Prevalence and Risk Factors for Intestinal Parasitic Infection in Schoolchildren in Battambang, Cambodia

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Abstract. Most intestinal parasitic infections (IPIs), commonly endemic in tropical resource-poor developing countries, are neglected tropical diseases. Parasitic infections and malnutrition are most commonly found in children. We determined the prevalence of IPIs and the risk factors in Battambang Province, northwestern Cambodia, from August to September 2015. This study collected 308 valid questionnaires and specimens from Dontri (173, 56.2%) and Kon Kaëk (135, 43.8%) primary schools. All stool samples were examined using Chang's Feces Examination Apparatus through the merthiolate–iodine–formaldehyde technique. Headache (259, 84.1%), recurrent cough (249, 80.8%), and abdominal pain (235, 76.3%) were the most common symptoms as detected from questionnaire investigation. A total of 155 students were positive for any parasite type; a single parasite type was observed in 97 students (31.5%), two types in 40 students (13.0%), three types in 14 students (4.6%), and four types in four students (1.3%). Nine gastrointestinal parasite species (three helminths and six protozoa) were identified in the stool samples. The most common parasites in schoolchildren were *Giardia intestinalis* (31.5%) and *Entamoeba histolytica/dispar* (17.5%). This is the first IPIs study, and more than half of the schoolchildren were infected with parasite species in Moug Russey District of Battambang Province. We found nine parasite species, including helminths and protozoa, and pathogenic protozoa were the main source of IPIs. Improving the detection method, sanitation facilities, and personal hygiene as well as utilizing combined drugs are all important measures to greatly reduce IPIs in Cambodian schoolchildren.

INTRODUCTION

Gastrointestinal parasites are a substantial public health problem worldwide, particularly in the rural areas of developing countries.¹ A total of 1.2 billion people are estimated to be infected with soil-transmitted helminths and schistosomes in the Asia-Pacific region.² Pediatric parasite infections can lead to anemia and contribute to detrimental effects on nutrition, cognition, and growth.² The World Health Assembly set the global aim of treating 75% of schoolchildren at risk of helminthiasis and schistosomiasis by administering chemotherapy.³

Cambodia is located in southeast Asia and is divided into 24 provinces.⁴ More than two-thirds of the population do not have access to improved sanitation facilities and clean drinking water. The main source of drinking water for most inhabitants is rainwater.⁵ Parasitic infections and malnutrition are most commonly found in children.³ However, a limited number of intestinal parasitic studies have been conducted in Cambodia. Almost all these studies have focused on *Ascaris lumbricoides* (2–40%), Hook worm (3.4–65%), *Trichuris trichiura* (0.4–17.3%), and *Strongyloides stercoralis* (0.4–31.5%) in communities and hospitals.^{6–13} The Cambodian Ministry of Health has implemented national deworming programs. However, mass treatment has only focused on the most common parasites, such as *A. lumbricoides*, Hook worm, and *T. trichiura*. Other nematodes, trematodes, cestodes, and pathogenic protozoan infections have not been addressed.¹

The merthiolate–iodine–formaldehyde (MIF) technique recommended by Taiwan Centers for Disease Control (Taiwan CDC)¹⁴ has very high sensitivity for intestinal helminth and protozoa

examination.^{15,16} In this study, all stool samples were examined using Chang's Feces Examination Apparatus through the MIF technique. In this study, we determined the prevalence of intestinal parasitic infections (IPIs) and the risk factors in Battambang Province. We conducted a cross-sectional study of hygiene education and IPIs and used the MIF technique to examine each specimen from 308 schoolchildren in the Moug Russey District of Battambang Province, northwestern Cambodia.

MATERIALS AND METHODS

Ethical considerations. The study protocol was approved by the Battambang Provincial Health Department. All participants were informed about the study purpose, and their parents or legal guardian provided written informed consent. All diagnosis data were provided to the health center, and participants with parasitic infection were treated according to the standard guidelines of the Cambodian Ministry of Health.

