	11,294 (82.9)	56.8	15.0	15.2	30.2	1.2	40.7	0.8	1.6	0.0	-	0.3	-	0.5	0.3	-
	1981	20,569 (87.9)	35.1	6.0	2.4	8.5	0.2	19.5	0.2	2.5	0.0	1.1	0.6	0.005	0.4	0.0	10.3
	1986	27,318 (93.5)	7.0	0.6	0.1	0.8	0.02	2.5	0.01	1.6	0.004	0.5	0.07	0.004	0.2	0.05	2.0
	1992	34,361 (91.1)	2.5	0.1	0.06	0.2	0.006	0.1	0.0	1.3	0.0	0.2	0.02	0.003	0.1	0.003	0.7
	1997	34,820 (92.9)	2.1	0.03	0.02	0.05	0.0	0.03	0.0	1.3	0.0	0.2	0.02	0.0	0.01	0.003	0.6
	2004	15,951 (88.8)	3.1	0.04	0.01	0.05	0.0	0.2	0.0	2.0	0.0	0.4*	0.0	0.0	0.0	0.0	0.6
Rural areas	1971	15,976 (98.4)	84.7	-	-	59.6	12.0	63.1	5.9	5.3	0.1	-	2.1	-	-	0.6	1.6
	1976	15,884 (95.7)	67.7	15.3	33.3	48.6	3.0	42.8	1.1	2.0	0.01	-	1.0	-	0.6	0.5	-
	1981	14,449 (86.5)	49.6	8.8	10.5	19.4	0.9	29.0	0.3	2.8	0.0	1.3	1.8	0.01	0.5	0.0	14.6
	1986	16,272 (88.2)	22.8	2.6	1.8	4.4	0.3	8.6	0.04	4.6	0.0	1.9	0.6	0.006	0.3	0.0	6.2
	1992	12,551 (90.7)	7.4	0.4	0.2	0.6	0.04	0.4	0.02	4.5	0.0	0.5	0.2	0.0	0.02	0.02	1.4
	1997	11,012 (88.0)	3.3	0.05	0.05	0.1	0.03	0.07	0.0	1.7	0.0	0.6	0.04	0.0	0.04	0.02	0.7
	2004	4,419 (90.3)	6.8	0.02	0.05	0.07	0.0	0.6	0.0	4.8	0.01	1.0*	0.0	0.0	0.0	0.02	0.6

[a]Some of these data were presented previously in a review paper by Hong et al. (2006).

Al, *Ascaris lumbricoides*; U, Unfertilized egg passer; F, Fertilized egg passer; Hw, Hookworm; Tt, *Trichuris trichiura*; To, *Trichostrongylus orientalis*; Cs, *Clonorchis sinensis*; Pw, *Paragonimus westermani*; Het, heterophyids including *Metagonimus yokogawai*, Ts, *Taenia* spp.; Hd, *Hymenolepis diminuta*; Hn, *Hymenolepis nana*; Unident, unidentified; Ev, *Enterobius vermicularis*.

Regarding the type of parasites, hookworms, *T. orientalis*, and tapeworms were not found, and the roundworm, lung fluke, and other parasites revealed very low positive rates. However, *C. sinensis* and pinworms showed higher egg positive rates in all regions except Jeju-do. The total egg positive rate of *T. trichiura* was 0.3%, and the number of people infected was estimated to be 130,000. The rate was the highest in Chungcheongnam-do, 2.5%. The average egg positive rate of heterophyids was 0.5% indicating the presence of 220,000 infected people and was the third most prevalent type of parasite following *C. sinensis* and pinworms. The egg positive rate of heterophyids in Gyeongsangnam-do was 4.6% (120,000 infected people), which was the highest followed by Daejeon of 1.7%. The estimated prevalence of pinworm infection was 0.6% (290,000 infected) and was evenly distributed in all regions except for Daejeon which showed a remarkably higher prevalence of 4.0%. *C. sinensis* showed the highest prevalence of 2.4% which comprise about 1,170,000 infected people. The regional egg positive rate was the highest in Gyeongsangnam-do with 11.3% followed by Daejeon 6.9%, Chungcheongnam-do 6.8%, and Jeollanam-do 6.2%. The estimated number of infected people was 310,000 in Gyeongsangnam-do, 130,000 in Jeollanam-do, and 110,000 in Busan. It seems that *C. sinensis* egg positive rates had great effects on the total egg positive rate of each district. The egg positive rate of each parasite, estimated number of infections, and upper and lower confidence limits are in Table 2. Although there were 879 infected cases among 20,370 showing a 4.3% egg positive rate, it was a simple proportion without weights. The estimated egg positive rates calculated by using weights are presented in Table 2.

