

A survey of cryptosporidiosis among 2,541 residents of 25 coastal islands in Jeollanam-do (Province), Republic of Korea

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Abstract: In order to determine the distribution and prevalence of human cryptosporidiosis on western and southern coastal islands of Jeollanam-do (Province), fecal samples were collected from 2,541 people residing on 25 islands, 13 in the western coasts and 12 in the southern coasts, during July and August 2000. Fecal smears were prepared following formalin-ether sedimentation of the samples and stained by a modified acid-fast procedure. The presence of *Cryptosporidium* oocysts was determined by light microscopy. *Cryptosporidium* oocysts were detected in 38 specimens (1.5%). The oocyst positive rate varied (0-6.0%) according to island; the highest was detected on Oenarodo (6.0%), followed by Naenarodo (5.6%) and Nakwoldo (5.4%). The majority (35 persons, 94.6%) of *Cryptosporidium*-infected individuals were older than 50 years of age. Men (22/1,159; 1.9%) were infected at a higher rate than women (16/1,382; 1.2%). The results of the present survey indicate that human *Cryptosporidium* infections (due to *Cryptosporidium hominis* and/or *C. parvum*) are maintained at a relatively low prevalence on coastal islands of Jeollanam-do, Republic of Korea.

Key words: *Cryptosporidium hominis*, *Cryptosporidium parvum*, cryptosporidiosis, prevalence, coastal islands, Jeollanam-do (Province)

Cryptosporidium is a small coccidian protozoan which infects mammals, birds, reptiles, and fishes. The agents responsible for the majority of human infections are *Cryptosporidium hominis* (strong anthroponotic transmission) and *Cryptosporidium parvum* (zoonotic transmission) (Morgan-Ryan et al., 2002; Park et al., 2006).

In the Republic of Korea, after the first confirmation

of the presence of *C. parvum* in laboratory mice (Chai et al., 1990), high prevalences (according to detection methods: 10-22%) of human cryptosporidiosis were detected among out-patients at the Severance Hospital (Cho et al., 1993). Thereafter, cryptosporidiosis has been regarded as an important disease from the public health aspect in the Republic of Korea. Subsequently, several investigators have reported variable prevalences in differing localities (Chai et al., 1996; Seo et al., 2001; Yu et al., 2004; Park et al., 2006). In particular, epidemiological studies on human cryp-

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tosporidiosis in Jeollanam-do uncovered unique epidemiological characteristics, including a predominance of infection among aged people, caused by both *C. hominis* and *C. parvum*, and animal infections with *C. hominis* (Chai et al., 2001; Park et al., 2006). Cryptosporidiosis can persist for extended periods of time on coastal islands, because immunocompetent humans infected with *Cryptosporidium* tend to exhibit only mild symptoms, including self-limiting diarrhea, thus can play a role of the reservoir likewise domestic animals (Okhuysen et al., 1999; Chai et al., 2001).

There are a total of 278 human-inhabited islands in Jeollanam-do (Province). The majority of small coastal islands are both geographically and socio-economically isolated from the mainland. The provision of sufficient medical services for the people on coastal islands has proved difficult, and the residents may have somewhat peculiar life patterns, eating different foods, doing different works, and inhabiting in a different environment from that of the mainland. Therefore, patterns of parasitic infections on coastal islands may also differ from inland patterns. For example, intestinal fluke infections caused by brackish water fishes or bivalves tend to prevail among people living on western and southern coastal islands (Chai and Lee, 2002). However, only a little information is available on the prevalence of intestinal protozoa on coastal islands. A relatively low prevalence (5.5%) of intestinal protozoa, including *Entamoeba histolytica*, *Giardia lamblia*, *Entamoeba coli*, and *Endolimax nana*, has been reported on the coastal island, Yondo, which is located within the southern regions of Jeollanam-do (Goo et al., 1988). However, no information is currently available regarding *Cryptosporidium* infections on coastal islands. The present study was conducted in order to characterize the distribution and prevalence of human cryptosporidiosis occurring on coastal islands of Jeollanam-do, Republic of Korea.