Study setting, sampling, and population. This study was performed in Moug Russey District (12° 42' 56" N, 103° 46' 30" E), which is located in the southeast region of Battambang Province, northwestern Cambodia (Figure 1). Agriculture is the main economic activity in this district. Furthermore, there are insufficient health centers, which are located close to a few primary schools. In this study, the Kon Kaëk primary school is close to the Kon Kaëk health center, and the Dontri primary school is a 45-minute drive from the Kon Kaëk health center. This survey was conducted during the rainy season from August to September 2015.

Since no pilot study was done, the sample size was determined using the general formula, $n = z^2 p (1 - p) / d^2$ where, n is the sample size, z (1.96) is the standard deviation at a 95% confidence interval (CI), p is the estimated

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FIGURE 1. The Mung Russey district of Battambang province, northwestern Cambodia.

prevalence (50%), and d is the allowed relative error (0.05).¹⁷ The minimum sample size after calculation was 278 children.

Field procedures. On the first day, we explained the study protocol to all participants and then provided each participant with the informed consent form and a pre-labeled plastic container (number, name, gender, and date) for stool sample collection. Subsequently, we educated schoolchildren on major and essential hygiene practices, including parasitic education. On the second day, the filled stool plastic container was collected from each student and confirmed by their number, name, and gender. The informed consent form signed by parents or the legal guardian was also collected from each participant. Thereafter, a questionnaire was administered to each participant to obtain demographic data (age, gender, and school), the presence of symptoms (lung discomfort or breathlessness, recurrent cough, cough with worms, eye discomfort or unclear vision, abdominal pain, diarrhea, constipation, excretion with worms, bloating or gas, anal itching, anemia, weight loss, headache, dizziness, weakness and/or fatigue, muscle aches and pains, unexplained fever, allergies, food sensitivities, nausea or vomiting, and skin problems), potential risk factors (medication for deworming, eat raw or undercooked meats, eat raw vegetables, and drink untreated or unboiled water), source of drinking water in daily life (bore well, drain water, mineral water, open well, other, rain water, and tap water), personal risk perception (wash hands before meals, wash hands after using toilet, frequently clean pets, wash hands after petting or cleaning animals, eat anything picked from the ground, wear shoes when going out, and touch soil without wearing gloves), animals raised at home (buffalo, cat, cattle, chicken, dog, duck, fish, horse, and pig), and the number of animal species at home (Figure 2A).

All specimens were transported to the Kon Kaëk health center at ambient temperature within 60 minutes after collection.

Laboratory procedures. The stool samples were examined using the MIF technique. A piece of stool (5–10 g) from each filled stool plastic container was transferred into Chang's Feces Examination Apparatus. MIF (5 mL; merthiolate-formaldehyde solution: iodine solution = 15:1) was added and well mixed. Subsequently, the MIF stool-mixed solution was filtered through gauze into a new 15-mL tube. After staining for 4–8 hours, each specimen was examined under a light microscope (Olympus CHT, Japan) at high power field

FIGURE 2. Field procedures (A) and laboratory procedures (B) workflow.

($\times 400$) magnification to detect the helminth ova and protozoan cyst (Figure 2B).

Statistical analyses. This study collected 308 valid questionnaires and specimens from Dontri (173, 56.2%) and Kon Kaëk (135, 43.8%) primary schools. All participants were divided into two age groups for analysis: 6–11 years and 12–16 years. We determined whether demographic data, the presence of symptoms, prevalence of nine types of intestinal parasites, hygienic status, and personal habits were significant risk factors for IPI by using the χ^2 test. Subsequently, logistic regression adjusted for confounding factors was performed using an odds ratio (OR) with 95% CI. Multivariate logistic regression was used to calculate symptoms that are risk factors. Finally, multivariate logistic regression adjusted for the hygienic status and personal habit risk factors was focused to explore the associations between intestinal parasites and symptoms. A P value less than 0.05 was considered statistically significant, and statistical analyses were performed using SAS software (version 9.3; SAS Institute, Cary, NC).