Comparison according to the year of survey

National surveys of the prevalence of intestinal parasitic infections have been conducted 7 times from the 1st in 1971 until the 7th in 2004 having a 5-7 year gap between surveys. In this section, trends of intestinal parasitic infections were analyzed by comparing the results of all 7 surveys so as to be referred for policy development of the government in the future. According to Table 3, the egg positive rates in the 1st (1971) and the 2nd (1976) surveys were 84.3% and 63.2%, respectively, indicating

Table 4. Sex-related prevalence of intestinal helminths among the Korean people during 1971-2004

	Year	No. of people examined (%)	Egg positive rate	Al			Hw	Tt	To	Cs	Pw	Het	Ts	Hd	Hn	Unident	Ev
				U	F	Total											
Total	1971	24,887 (95.8)	84.3	-	-	54.9	10.7	65.4	7.7	4.6	0.09	-	1.9	-	-	0.6	1.3
	1976	27,178 (89.9)	63.2	15.2	25.8	41.0	2.2	42.0	1.0	1.8	0.01	-	0.7	-	0.6	0.4	-
	1981	35,018 (87.3)	41.1	7.2	5.8	13.0	0.47	23.4	0.22	2.6	0.0	1.2	1.1	0.01	0.43	-	12.0
	1986	43,590 (91.4)	12.9	1.4	0.77	2.1	0.1	4.8	0.02	2.7	0.002	1.0	0.27	0.005	0.22	0.03	3.6
	1992	46,912 (91.0)	3.8	0.2	0.1	0.3	0.01	0.2	0.004	2.2	0.0	0.3	0.06	0.002	0.01	0.009	0.9
	1997	45,832 (91.7)	2.4	0.03	0.03	0.06	0.007	0.04	0.0	1.4	0.0	0.3	0.02	0.0	0.02	0.007	0.6
	2004	20,370 (89.1)	3.7	0.04	0.01	0.05	0.0	0.3	0.0	2.4	0.002	0.5*	0.0	0.0	0.0	0.003	0.6
Male	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	13,427 (89.3)	61.0	14.7	23.6	38.2	1.9	39.9	0.9	2.5	0.01	-	0.9	-	0.6	0.4	-
	1981	17,275 (85.8)	39.5	6.4	4.9	11.3	0.34	21.3	0.19	3.7	0.0	1.6	1.4	0.01	0.53	-	11.4
	1986	21,406 (89.8)	13.4	1.1	0.67	1.8	0.08	4.1	0.02	3.8	0.005	1.4	0.37	0.005	0.28	0.04	3.6
	1992	23,000 (89.4)	4.6	0.2	0.07	0.3	0.004	0.2	0.009	2.9	0.0	0.4	0.06	0.0	0.02	0.009	0.9
	1997	22,484 (90.1)	3.1	0.04	0.03	0.07	0.009	0.04	0.0	1.9	0.0	0.4	0.03	0.0	0.03	0.01	0.7
	2004	9,906 (87.4)	4.6	0.03	0.02	0.05	0.0	0.2	0.0	3.2	0.0	0.7*	0.0	0.0	0.0	0.006	0.6
Female	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	13,751 (90.5)	65.3	15.7	27.9	43.6	2.6	43.9	1.0	1.0	0.01	-	0.5	-	0.5	0.4	-
	1981	17,743 (88.8)	42.6	8.0	6.7	14.6	0.59	25.6	0.24	1.6	0.0	0.81	0.81	0.01	0.32	-	12.7
	1986	22,184 (93.0)	12.5	1.6	0.86	2.4	0.13	5.4	0.03	1.7	0.0	0.68	0.18	0.005	0.17	0.02	3.6
	1992	23,912 (92.6)	3.1	0.2	0.1	0.3	0.03	0.3	0.0	1.5	0.0	0.1	0.05	0.004	0.008	0.008	0.9
	1997	23,348 (93.3)	1.7	0.03	0.03	0.05	0.004	0.03	0.0	0.9	0.0	0.2	0.02	0.0	0.004	0.0	0.6
	2004	10,464 (90.8)	2.7	0.04	0.01	0.05	0.0	0.3	0.0	1.6	0.004	0.27*	0.0	0.0	0.0	0.0	0.5

