Prevalence and Health Effects of Intestinal Parasitic Infection in School Children in Satun Province, Thailand: A Cross-Sectional Study

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ABSTRACT

Objective: Intestinal parasitic infection is a major health problem in the southern region of Thailand. Despite an established annual deworming program, many school age children still suffer from parasitic infection. The aim of this study was to investigate the prevalence and health effects of intestinal parasitic infection in school children in Satun Province, Thailand.

Methods: This cross-sectional study was conducted in children aged of 3 to 15 years during the period December 2014 to January 2015. Body mass index and hematocrit measurements were performed. Stool samples were collected for parasite detection by direct examination and concentration technique.

Results: The prevalence of intestinal parasitic infection was 18.42%. *B.hominis* (29%), *Giardia lamblia* (13.3%), *Trichuris trichiura* (13.3%), and hookworm (13.3%) were the most commonly isolated parasites. School KY had the highest rate of intestinal parasitic infection, followed by schools RC, YT, and SD. Rate of soil-transmitted helminthic (STH) infection was highest at school RC, while the highest rate of protozoa infection was found at school KY. Only STH infection was significantly associated with anemia. No significant association was observed between weight status and parasitic infection.

Conclusion: Intestinal parasitic infection continues to be a problem in school children in Satun Province, Thailand. STH infection was found to be significantly associated with anemia. The majority of parasite types detected at each school varied substantially, which may indicate distinctly different sanitation-related problems at each school. Therefore, improvement in personal sanitation and health education should be emphasized at every school in the area to prevent parasitic infection.

Keywords: Prevalence of parasitic infection; intestinal parasites; Thailand; school children (Siriraj Med J 2017;69: 167-174)

INTRODUCTION

One of the major global health issues that primarily affects people living in developing countries is intestinal parasitic infection. Two major groups of parasite found in the human gastrointestinal system are helminths (nematodes, cestodes, and trematodes) and protozoa. Soil-transmitted helminths (STH), including *Ascaris lumbricoides*, *Trichuris trichiura*, *Strongyloides stercoralis*, and hookworm, affect approximately 24% of the world's population and are the most prevalent group of causative pathogens.[1] From a global survey conducted during 1990 to 2010, *A.lumbricoides* infection was found to be the most common STH, followed by *T.trichiura* and hookworm infections.[2] Surveys of soil-transmitted helminthic infection were performed in Thailand at various time points during 2000 to 2015, and those studies found that STH infection continues to be a public health problem, especially in rural and underdeveloped areas.[3,4,5,6,7,8] In some regions,

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including the Southern part of Thailand, up to 50% of the population has been infected with soil-transmitted helminths at least once in their lifetime.[3,5,8,9] Most infected individuals are preschool and school age children. Prolonged infection of STH infection adversely affects the health and development of this vulnerable population. The second most common intestinal parasitic infection is caused by food and waterborne protozoa, including *Blastocystis hominis, Endolimax nana, Giardia lamblia, Entamoeba* spp., *Cryptosporidum* spp., and *Cyclospora cayetanenensis*.[6,10,11,12,13] In Thailand, the prevalence of intestinal protozoa infections was reported to be as high as 80% in some areas.[10,12,14,15] Infection with pathogenic intestinal protozoa can cause serious symptoms, such as abdominal pain, watery diarrhea, and dehydration. In children, severe infection may even lead to death. Therefore, the surveillance of intestinal parasitic infection in children should be regularly conducted.

Factors that promote parasitic infection are lack of good sanitation, poor personal hygiene, and inaccessibility to clean food and water. Soil-transmitted helminth infection is the most prevalent in the southern region of Thailand due to its year-round warm and humid climate.[3,5,8,10] Although an annual deworming program was implemented, people living in Thailand's southern region, particularly preschool and school children, continue to be afflicted with intestinal parasitic infection.[8,10] Current data regarding the prevalence and health effects of intestinal parasitic infection among school children in Southern Thailand will help in the development and implementation of targeted prevention and control strategies to eradicate intestinal parasitic infection in this high-risk population.

Accordingly, the aim of this study was to investigate the prevalence and health effects of intestinal parasitic infection in school children in Satun Province, Thailand.

MATERIALS AND METHODS

Study area

This cross-sectional study was conducted at 4 different schools located in the southern region of Thailand in children during the study period December 2014 to January 2015. All 4 schools are located within Satun Province.