RESULTS

Overall, we enrolled 360 schoolchildren from two primary schools, of which 312 (86.7%) students submitted stool samples. The final analysis included 308 (85.6%) students with stool samples and completed questionnaires.

TABLE 1

Descriptive analysis of demographic data, the presence of symptoms, potential risk factors, the drinking water sources in daily life, personal risk perception, and raising animals and the number of animal species at home

Variables	n (%)	Variables	n (%)
Gender		Drinking water sources in daily lives	
Male	123 (39.9)	Bore well	9 (2.9)
Female	185 (60.0)	Drain water	4 (1.3)
Age	308*	Mineral water	2 (0.7)
School		Open well	9 (2.9)
Dontri primary school	173 (56.2)	Other	47 (15.3)
Kon Kaëk primary school	135 (43.8)	Rain water	242 (78.6)
Symptoms		Tap water	9 (2.9)
Lung discomfort or breathlessness	65 (21.1)	Wash hands before meals	288 (93.5)
Recurrent cough	249 (80.8)	Wash hands after using toilet	288 (93.5)
Cough with worms	5 (1.6)	Frequently clean pets	205 (66.6)
Eye discomfort or unclear vision	107 (34.7)	Wash hands after petting or cleaning up animals	237 (77.0)
Abdominal pain	235 (76.3)	Eat anything picked from the ground	24 (7.8)
Diarrhea	195 (63.3)	Always wear shoes when going out	293 (95.13)
Constipation	50 (16.2)	Unexplained fever	163 (52.9)
Excretion with worms	47 (15.3)	Allergies, food sensitivities	63 (20.5)
Bloating or gas	201 (65.3)	Nausea or vomiting	171 (55.5)
Anal itching	78 (25.3)	Skin problems(rashes, hives, itchy skin)	141 (45.8)
Anemia (pale or yellowish skin)	71 (23.1)	Medication for deworming	265 (86.0)
Weight loss	146 (47.4)	Having eaten raw or undercooked meats	83 (27.0)
Headache	259 (84.1)	Having eaten raw vegetables	255 (82.8)
Dizziness	207 (67.2)	Having drunk untreated or unboiled water	155 (50.3)
Weakness and/or fatigue	138 (44.8)	Having touched the soil without wearing gloves	235 (76.3)
Muscle aches and pains	52 (16.9)	Raise animals at home	293 (95.1)

* Age: 11.6 ± 1.7 years.

Descriptive analysis. The average age of the students was 11.60 years. Moreover, 39.9% (123/308) of the students were boys, and 60.1% (185/308) were girls (Table 1). Questionnaire investigations revealed that headache (259, 84.1%), recurrent cough (249, 80.8%), and abdominal pain (235, 76.3%) were the most common symptoms. Moreover, cough with worms (5, 1.6%), excretion with worms (47, 15.3%), and medication for deworming (265, 86.0%) were directly related to parasitic infection. Regarding the hygienic status and personal habits, 82.8%, 50.3%, and 27.0% of schoolchildren had eaten raw vegetables, drunk untreated or unboiled water, and eaten raw or undercooked meat, respectively. The main source of drinking water for most schoolchildren was rainwater (78.6%). Regarding hand-washing habits, 93.5%, 93.5%, and 77.0% of schoolchildren washed their hands before meals, after using the toilet, and after petting or cleaning up animals, respectively. More than 90% always wore shoes when going out. Three-quarters of schoolchildren touched soil without wearing gloves. How-

ever, most of them did not eat anything picked from the ground. Moreover, 95.1% raised animals at home, and 41.2% and 28.6% raised one and two animal species, respectively. In addition, more than two-thirds of schoolchildren frequently cleaned pets (Table 1).