Among 278 inhabited islands located off the western and southern coasts of Jeollanam-do, 13 western and 12 southern islands (Fig. 1), on which more than 100 people resided, were randomly selected and epidemiological surveys were conducted. Fecal samples were collected from 2,541 of the islanders during July

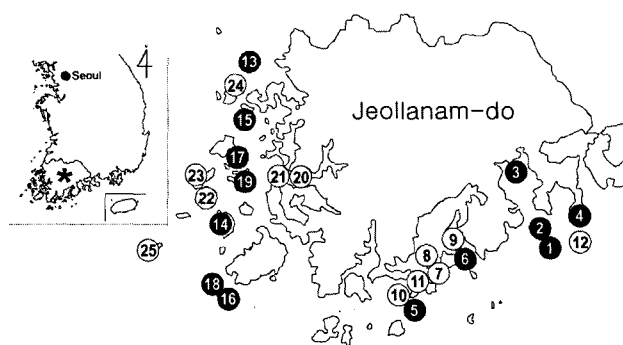


Fig. 1. Map showing the surveyed islands and the distribution of cryptosporidiosis. The islands are illustrated with numbers, in accordance with Table 1. Islands with *Cryptosporidium* oocyst positive cases are in black circles and those without positive cases are shown in white circles.

and August 2000, with the help of the branch offices of the Korea Association of Health Promotion. Fecal examinations were conducted by the formalin ether concentration technique. The fecal sediments were smeared onto glass slides and stained by a modified acid-fast procedure (Chai et al., 2001). The presence of *Cryptosporidium* oocysts, which are 4-5 μm in diameter, harboring 4 sporozoites, and stained red on a blue background, was visualized under the oil immersion lens of a light microscope. The statistical significance of prevalences, in accordance with geographical location, age, and sex, were analyzed by the chi-square test. Values of $P < 0.05$ were considered to be significant.

Cryptosporidium oocysts were detected in 38 (1.5%) of 2,541 fecal specimens (Table 1; Fig. 1). On 13 islands which showed oocyst positive cases, the average oocyst positive rate was 2.8%. These islands were scattered along the western and southern coasts, with no special predilection for locality. Of the 12 islands located along the southern coasts, *Cryptosporidium* infections were detected on 6 islands, Oenarodo (oocyst positive rate: 6.0%), Naenarodo (5.6%), Changdo (4.6%), Tolsando (1.1%), Nopdo (1.0%), and Keogumdo (0.9%) (Table 1; Fig. 1). The average oocyst positive rate on the 12 southern islands was 1.7% (21/1,263 examined) (Table 1). Similarly, among 13 western islands, *Cryptosporidium* oocysts were detected on 7 islands, including Nakwoldo (5.4%), Hauido

Table 1. Prevalence of human cryptosporidiosis on 25 southern and western coastal islands of Jeollanam-do (Province), Republic of Korea

Location in Jeollanam-do	Name of island	Area code in Fig. 1	No. of positive / No. examined ^{a)} (%)
Southern coasts			
	Oenarodo	1	7 / 117 (6.0)
	Naenarodo	2	6 / 107 (5.6)
	Changdo	3	5 / 109 (4.6)
	Tolsando	4	1 / 93 (1.1)
	Nopdo	5	1 / 102 (1.0)
	Keogumdo	6	1 / 113 (0.9)
	Pyeongildo	7	0 / 108 (0.0)
	Kogumdo	8	0 / 111 (0.0)
	Sorokdo	9	0 / 91 (0.0)
	Pogildo	10	0 / 103 (0.0)
	Nohwado	11	0 / 109 (0.0)
	Sodo	12	0 / 100 (0.0)
Subtotal			21 / 1,263 (1.7)
Western coasts			
	Nakwoldo	13	5 / 93 (5.4)
	Hauido	14	4 / 96 (4.2)
	Cheungdo	15	3 / 92 (3.0)
	Hachodo	16	2 / 108 (1.9)
	Amtaedo	17	1 / 99 (1.0)
	Sangchodo	18	1 / 103 (1.0)
	Anchwado	19	1 / 110 (0.9)
	Kohado	20	0 / 85 (0.0)
	Dallido	21	0 / 104 (0.0)
	Tochodo	22	0 / 95 (0.0)
	Pikeumdo	23	0 / 104 (0.0)
	Imchado	24	0 / 99 (0.0)
	Heuksando	25	0 / 90 (0.0)
Subtotal			17 / 1,278 (1.3)
Total			38 / 2,541 (1.5)