Al, *Ascaris lumbricoides*; U, Unfertilized egg passer; F, Fertilized egg passer; Hw, Hook worm; Tt, *Trichuris trichiura*; To, *Trichostrongylus orientalis*; Cs, Clonorchis sinensis; Pw, *Paragonimus westermani*; Het, heterophyids including *Metagonimus yokogawai*, Ts, *Taenia* spp.; Hd, *Hymenolepis diminuta*; Hn, *Hymenolepis nana*; Unident, unidentified; Ev, *Enterobius vermicularis*.

Table 5. Age-related prevalence of intestinal helminths among the Korean people during 1971-2004

Age	Year	No. of people examined (%)	Egg positive rate (%)	Al			Hw	Tt	To	Cs	Pw	Het	Ts	Hd	Hn	Un-ident	Ev
				U	F	Total											
Total	1971	24,887 (95.8)	84.3	-	-	54.9	10.7	65.4	7.7	4.6	0.09	-	1.9	-	-	0.6	1.3
	1976	27,178 (89.9)	63.2	15.2	25.8	41.0	2.2	42.0	1.0	1.8	0.01	-	0.7	-	0.6	0.4	-
	1981	35,018 (87.3)	41.1	7.2	5.8	13.0	0.47	23.4	0.22	2.6	0.0	1.2	1.1	0.01	0.43	-	12.0
	1986	43,590 (91.4)	12.9	1.4	0.77	2.1	0.1	4.8	0.02	2.7	0.002	1.0	0.27	0.005	0.22	0.03	3.6
	1992	46,912 (91.0)	3.8	0.2	0.1	0.3	0.01	0.2	0.004	2.2	0.0	0.3	0.06	0.002	0.01	0.009	0.9
	1997	45,832 (91.7)	2.4	0.03	0.03	0.06	0.007	0.04	0.0	1.4	0.0	0.3	0.02	0.0	0.02	0.007	0.6
	2004	20,370 (89.1)	3.7	0.04	0.01	0.05	0.0	0.3	0.0	2.4	0.002	0.5*	0.0	0.0	0.0	0.003	0.6
0-9	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	5,871 (92.7)	57.4	14.0	26.6	40.6	0.72	33.9	0.29	0.7	0.0	-	0.2	-	0.73	0.66	-
	1981	7,278 (92.6)	42.2	6.13	6.16	12.29	0.12	15.6	0.04	0.51	0.0	0.34	0.7	0.01	0.66	-	26.3
	1986	7,510 (96.8)	14.4	1.2	0.76	1.96	0.05	3.0	0.0	0.65	0.0	0.24	0.05	0.01	0.53	0.08	9.8
	1992	6,062 (91.6)	3.8	0.099	0.08	0.179	0.0	0.099	0.016	0.33	0.0	0.049	0.0	0.016	0.016	0.016	3.167
	1997	5,719 (93.4)	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.09	0.0	0.0	0.02	0.0	2.728
	2004	2,498 (91.7)	3.4	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.04*	0.0	0.0	0.0	0.0	2.8
10-19	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	7,236 (94.3)	62.8	14.1	24.6	38.8	1.2	44.6	0.65	1.0	0.03	-	0.35	-	0.26	0.33	-
	1981	8,659 (87.2)	42.3	6.9	5.2	12.1	0.18	26.7	0.1	1.16	0.0	0.51	0.52	0.01	0.82	-	13.77
	1986	9,924 (91.6)	11.8	1.18	0.87	2.05	0.07	5.6	0.04	1.17	0.0	0.52	0.09	0.0	0.35	0.02	3.8
	1992	9,182 (91.8)	2.6	0.163	0.065	0.228	0.0	0.185	0.0	0.893	0.0	0.065	0.0	0.0	0.044	0.0	1.242
	1997	7,392 (92.0)	1.2	0.027	0.0	0.027	0.0	0.027	0.0	0.298	0.0	0.176	0.0	0.0	0.041	0.014	0.636
	2004	2,886 (87.0)	1.5	0.0	0.0	0.0	0.0	0.2	0.0	0.6	0.0	0.17*	0.0	0.0	0.0	0.0	0.55
20-29	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	3,147 (84.9)	64.6	16.2	25.5	41.8	2.8	43.1	0.95	1.97	0.0	-	0.64	-	0.48	0.32	-
	1981	5,582 (74.4)	36.6	9.0	5.2	14.2	0.41	23.6	0.23	2.8	0.0	1.7	0.61	0.02	0.27	-	5.03