Parasitological findings and polyparasitism. Overall, positive results were obtained for 50.3% (155/308) of stool samples (Table 2). A total of 155 students were positive for any parasite type; a single parasite type was observed in 97 students (31.5%), two types in 40 students (13.0%), three types in 14 students (4.6%), and four types in four students (1.3%). Nine gastrointestinal parasite species (three helminths and six protozoa) were found in the stool samples. *Giardia intestinalis* and *Entamoeba histolytica/dispar* were the predominant protozoan species and were present in 31.5% and 17.5% of students, respectively. *Entamoeba coli*, *Endolimax nana*, Hook worm, *Blastocystis hominis*, *Hymenolepis nana*, *S. stercoralis*, and *Chilomastix mesnili* were present in 8.1%, 5.5%, 4.9%, 4.9%, 2.9%, 0.3%, and

TABLE 2
Parasitological findings and polyparasitism

	Single infection (%)	Dual infection (%)	Triple infection (%)	Quad infection (%)	Total cases	Prevalence(%)*
Helminth						
Hook worm	8 (8.3)	5 (12.5)	2 (14.3)	0 (0.0)	15	4.9
<i>Strongyloides stercoralis</i>	1 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	1	0.3
<i>Hymenolepis nana</i>	3 (3.1)	3 (7.5)	2 (14.3)	1 (25.0)	9	2.9
Pathogenic protozoa						
<i>Entamoeba histolytica/dispar</i>	21 (21.7)	17 (42.5)	12 (85.7)	4 (100.0)	54	17.5
<i>Giardia intestinalis</i>	52 (53.6)	30 (75.0)	12 (85.7)	3 (75.0)	97	31.5
<i>Blastocystis hominis</i>	4 (4.1)	5 (12.5)	3 (21.4)	3 (75.0)	15	4.9
Nonpathogenic protozoa						
<i>Entamoeba coli</i>	3 (3.1)	12 (30.0)	7 (50.0)	3 (75.0)	25	8.1
<i>Chilomastix mesnili</i>	0 (0.0)	1 (2.5)	0 (0.0)	0 (0.0)	1	0.3
<i>Endolimax nana</i>	5 (5.2)	7 (17.5)	4 (28.6)	2 (50.0)	18	5.8
N	97 (31.5)	40 (13.0)	14 (4.6)	4 (1.3)	155	50.3

* Percentage of children with positive results divided by the total number of children.

TABLE 3
Risk factors for intestinal parasitic infection (univariate analysis-risk factor versus infection)

Infection species	No. of cases positive (%)					
	School			Having drunk untreated or unboiled water		
	Dontri	Kon Kaëk	χ^2/P	Yes	No	χ^2/P
Hook worm	13 (7.5)	2 (1.5)	0.0297*	7 (4.5)	7 (4.6)	1.0000
<i>Strongyloides stercoralis</i>	0 (0.0)	1 (0.7)	0.4383	0 (0.0)	1 (0.7)	0.4951
<i>Hymenolepis nana</i>	8 (4.6)	1 (0.7)	0.0829	8 (5.2)	1 (0.7)	0.0364*
<i>Entamoeba histolytica/dispar</i>	31 (17.9)	23 (17.0)	0.9593	24 (15.5)	30 (19.7)	0.4073
<i>Giardia intestinalis</i>	56 (32.4)	41 (30.4)	0.8016	53 (34.2)	44 (29.0)	0.3866
<i>Blastocystis hominis</i>	6 (3.5)	9 (6.7)	0.3043	7 (4.5)	8 (5.3)	0.9690
<i>Entamoeba coli</i>	18 (10.4)	7 (5.2)	0.1459	11 (7.1)	13 (8.6)	0.7930
<i>Chilomastix mesnili</i>	1 (0.6)	0 (0.0)	1.0000	0 (0.0)	1 (0.7)	0.4951
<i>Endolimax nana</i>	13 (7.5)	5 (3.7)	0.2421	11 (7.1)	7 (4.6)	0.4927
Stool examination positive	94 (54.3)	61 (45.5)	0.1392	79 (51.0)	75 (49.3)	0.8645
Helminth	19 (11.0)	4 (3.0)	0.0148*	13 (8.4)	9 (5.9)	0.5377
Soil-transmitted helminth	13 (7.5)	3 (2.2)	0.0691	7 (4.5)	8 (5.3)	0.9690
Protozoa	83 (48.0)	58 (43.0)	0.4466	71 (48.5)	69 (45.4)	1.0000
Pathogenic protozoa	75 (43.4)	55 (40.7)	0.7307	65 (41.9)	65 (42.8)	0.9751
Nonpathogenic protozoa	26 (15.0)	12 (8.9)	0.1467	20 (12.9)	17 (11.2)	0.7739

* $P < 0.05$.