^{a)}Examined by formalin-ether sedimentation and modified acid-fast (MAF) stain.

(4.2%), Cheungdo (3.0%), Hachodo (1.9%), Amtaedo (1.0%), Sangchodo (1.0%), and Anchwado (0.9%) (Table 1; Fig. 1). The average oocyst positive rate on the 13 western islands was 1.3% (17/1,278 examined). Among the total of 38 positive individuals, 22 (1.9%) were males and 16 (1.2%) were females (Fig. 2). The majority (94.6%) of the oocyst positive cases were over 50 years of age ($P = 0.000$) (Fig. 2).

In this epidemiological study, the overall human *Cryptosporidium* oocyst positive rate on the coastal

islands of Jeollanam-do, Korea was lower (1.5%) than expected. *Cryptosporidium* infections were detected on approximately half of the islands (13 of 25 islands). This relatively low prevalence of *Cryptosporidium* and the limited distribution on coastal islands of Jeollanam-do are interesting results. In previous studies conducted in inland areas of Jeollanam-do, higher prevalences were reported, 10.6% in 1992 (Chai et al., 1996) and 8.2% in 2002 (Yu et al., 2004). These discrepancies between coastal islands and inland areas

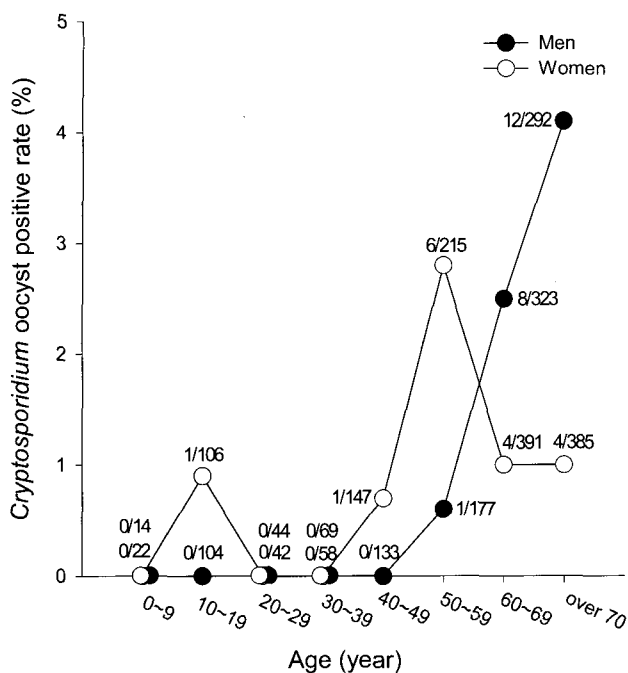


Fig. 2. The age- and sex-prevalence of cryptosporidiosis among people on the southern and western coastal islands of Jeollanam-do, Korea. Numbers (a/b) for each circle represent the number of oocyst positive cases (a) and the number of residents evaluated (b).

appear to be influenced by a variety of geographical and environmental factors.

Most coastal islands are geographically separated from inland areas. Migrations of people, as well as reservoir animals, between coastal islands and inland areas are less frequent than are observed within inland areas. Therefore, *Cryptosporidium* infection and transmission may be limited within islands.