	1986	6,991 (81.5)	8.7	1.07	0.49	1.56	0.06	3.5	0.01	2.0	0.0	0.99	0.19	0.0	0.2	0.06	1.5
	1992	7,101 (81.0)	2.6	0.253	0.127	0.38	0.0	0.099	0.0	1.59	0.0	0.183	0.028	0.0	0.0	0.014	0.31
	1997	7,485 (81.2)	1.0	0.013	0.013	0.026	0.013	0.013	0.0	0.655	0.0	0.134	0.0	0.0	0.013	0.0	0.12
	2004	2,186 (76.5)	1.8	0.0	0.0	0.0	0.0	0.2	0.0	1.1	0.0	0.48*	0.0	0.0	0.0	0.0	0.21
30-39	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	3,509 (88.3)	66.7	16.9	25.6	43.0	3.1	44.2	1.3	3.2	0.0	-	0.83	-	0.34	0.46	-
	1981	4,508 (90.6)	40.2	7.9	5.1	13.0	0.44	24.0	0.29	4.7	0.0	2.17	1.09	0.0	0.18	-	7.34
	1986	6,567 (93.4)	12.9	1.5	0.59	2.09	0.06	4.2	0.0	4.2	0.0	1.5	0.15	0.0	0.06	0.0	2.5
	1992	8,510 (92.4)	3.7	0.165	0.106	0.271	0.0	0.141	0.0	2.491	0.0	0.341	0.024	0.0	0.012	0.0	0.576
	1997	8,073 (93.8)	2.3	0.075	0.012	0.087	0.0	0.025	0.0	1.35	0.0	0.384	0.012	0.0	0.0	0.0	0.471
	2004	3,390 (89.3)	3.3	0.0	0.03	0.03	0.0	0.38	0.0	1.99	0.0	0.66*	0.0	0.0	0.0	0.02	0.47
40-49	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	3,431 (85.5)	66.0	16.6	27.1	43.7	3.5	44.1	1.6	2.9	0.0	-	1.2	-	0.17	0.41	-
	1981	4,296 (93.2)	41.5	7.6	6.9	14.5	0.91	24.5	0.23	5.1	0.0	2.16	2.1	0.0	0.14	-	5.66
	1986	5,449 (94.9)	14.2	1.6	0.8	2.4	0.09	5.2	0.02	5.0	0.02	1.6	0.29	0.0	0.02	0.0	1.6
	1992	5,874 (94.1)	4.9	0.102	0.102	0.204	0.102	0.375	0.0	3.592	0.0	0.511	0.102	0.0	0.0	0.0	0.221
	1997	6,458 (95.7)	3.3	0.046	0.062	0.108	0.0	0.046	0.0	2.539	0.0	0.465	0.046	0.0	0.0	0.0	0.124
	2004	3,769 (91.6)	4.9	0.15	0.0	0.15	0.0	0.2	0.0	4.0	0.01	0.49*	0.0	0.0	0.0	0.0	0.18
50-59	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	2,158 (83.0)	65.7	15.3	25.8	41.1	3.8	43.8	1.5	3.1	0.0	-	1.4	-	0.37	0.46	-
	1981	2,437 (92.2)	42.6	7.4	6.7	14.1	1.1	26.9	0.62	4.8	0.0	2.1	2.4	0.0	0.0	-	4.27
	1986	3,942 (94.5)	15.5	1.4	1.0	2.4	0.15	6.6	0.05	4.8	0.0	1.6	0.79	0.0	0.08	0.03	1.14
	1992	5,504 (95.3)	5.3	0.309	0.091	0.4	0.036	0.273	0.0	3.852	0.0	0.491	0.164	0.0	0.0	0.0	0.254
	1997	5,394 (96.5)	3.7	0.037	0.056	0.093	0.037	0.056	0.0	2.781	0.0	0.556	0.019	0.0	0.056	0.019	0.148
	2004	2,365 (94.1)	6.9	0.0	0.0	0.0	0.0	0.42	0.0	5.64	0.0	0.72*	0.0	0.0	0.0	0.0	0.2
60-69	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	1,825 (95.0)	66.0	15.1	25.1	40.2	4.7	45.2	1.8	2.2	0.0	-	2.2	-	0.8	0.1	-
	1981	2,134 (86.4)	43.3	7.3	5.4	13.7	1.3	28.7	0.56	3.6	0.0	0.84	2.8	0.0	0.05	-	6.4
	1986	3,207 (90.3)	16.6	2.0	1.0	3.0	0.34	7.4	0.06	4.7	0.0	1.7	1.1	0.03	0.0	0.0	1.7
	1992	4,679 (92.9)	5.4	0.342	0.128	0.47	0.06	0.5	0.02	3.6	0.0	0.4	0.1	0.0	0.02	0.04	0.3
	1997	5,311 (93.9)	3.2	0.04	0.06	0.09	0.0	0.1	0.0	2.4	0.0	0.4	0.1	0.0	0.0	0.02	0.2
	2004	2,045 (94.4)	4.9	0.14	0.11	0.25	0.0	0.29	0.0	3.9	0.0	0.7*	0.0	0.0	0.0	0.0	0.03