0.3% of students, respectively. *Strongyloides stercoralis* and *C. mesnili* were only diagnosed in one student. Therefore, we focused on the other seven types of intestinal parasites by using stratified analysis and logistic regression.

Risk factors for IPIs. As shown in Table 3, we conducted stratified analysis to obtain the risk factors associated with IPI. Regarding demographic variables, no statistical difference was observed in gender and age in students positive for intestinal parasites. However, the school was significantly associated with Hook worm infection ($P = 0.0297$). Other parasites and infection species were not associated with Kon Kaëk and Dontri primary schools. Regarding the hygienic status and personal habits, having drunk untreated or unboiled water was significantly associated with *H. nana* infection ($P = 0.0364$). Moreover, having eaten raw vegetables and frequently cleaning pets were considerably associated with a lower infection rate. These results may be attributed to the presence of con-

founding factors. In addition, other variables were not statistically associated with infection.

We used a multivariate logistic regression model adjusted for confounding factors to obtain suitable risk factors. For example, raising animals at home was positively related to infection after adjustment for other risk factors. Students raising animals at home were 3.901 times more likely to exhibit parasitic infection than those who did not raise animals at home (OR = 3.901, 95% CI = 1.128–13.493, $P = 0.0315$) (Table 4). Other risk factors were not statistically significantly associated with infection. Furthermore, the association of infection with helminths, pathogenic protozoa, and nonpathogenic protozoa with raising animals at home was analyzed. Raising animals at home was only positively related to pathogenic protozoa (OR = 4.249, 95% CI = 1.102–16.390, $P = 0.0357$). No other variables were statistically significantly associated with helminths and nonpathogenic protozoa.

TABLE 4
Risk factors for intestinal parasitic infection (multivariate analysis-risk factors versus infection)

Variable	Intestinal parasitic infection			Pathogenic protozoa infection		
	OR	95% CI	P value	OR	95% CI	P value
Gender						
Male	1 (ref)	—	—	1 (ref)	—	—
Female	0.784	0.482–1.273	0.3250	0.959	0.588–1.565	0.8685
Age						
6–11	1 (ref)	—	—	1 (ref)	—	—
12–16	0.741	0.461–1.192	0.2164	0.790	0.489–1.276	0.3354
School						
Dontri primary school	1 (ref)	—	—	1 (ref)	—	—
Kon Kaëk primary school	0.804	0.485–1.333	0.3982	1.038	0.621–1.735	0.8860
Ever eaten raw or undercooked meats	0.975	0.572–1.662	0.9263	0.821	0.478–1.411	0.4753
Having eaten raw vegetables	0.896	0.479–1.678	0.7319	1.291	0.680–2.451	0.4349
Having drunk untreated or unboiled water	1.093	0.670–1.784	0.7211	1.035	0.632–1.698	0.8902
Eat anything picked from the ground	0.663	0.265–1.655	0.3782	0.952	0.379–2.390	0.9165
Having touched the soil without wearing gloves	1.021	0.589–1.769	0.9417	1.104	0.632–1.928	0.7277
Always wear shoes when going out	1.249	0.413–3.776	0.6938	1.299	0.414–4.082	0.6538
Wash hands before meals	1.142	0.404–3.231	0.8019	1.076	0.377–3.070	0.8914
Wash hands after using toilet	0.928	0.336–2.567	0.8858	0.787	0.286–2.167	0.6429
Wash hands after petting or cleaning up animals	0.844	0.418–1.705	0.6362	0.696	0.343–1.409	0.3134
Raise animals at home	3.901	1.128–13.493	0.0315*	4.249	1.102–16.390	0.0357*
Frequently clean pets	0.888	0.479–1.647	0.7069	0.776	0.417–1.446	0.4244

CI = confidence interval; OR = odds ratio.