Sample population

The sample size was calculated using the infinite population proportion formula $Z^2_{1-\alpha/2}\, p(1-p) / d^2$, where prevalence of intestinal parasites from previous study (p) was 12.6%[6], and allowable error and type I error (α) were 0.03 and 0.05, respectively. Calculation yielded a sample size of 471 students. Recruitment was increased by 7% to compensate for reversal in decision to participate and missing data. Based on these sample size criteria, a total of 505 preschool or school age children were required for this study.

Subjects and specimen collection

The protocol for this study was approved by the Siriraj Institutional Review Board (SIRB), Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand (approval no. Si 350/2016). The director of each school was formally contacted and informed by official letter. The parent(s) or guardian(s) of all student participants were informed prior to the study. The examination of student health is a part of the annual check-up program performed regularly. Waiver of written informed consent was approved by the IRB. Five hundred and five students from 4 different schools in Satun Province, Thailand voluntarily participated in this study. Participants were aged from 3 to 15 years. After receiving proper instruction, each student was given a labelled plastic container to collect feces one day prior to the examination. Physical examination, including body weight, height measurement, and blood drawn to measure hematocrit level, was performed by physicians. Students found to have intestinal parasitic infection by onsite microscopic examination were provided appropriate medication for treatment.

Stool examination

Stool samples were microscopically examined by simple smear for parasite detection by medical laboratory technologists at the study sites. Residual stool samples were then transported on ice to the Parasitology Laboratory, Department of Parasitology, Siriraj Hospital for analysis by quantitative formalin-ethyl acetate concentration (QFEC) technique. The species of parasites found in stool specimens by both simple smear and QFEC methods were reported.

Hematocrit and body mass index measurements

Blood samples were collected for hematocrit measurement. Anemia was diagnosed using World Health Organization (WHO) anemic cut points for children according to age.[16] Body mass index (BMI) was calculated by dividing body weight in kilograms by the square of body height in meters. BMI status was obtained by comparing individual BMI to the body mass index-for-age percentile (growth) charts for boys and girls aged 2 to 20 years provided by the US Centers of Disease Control (CDC).[17] BMIs below the 5th and above the 95th percentiles were considered as underweight and overweight, respectively.

Statistical analysis

Data analysis was performed using SPSS Statistics version 18 (SPSS, Inc., Chicago, IL, USA). Demographic data was analyzed using descriptive statistics. Results were expressed as frequency and percentage or mean ± standard deviation. Association between demographic, anthropometric, and clinical factors and parasitic infection was assessed using Pearson's chi-square test or Fisher's exact test. A *p*-value less than 0.05 was considered to be statistically significant.

RESULTS

Overall prevalence of intestinal parasitic infection

A total of 505 students with a mean ± standard deviation age of 8.8±2.5 years participated in this study. Baseline demographic and clinical characteristics of study participants are shown in Table 1.

TABLE 1. Baseline characteristics of school age children participated in the study.

Baseline characteristics	Total (n = 505)	KY (n = 72)	RC (n = 269)	SD (n = 63)	YT (n = 101)
	n (%) or mean (SD)				
Sex					
Male	254 (50.3%)	33 (45.8%)	134 (49.8%)	31 (49.2%)	56 (55.4%)
Female	251 (49.7%)	39 (54.2%)	135 (50.2%)	32 (50.8%)	45 (44.6%)
Age (years)					
3 – 5	77 (15.2%)	19 (26.4%)	N/A	13 (20.6%)	25 (24.8%)
6 – 11	264 (52.3%)	46 (63.9%)	85 (31.6%)	41 (65.1%)	67 (66.3%)
≥ 12	164 (32.5%)	7 (9.7%)	184 (68.4%)	9 (14.3%)	9 (8.9%)
Weight status	**n = 327**	**n = 72**	**n = 104**	**n = 55**	**n = 96**
BMI (kg/m^2)	16.8 ± 3.2	16.8 ± 3.0	16.3 ± 2.5	16.5 ± 3.2	17.5 ± 3.9
Underweight (< 5th percentile)	26 (8%)	7 (9.7%)	13 (12.5%)	2 (3.6%)	4 (4.2%)
Normal weight (between 5th-95th percentile)	279 (85.3%)	61 (84.7%)	88 (84.6%)	51 (92.7%)	79 (82.3%)
Overweight (>95th percentile)	22 (6.7%)	4 (5.6%)	3 (2.9%)	2 (3.6%)	13 (13.5%)
Blood concentration	**n = 320**	**n = 67**	**n = 101**	**n = 56**	**n = 96**
Hct (%)	38.4 (3)	39.1 (2.6)	37.2 (3.2)	38.9 (2.8)	39 (2.7)
Anemic	21 (6.6%)	2 (3%)	14 (13.9%)	2 (3.6%)	3 (3.1%)
Nonanemic	299 (93.4%)	65 (97%)	87 (86.1%)	54 (96.4%)	93 (96.9%)
Number of parasitic infection					
Parasite free	412 (81.6%)	36 (50%)	226 (84%)	62 (98.4%)	88 (87.1%)
Single infection	73 (14.5%)	25 (34.7%)	34 (12.6%)	1 (1.6%)	13 (12.9%)
Coinfection with 2 parasites	12 (2.4%)	5 (7%)	7 (2.6%)	0 (0%)	0 (0%)
Coinfection with 3 parasites	8 (1.6%)	6 (8.3%)	2 (0.7%)	0 (0%)	0 (0%)
Parasitic infection					
Helminthic infection	28 (5.5%)	0 (0%)	26 (9.7%)	1 (1.6%)	1 (1%)
Protozoa infection	61 (12.1%)	34 (47.2%)	15 (5.6%)	0 (0%)	12 (11.8%)
Coinfection with helminths and protozoa	4 (0.8%)	2 (2.8%)	2 (0.7%)	0 (0%)	0 (0%)