(continued next)

Table 5. *(Continued from the previous page)*

Age	Year	No. of people examined (%)	Egg positive rate (%)	Al			Hw	Tt	To	Cs	Pw	Het	Ts	Hd	Hn	Un-ident	Ev
				U	F	Total											
70-79	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2004	986 (92.2)	5.55	0.0	0.0	0.0	0.0	0.35	0.0	4.58	0.0	0.63*	0.0	0.0	0.0	0.0	0.12
80-89	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2004	236 (84.3)	4.0	0.0	0.0	0.0	0.0	0.0	0.0	3.29	0.0	0.88*	0.0	0.0	0.0	0.0	0.0
Over 90	1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1976	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1986	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2004	9 (42.9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0*	0.0	0.0	0.0	0.0	0.0

Al, *Ascaris lumbricoides*; U, Unfertilized egg passer; F, Fertilized egg passer; Hw, Hook worm; Tt, *Trichuris trichiura*; To, *Trichostrongylus orientalis*; Cs, *Clonorchis sinensis*; Pw, *Paragonimus westermani*; Het, heterophyids including *Metagonimus yokogawai*, Ts, *Taenia* spp.; Hd, *Hymenolepis diminuta*; Hn, *Hymenolepis* nana; Unident, unidentified; Ev, *Enterobius vermicularis*.

that most of the people in the country were infected with at least 1 type of parasite. The major parasitic infections at that time were soil-transmitted parasites such as the roundworm, whipworm, and hookworms. However, the egg positive rate decreased dramatically to a 1 digit level from the 5th and 6th surveys conducted in 1992 and 1997, respectively. However, the 7th showed a little bit increased rate (3.7%) than the 6th (2.4%). In the case of snail-transmitted helminths like *C. sinensis*, they did not contribute much to the total egg positive rate until the 4th survey in 1986. However, in recent surveys, they showed less dramatic decreases in the egg positive rate compared to other types of parasites. Therefore, it became apparent that it would be important to manage snail-transmitted helminths, in particular, *C. sinensis*.