* $P < 0.05$.

TABLE 5

Association of intestinal parasitic infection with related symptoms (multivariate analysis-infection versus symptoms, adjusted for risk factors)

	Diarrhea			Headache			Unexplained fever			Weakness and/or fatigue		
	aOR†	95% CI	P value	aOR†	95% CI	P value	aOR†	95% CI	P value	aOR†	95% CI	P value
Helminth												
Hook worm	0.509	0.155–1.672	0.2655	0.607	0.151–2.450	0.4834	0.899	0.257–3.144	0.8679	0.330	0.080–1.356	0.1241
<i>Hymenolepis nana</i>	0.397	0.088–1.795	0.2303	0.079	0.013–0.466	0.0051*	0.192	0.037–0.986	0.0481*	2.174	0.467–10.109	0.3222
Pathogenic protozoa												
<i>Entamoeba histolytica/dispar</i>	1.183	0.582–2.402	0.6428	1.132	0.426–3.013	0.8032	3.209	1.547–6.657	0.0017*	0.659	0.323–1.345	0.2518
<i>Giardia intestinalis</i>	1.597	0.889–2.869	0.1171	2.602	1.099–6.160	0.0297*	1.228	0.707–2.132	0.4652	0.706	0.400–1.247	0.2304
<i>Blastocystis hominis</i>	0.247	0.074–0.824	0.0230*	1.474	0.275–7.911	0.6508	0.780	0.244–2.497	0.6761	8.229	1.986–34.093	0.0037*
Nonpathogenic protozoa												
<i>Entamoeba coli</i>	0.735	0.272–1.982	0.5426	1.167	0.246–5.528	0.8459	0.676	0.247–1.849	0.4456	0.774	0.280–2.139	0.6217
<i>Endolimax nana</i>	1.688	0.506–5.637	0.3944	0.475	0.112–2.023	0.3143	2.035	0.633–6.545	0.2332	2.789	0.813–9.574	0.1031

aOR = adjusted odds ratio; CI = confidence interval.

*P < 0.05.

†aOR was adjusted for gender, school, age, having eaten raw or undercooked meats, having eaten raw vegetables, having eaten anything picked from the ground, wore shoes when going out, washed hands before meal, washed hands after toilet, washed hands after petting or cleaning up animals, raised animals or pets in family, and frequently cleaned pets.

Association of IPIs with related symptoms. We also used a multivariate logistic regression model adjusted for confounding factors to determine the association of IPIs, except for *S. stercoralis* and *C. mesnili* infection, with related symptoms. *Hymenolepis nana* infection was negatively related to headache (OR = 0.079, 95% CI = 0.013–0.466, $P = 0.0051$) and unexplained fever (OR = 0.192, 95% CI = 0.037–0.986, $P = 0.0481$) (Table 5). *Entamoeba histolytica/dispar* infection was positively related to unexplained fever (OR = 3.209, 95% CI = 1.547–6.657, $P = 0.0017$). *Giardia intestinalis* infection was positively related to headache (OR = 2.602, 95% CI = 1.099–6.160, $P = 0.0297$). *Blastocystis hominis* infection was negatively related to diarrhea (OR = 0.247, 95% CI = 0.074–0.824, $P = 0.0230$), but positively related to weakness and/or fatigue (OR = 8.229, 95% CI = 1.986–34.093, $P = 0.0037$). In addition, Hook worm, *E. coli*, and *E. nana* infections were not associated with related symptoms (Table 5).