Contamination of drinking water with oocysts constitutes an important risk factor for high cryptosporidiosis prevalence (Kelly et al., 1997). The islands examined in this study are geographically remote from inland areas, and the residents are unable to access treated water from inland. Thus, drinking water is supplied to the islanders from water reservoirs constructed within each island, or from underground. If water reservoirs were contaminated with *Cryptosporidium* oocysts, many populations would clearly be exposed to infection with the oocysts (Yamamoto et al., 2000). However, in the present study, we detected generally low cryptosporidiosis

prevalence on coastal islands, which may imply a relatively low possibility of water reservoir contamination. Another possibility includes the contamination of underground water. However, this possibility is also quite low, as the contamination of underground water with oocysts is uncommon and, on the majority of coastal islands, available water tends to contain some degree of salinity, which can negatively influence the viability of *Cryptosporidium* oocysts (El Mansoury et al., 2004).

In cases in which the probability of water contamination is low, contact with animal reservoirs should be considered. Domestic animals, including cattle and goats, represent important reservoir hosts for human cryptosporidiosis, and attendants for these animals are regularly exposed to the risk of cryptosporidiosis (Rahaman et al., 1984). However, it is regrettable that no studies have yet been published regarding the status of cryptosporidiosis in domestic animals on island areas in the Republic of Korea. In the case of inland Jeollanam-do, the *Cryptosporidium* oocyst positive rate among calves suffering from diarrhea was found to be 14.4% (Wee et al., 1996), and this rate was similar to that of humans (10.6%) occupying the same area (Chai et al., 1996). In another observation, the prevalence of cryptosporidiosis was surprisingly high (94%) among the domestic livestock reared in inland areas of Jeollanam-do (Yu et al., 2004).

Cryptosporidiosis induces mild, self-limiting diarrhea in healthy individuals, but can also cause severe diarrhea in young, elderly, or immunocompromised patients (Okhuysen et al., 1999). In the present study, it is worthy of note that the majority (94.6%) of oocyst positive cases were people over 50 years of age. In the questionnaire study, none of these people was determined to suffer from immunocompromised conditions or debilitating diseases. The majority of these patients complained only of mild degenerative diseases, which are common in subjects of advanced age. A similar predilection with regard to age has been reported in an inland rural village of Hwasun-gun, Jeollanam-do (Chai et al., 2001). This high prevalence among elderly subjects is distinct from other reports in other countries; human cryptosporidiosis appears

to predominate in children under 10 years of age (Esteban et al., 1998; Leach et al., 2000). One of the reasons for these differences includes that the majority of people living on the islands surveyed in the present study were adults of over 30 years of age and very few children were living on these islands.

Seasonal variations of human cryptosporidiosis have also been reported (McLauchlin et al., 2000; Chai et al., 2001). In the Republic of Korea, as the result of monthly observations in an inland village of Jeollanam-do, the *Cryptosporidium* oocyst positive rate was lower during summer than in the spring and autumn seasons (Chai et al., 2001). The present study was conducted during the summer season, from July to August. In order to elucidate the seasonal tendencies on the islands surveyed herein, further studies will be necessary.

Unfortunately, we could not isolate *Cryptosporidium* DNA, due to the insufficient amount of fecal samples and of oocysts collected from each of the individuals assessed in this study. Therefore, we were unable to analyze the genotype and species of *Cryptosporidium* present on these islands. Our speculation, although unsupported by evidence, is that the infections may represent a mixed population of *C. hominis* and *C. parvum*, as has been previously observed in an inland area of Jeollanam-do (Park et al., 2006).

In conclusion, the status of human cryptosporidiosis on the coastal islands of Jeollanam-do, Republic of Korea, has been studied in this work for the first time. It has been determined that these islands evidence a relatively low and variable prevalence (0-6.0%) of cryptosporidiosis. The species of *Cryptosporidium* involved, i.e., *C. hominis*, *C. parvum*, or both, transmission modes, and other epidemiological characteristics of cryptosporidiosis on these islands remain to be studied in the future.

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