According to the egg positive rate based on the gender, the egg positive rate of women was higher until the 3rd survey. However, men showed higher prevalences than women after then (Table 4). Females had more infections with soil-transmitted parasites, whereas males had more infections with snail-transmitted helminths like *C. sinensis* and heterophyids. Especially, the egg positive rate of *C. sinensis* was much higher in males than in females. The heterophyid egg positive rate also was higher in males than in females. It is considered that the infection by these parasites is directly related to the eating habit of raw freshwater fish.

Until the 6th survey, the age gap was set at 5 year to compare the results according to the subjects' age and the upper age limit was set at 60 year. However, the age gap was set at 10 year from the 7th survey since the difference between age groups became minor, and comparison between each age group seemed less meaningful. Also, the upper age limit was increased from 60 year to 90 year. Since the average life expectancy in Korea has been increasing steadily, and the number and proportion of aged population are also increasing as time goes by, it would be appropriate to subdivide the age group 60 year and over into 4 more age groups (61-70, 71-80, 81-90, and > 90 year) in future analysis. At this time, the data > 60 year of age was used. To compare the age-prevalence data, those collected from the 6 previous surveys were modified after binding them into 10 year intervals.

The overall helminth egg positive rates for the age groups 10s and 20s were much lower, 1.5% and 1.8%, respectively, compared to the total egg positive rate. On the other hand, the egg positive rate was higher for the age groups 40s and over (except the 90s) than the average egg positive rate. Especially, the egg positive rate of the 50s was the highest, 6.9%. Although the egg

Table 6. Significance test of the prevalence of intestinal helminths in 2004 by urban and rural areas in the Republic of Korea

Parasite	Relative risk	95% confidence interval of relative risk	Odds ratio	95% confidence interval of odds ratio
Ascaris lumbricoides (F)[a]	8.3426	(7.9382, 8.7676)	8.3463	(7.9417, 8.7716)
Ascaris lumbricoides (U)[b]	0.5338	(0.5078, 0.5612)	0.5337	(0.5077, 0.5611)
Trichuris trichiura	3.0666	(3.0324, 3.1012)	3.0792	(3.0447, 3.1141)
Clonorchis sinensis	2.4626	(2.4533, 2.4719)	2.5362	(2.5262, 2.5462)
Heterophyids	2.8334	(2.8094, 2.8576)	2.8523	(2.8279, 2.8769)
Enterobius vermicularis	1.0302	(1.0203, 1.0402)	1.0304	(1.0204, 1.0404)

[a]F, Fertilized egg passers; [b]U, Unfertilized egg passers.

Table 7. Significance test of the prevalence of intestinal helminthes 2004 by sex in the Republic of Korea

Parasite	Relative risk	95% confidence interval of relative risk	Odds ratio	95% confidence interval of odds ratio
Ascaris lumbricoides (F)[a]	1.6446	(1.5649, 1.7284)	1.6447	(1.5650, 1.7285)
Ascaris lumbricoides (U)[b]	0.7704	(0.7479, 0.7935)	0.7703	(0.7478, 0.7935)
Trichuris trichiura	0.8373	(0.8281, 0.8465)	0.8369	(0.8277, 0.8461)
Clonorchis sinensis	1.9850	(1.9775, 1.9936)	2.0177	(2.0099, 2.0255)
Heterophyids	2.4376	(2.4157, 2.4597)	2.4472	(2.4252, 2.4695)
Enterobius vermicularis	1.1885	(1.1799, 1.1972)	1.1897	(1.1811, 1.1985)

[a]F, Fertilized egg passers; [b]U, Unfertilized egg passers.

positive rate of *C. sinensis* was lower for the age groups of < 40 year compared to the average, over 40 year (except the 90s) showed much higher rates than the average, and the rate was the highest for the 50s at 5.64%. Heterophyids also revealed similar phases with *C. sinensis* and the highest egg positive rate was shown in the 50s. On the other hand, pinworm infection was higher in the age group 10s, 2.8%, which was much higher than the average value of 0.6% (Table 5).