DISCUSSION

The present study is the first to determine the prevalence of IPIs in schoolchildren in the Moung Russey District. A total of 155 schoolchildren were infected and 58 schoolchildren were infected with multiple parasites. Recent studies in Cambodia have reported that the proportion of IPIs-positive children ranges between 19.1% and 70.2%, and a child infected with multiple parasites is common.^{2–4, 6, 10–12} In this study, the most common parasites in schoolchildren were *G. intestinalis* (31.5%) and *E. histolytica/dispar* (17.5%). However, *E. histolytica* and *E. dispar* are not distinct under a microscope.¹⁸ We might use polymerase chain reaction to detect the *E. histolytica* infection rate in the future. According to the analysis of questionnaire data, 84.1% of schoolchildren were treated with mebendazole. Therefore, no *A. lumbricoides* ova was detected, a result similar to recent public studies in Cambodia.^{7,8} However, Hook worm and *G. intestinalis* were present in 4.9% and 31.5% of students, respectively. Khieu and others found a low cure rate for Hook worm infections treated with mebendazole.⁸ Recent

studies have found that mebendazole has limited efficacy for treating Hook worm and *G. intestinalis*.^{19–21}

In the present study, among nine parasitic species, only Hook worm infection was considerably associated with Dontri and Kon Kaêk primary schools ($P = 0.0297$). Although more than 90% of schoolchildren always wore shoes when going out, however, we found that many schoolchildren liked to take off their shoes when they played together, particularly in the Dontri primary school. It may be explained by that the Kon Kaêk primary school is very close to the Kon Kaêk health center taking only 5-minute walking distance, in contrast, the Dontri primary school is far from the Kon Kaêk health center taking about 45-minute driving distance thus making schoolchildren in Dontri primary school more difficult than Kon Kaêk primary school to get access essential medicine for proper treatment of parasitic infection including hookworm infection. These findings might contribute to the considerably higher Hook worm infection rates in the Dontri primary school than that in the Kon Kaêk primary school.

Regarding the hygienic status and personal habits, *H. nana* was considerably associated with drinking of untreated or unboiled water. In the Moung Russey District, most families do not have tap water or a water purification system. Rainwater (78.6%) is the major source of drinking water, similar to a recent public study by Nicholas and others in Cambodia.⁵ Consequently, acquiring clean water is an urgent problem in the Moung Russey District.

In this study, 95.1% of schoolchildren raised animals at home: chicken, dog, and duck were the most common animals. We found that schoolchildren raising animals were 3.9 times more likely to exhibit parasitic infection than those who did not raise animals. According to the additional analysis of pathogenic protozoan infection, schoolchildren raising animals were 4.3 times more likely to exhibit parasitic infection than those who did not raise animals.

The statistically significant results for zoonotic protozoa should be confirmed by conducting the genotype analysis of these protozoa.

Analysis of the association of IPIs with related symptoms revealed that *E. histolytica/dispar*, *G. intestinalis*, and *B. hominis*

were positively related to unexplained fever, headache, and weakness and/or fatigue symptoms, respectively. By contrast, *H. nana* and *B. hominis* were negatively related to headache and unexplained fever and diarrhea symptoms, respectively. More evidence-based diagnostic information is required to confirm these associations.

Fried insects are the most common food and are easy to buy in the market or night market in Cambodia. Nonetheless, insects are the intermediate host for *H. nana*. If fried insects are not cooked well, the larvae living in insects may infect humans. In this study, we found that *H. nana* was present in 2.9% of schoolchildren; whether schoolchildren might acquire *H. nana* infection through fried insects should be studied.

We also found that the health centers lacked diagnostic facilities, similar to the report of Nicholas and others.³ The staffs diagnose infections based on their past experiences. Therefore, they cannot efficiently control and treat the IPIs.

This is the first IPIs study, and more than half of schoolchildren were infected with parasite species in the Moung Russey District of Battambang Province. We found nine parasite species, including helminths and protozoa, and pathogenic protozoa were the main source of IPIs. The cycle of transmission of these intestinal parasites can be stopped by appropriate personal hygiene education and public health conditions. Public hygiene education, clean water, and sanitation remain a priority. Our research team will continue to provide public hygiene education and diagnostics for parasite detection and help the health center staffs to treat parasitic infections in this area.

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