The overall prevalence of intestinal parasitic infection was 18.4%, as shown in Table 1. Protozoa infection was found in 12.1% of students, and 5.5% of students had confirmed helminthic infection. Less than 1% of students had combined helminth and protozoa infection. A statistically significant association was observed between student age group and parasitic infection (p=0.02). Children aged 6 to 11 years had the highest prevalence of parasitic infection at 58.2% (95% CI: 52-64.5), as compared to 28.6% (95% CI: 22.5-34.7) and 13.2% (95% CI, 4.4-22) in the ≥12 age group and 3-5 year age group, respectively. School KY had the highest prevalence (50%) of intestinal parasitic infection, followed by schools RC (16%), YT (13%), and SD (1.6%), respectively.

The most frequent parasite found was *Blastocystis hominis* (29%), followed by *Giardia lamblia* (13.3%), hookworm (13.3%), *Trichuris trichiura* (13.3%), *Endolimax nana* (11.7%), *Entamoeba coli* (5.8%), *Entamoeba histolytica/dispar* (5%), *Ascaris lumbricoides* (3.3%), *Strongyloides stercoralis* (1.7%), *Iodamoeba buetschlii* (1.7%), *Enterobius vermicularis* (0.8%), and *Hymenolepis nana* (0.8%), respectively Table 2.

Type and number of parasitic infections found at each school

There was a statistically significant difference between schools regarding the types of parasitic infection (p<0.001). Protozoa were found in 34 of 72 (47.2%) students attending school KY Table 1. *B.hominis* was the most frequent type of protozoa, affecting 18 of 72 students (25%). Other protozoa, including *G.lamblia, E.nana, E.coli, E.histolytica/dispar,* and *I.buetschlii,* were detected in 15.2%, 13.9%, 7%, 7%, and 2.8% of students, respectively. Only 2 types of helminths [*A.lumbricoides* (1.3%) and *T.trichiura* (1.3%)] were found in stool samples from school KY Table 2.

Helminth infection was most prevalent at school RC, infecting 26 of 269 (9.7%) children. Of those helminths, hookworms were the most common, affecting 5.6% of students at that school. Prevalence of *T.trichiura, A.lumbricoides, S.stercoralis, E.vermicularis,* and *H.nana* was 5.2%, 1.1%, 0.7%, 0.4%, and 0.4%, respectively. Other types of protozoa, including *B.hominis* (3.7%), *G.lamblia* (1.1%), *E.nana* (1.1%), and *E.histolytica/dispar* (0.4%), were also found at school RC Table 2.

Regarding school YT, *B.hominis* (6.9%) was the most prevalent infection, followed by *G.lamblia* (2%), *E.coli* (2%), and *E.nana* (1%). Only one case of hookworm infection (1%) was discovered from school YT stool samples Table 2.

TABLE 2. Types of parasitic infection (helminths and protozoa) found in each school are categorized into 2 groups. The number and percentage represents parasites detected in stool samples from each school.