Through the 6th and 7th surveys, the egg positive rate of helminths has been dramatically decreasing. Especially, except for *T. trichiura, C. sinensis,* heterophyids, and the pinworm, the egg positive rates were lower than 0.1% which indicated that there were actually almost no infections. Instead, the 4 kinds of parasites should be managed more importantly. The egg positive rate of *T. trichuris* is dramatically decreasing along with the total positive rate, the rates of the pinworm, *C. sinensis*, and heterophyids are decreasing rather gradually. In particular, *C. sinensis* does not show any big difference. Moreover, compared with the 6th survey, the egg positive rate of *C. sinensis* increased a little whereas it was unchanged for heterophyids.

Association analysis

To observe the correlations among regions (urban and rural areas), genders, types of housing, and education, contingency tables were designed. According to Table 6 that showed the relative risk of parasitic infections by regions, the relative risk of parasites except *A. lumbricoides* (unfertilized) was higher than 1. The relative risk of *A. lumbricoides* (fertilized) was the highest (8.3426), followed by *T. trichuris* (3.0666), heterophyids (2.8334), and *C. sinensis* (2.4626). The relative risk 2.4626 of *C. sinensis* means that the infection rate in rural areas was 146% higher than in urban areas. Since 95% confidence interval is between 2.4533 and 2.4719, it is 95% confident to say that the rural area infection rate was between 2.4533 and 2.4719 times that of the urban area infection rate.

On the other hand, *C. sinensis* odds ratio was 2.5362, which means that *C. sinensis* infection rate in rural areas is 2.5362 times higher than in urban areas. Since the confidence interval of the odds ratio does not include 1, there were differences in odds ratios of *C. sinensis* infections between rural and urban areas. Table 7 showed the results of significance test of each parasite infection by gender. The relative risk was higher than 1 except in *A. lumbricoides* (unfertilized) and *T. trichiura*. The relative risk of heterophyids was 2.4376 which was the highest followed by *C. sinensis* of 1.9850. The relative risk of 2.4376 means that the heterophyid infection rate of men was 144% higher than that of women, and it was 95% confident to say that the infection rate of men was between 2.4157 and 2.4597 times higher than that of men. In the meantime, the odds ratio of heterophyids was 2.4472. This means that heterophyid infection rate of males

Table 8. Contingency table of sex vs *Clonorchis sinensis*

Frequency (total) percent row percent column percent	Positive	Negative	Total
Male	782,383 1.6104 3.2113 66.6298	23,580,702 48.5361 96.7887 49.7383	24,363,085 50.1465 100.0
Female	391,841 0.8065 1.6178 33.3702	23,828,880 49.0470 98.3822 50.2617	24,220,721 49.8535 100.0
Total	1,174,224 2.4169	47,409,582 97.5831	48,583,806 100.0

$P < 0.0001$.

was 2.4472 times higher than that of females. Because the confidence interval of the odds ratio does not include 1, it can be said that there was difference in the odds ratio of heterophyid infection between genders. Since 95% confidence interval of the odds ratio was 2.4252 and 2.4695, heterophyid infection rates in men was at least 143% higher than those of females.

Logistic regression analysis

Among various explanatory variables in *C. sinensis* data, the explanatory variable that shows the gender was considered to have effects on *C. sinensis* infection which is the response variable. The gender is a categorical variable that indicates male or female.

$$Y=\begin{cases}1, \text{positive}\\0, \text{negative}\end{cases} \quad X=\begin{cases}1, \text{male}\\0, \text{female}\end{cases}$$

The 2-way contingency table of the gender and *C. sinensis* is shown in Table 8. Among 48,583,806 total Korean people, 1,174,224 (2.4%) were estimated to be infected. Among them, the male infection rate was 66.6% and the female infection rate was 33.3%, indicating that *C. sinensis* infection rate of males was twice as high as that of females.