School	Hookworm	*T.trichiura*	*A.lumbricoides*	*S.stercoralis*	*E.vermicularis*	*H.nana*	*B.hominis*	*G.lamblia*	*E.nana*	*E.coli*	*E.histolytica*	*I.buetschlii*
KY (n=72)	0	1 (1.4%)	1 (1.4%)	0	0	0	18 (25%)	11 (15.2%)	10 (13.9%)	5 (7%)	5 (7%)	2 (2.8%)
RC (n=269)	15 (5.6%)	14 (5.2%)	3 (1.1%)	2 (0.7%)	1 (0.4%)	1 (0.4%)	10 (3.7%)	3 (1.1%)	3 (1.1%)	0	1 (0.4%)	0
SD (n=63)	0	1 (1.4%)	0	0	0	0	0	0	0	0	0	0
YT (n=101)	1 (1%)	0	0	0	0	0	7 (6.9%)	2 (2%)	1 (1%)	2 (2%)	0	0
Total (n=505)	**16 (3.2%)**	**16 (3.2%)**	**4 (0.8%)**	**2 (0.4%)**	**1 (0.2%)**	**1 (0.2%)**	**35 (6.9%)**	**16 (3.2%)**	**14 (2.8%)**	**7 (1.4%)**	**6 (1.2%)**	**2 (0.4%)**

Interestingly, only one case of *T.trichiura* infection (1.6%) was observed in school SD students, and none of the students at that school were infected with protozoa. Of the 4 schools that we evaluated, school SD and school KY had the lowest and highest rates of parasitic infection, respectively Table 2.

Individuals with intestinal parasite infection were categorized into 3 groups, as follows: single infection, double co-infection, or triple co-infection. Four percent of all infected students had infection with two or more parasites. By proportion, 2.4% and 1.6% of students were infected with two and three parasites, respectively Table 1. Interestingly, there was a strong significant association between multiple infection and school ($p<0.001$). At school KY, 4/53 (7.5%) students had double co-infection and 6/53 (11.3%) of students had triple co-infection. At school RC, 7/53 (13.2%) of students had double co-infection and 2/53 (3.8%) students had triple co-infection. Multiple infection was not observed at schools SD or YT Table 1. Of note, the types of parasites found in the majority of cases of multiple infection are transmitted via the same routes, as illustrated in Table 3.

TABLE 3. Parasite species detected in school with multiple infection. Double and triple co-infections are shown.

School	Double infection species			Mode of transmission
School KY	*G.lamblia*	*E.nana*		Both W/FB
	B.hominis	*E.nana*		Both W/FB
	B.hominis	*I.buetschlii*		Both W/FB
	T.trichiura	*E.histolytica*		ST and W/FB
School RC	Hookworm	*S.stercoralis*		Both ST
	*Hookworm	*T.trichiura*		Both ST
	A.lumbricoides	*T.trichiura*		Both ST
	B.hominis	*E.nana*		Both W/FB
	Hookworm	*B.hominis*		ST and W/FB
	T.trichiura	*B.hominis*		ST and W/FB
School	**Triple infection species**			**Mode of transmission**
School KY	*G.lamblia*	*E.coli*	*E.histolytica*	All W/FB
	G.lamblia	*E.coli*	*B.hominis*	All W/FB
	**B.hominis*	*E.nana*	*E.histolytica*	All W/FB
	E.nana	*E.coli*	*I.buetschlii*	All W/FB
	B.hominis	*G.lamblia*	*E.nana*	All W/FB
School RC	Hookworm	*T.trichiura*	*S.stercoralis*	All ST
	Hookworm	*T.trichiura*	*A.lumbricoides*	All ST

*The frequency of this co-infection is 2. The frequency of all other co-infections is 1.
Abbreviations: W/FB water or Food-Borne, ST soil-transmitted

Association between schools and mode of transmission

Parasites found in infected individuals were classified by mode of transmission into the 3 following groups: soil-transmitted, food/water-borne, and fecal-borne. Hookworm, *T.trichiura, A.lumbricoides*, and *S.stercoralis* were classified as soil-transmitted helminths. Food/water-borne protozoa included *B.hominis, G.lamblia, E.nana, E.coli, E.histolytica, I.buetschlii,* and *E.vermicularis. H.nana* was classified as a fecal-borne helminth. The association between schools and mode of transmission was found to be statistically significant ($p<0.001$). Among the 4 studied schools, school KY had the highest percentage (96.3%) of food/waterborne protozoa infection. The majority of parasites (64%) found at school RC were soil-transmitted. Approximately 32% and 4% of parasites found at school RC were food/water-borne and fecal-borne, respectively.

The prevalence of parasitic infection at school SD was very low, with the identification of only one food/water-borne protozoa Fig 2.