DISCUSSION

The national egg positive rate of intestinal helminths and the number of infected people as well as the errors of estimates for each parasite species have been estimated in the present study. The total helminth egg positive rate appeared to be 3.7%, and the estimated total infected number of people among the whole population was 1,780,000. Some results of the present survey were presented in a review paper by Hong et al. [19] who referred the monographic series reports [3]. The overall egg positive rate appeared to have increased a little compared to the 6th survey conducted in 1997 [3]. According to regions, Gyeongsangnam-do showed the highest prevalence, 16.3%, followed by 13.3% of Daejeon, 10.9% of Chungcheongnam-do, and 8.6% of Jeollanam-do. In a survey conducted 28 year previously on 13,373 people living along the 8 large riverside areas in Korea [20], the egg positive rate of any kind of parasites was 58.7% which was remarkably higher than the present figures. Among them, the whipworm (35.2%), roundworm (22.9%), *C. sinensis* (21.5%), and heterophyids (4.8%) comprised the majority of parasite species involved [20]. Also, the rate of intestinal parasitic infections of the residents in Geum-gang (= river) area, in the middle region of Korea, was reported to be 40.8%, and *C. sinensis* and heterophyids were the major parasites [9].

In the present survey, *C. sinensis* revealed the highest prevalence among all parasite species involved. Its nationwide egg positive rate was 2.4% and the estimated number of infected people was at least 1,170,000. According to regions, the egg positive rate was the highest (11.3%) in Gyeongsangnam-do, followed by Daejeon (6.9%), Chungcheongnam-do (6.8%), and Jeollanam-do (6.2%). These figures were comparatively lower than those of a previous report that showed a 16% *C. sinensis* prevalence in Hamyang, Gyeongsangnam-do in 2002 [4]. The present results of *C. sinensis* prevalence were also lower than those reported in 4 southern endemic areas; 17.1% in Nakdong-gang, 11.2% in Seomjin-gang, 5.5% in Youngsan-gang, and 4.6% in Geum-gang [21]. However, the results of the present survey were similar to a previous local survey at Geum-gang [5], where the egg positive rate of *C. sinensis* was 9.3% and that of *Metagonimus* spp. was 5.5%.

The egg positive rates of *C. sinensis* and heterophyids appeared to be higher in the present survey than in the 6th survey [3], although it should be considered that the egg positive rate may vary to some extent according to sampling bias of subjected cases. For example, the more riverside people are included in the examination the higher the prevalence would appear to be. Anyhow, in the present study, rural areas compared to urban areas, and males compared to females, had higher total egg positive rates. Since a much higher infection rate was observed in males than females, males should pay more attention to sanitation. Infected men may have difficulties in labor and other social activities, so that the infection could affect the total productivity of the regional society [20]. Regarding the age-dependent prevalence, the age groups of the 10s and 20s had lower egg positive rates than the average rate, and the age group of the 40s and over showed higher egg positive rates than the average. In particular, the age group of the 50s showed the highest egg positive rate of 6.9%. It is suggested that the age group with higher infection rate should have eaten more freshwater fish contaminated with *C. sinensis* or *Metagonimus* spp. compared to other age groups [4].

The results of the present survey, together with previous ones, can be used as basic data to claim successful control of soil-transmitted helminths in Korea [19]. Especially, it can be said that Korea achieved one of the standards required by OECD, since the data of soil-transmitted helminths including the roundworm, whipworm, hookworms, and *T. orientalis* could be used as an index that can evaluate the level of parasitic diseases control, sanitation, and status of economy.

However, the most important focus of this 7th survey was that fishborne parasitic infections, including *C. sinensis* and heterophyid infections, are steadily prevalent along river side areas. Health education can guide people to be more cautious about eating raw freshwater fish and is in urgent need. It is considered that the present data can be used as a reference by other countries, WHO, and other international health organizations which would like to establish parasite control projects in parasite endemic areas. The present data and files could be used for project analyses and other connected researches in the future.

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