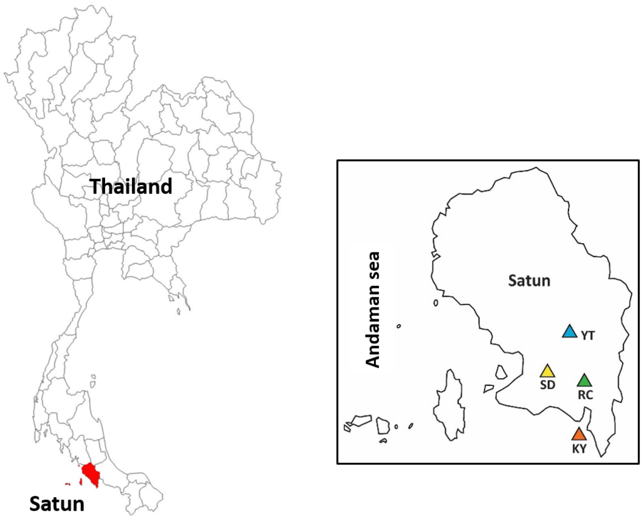

Fig 1. Locations of schools KY, RC, SD and YT within Satun Province, Thailand. School KY is located on an island that is a part of Satun Province.

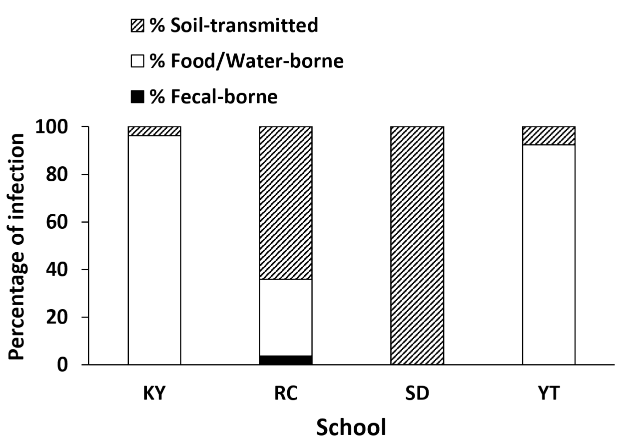

Fig 2. Percentage of parasitic infection at each school by mode of transmission.

Effects of parasitic infection on health status

Parasitic infection has vast, yet silent adverse effects on child well-being. We, therefore, set forth to investigate the relationship between parasitic infection and both anemia and growth by measuring hematocrit and body mass index (BMI). Significant association was found between type of parasitic infection and anemia (p=0.003). Approximately 28% of individuals who had helminthic infection were anemic. However, anemia was found in only 4.3% of protozoa-infected and 5.5% of parasite-free individuals. No significant association was observed between parasitic infection and child growth status (p=0.58 and p=0.48). Moreover, no significant correlation between multiple parasitic infection and anemic status or low BMI was found.

DISCUSSION

Children in the southern region of Thailand are at risk of contacting intestinal parasitic infection. Although a deworming program was initiated among schools in the study area, the rate of infection remains high. It is, therefore, necessary to continue surveillance to determine the current prevalence of infection in endemic areas. We found that about 18% of the children in this study were infected with at least one parasite, which was lower than estimated 24% prevalence in the study area.[2,3,5] Most children in this study were infected with protozoa (12.1%), while 5.5% were found to be infected with helminths. A possible explanation for this difference between the current study and others is that the deworming program initiated in the area might have been effective in reducing STH infection. Agents used to eliminate helminths have no effect on protozoa.

We also observed that the prevalence and types of parasitic infection varied widely among schools. The prevalence of parasitic infection was nearly 50% in school KY, while only 16% and 13% of students at schools RC and YT were infected. Only one student at school SD had parasitic infection. This suggested that hygiene, sanitation, and environment varied greatly among the 4 schools evaluated in this study. Type of parasite and mode of transmission data from this study may help to reveal school-specific vulnerabilities and shortcomings that can be corrected to reduce the prevalence of infection in this area.

Interestingly, school KY is located on a small island that receives its water supply from a single rainwater reservoir. Boiling water before drinking was not usually performed. Given that the highest prevalence of food/waterborne protozoa infection was found at this school, problems with its water supply should be suspected as the primary cause of infection. In addition to treating infected individuals, modernization of the water supply and sewage systems on the island should be funded. Additionally, proper water treatment methods, such as boiling of water and water filtration, should be taught to residents of the island so they know and understand safe methods of how to prepare drinking water. Additional mitigation efforts at school KY should include ongoing education of children regarding how to prevent reinfection by intestinal protozoa.

In contrast to the predominance of protozoa infection at school KY, soil-transmitted helminthic infection was found to be the cause of infection at school

RC. Transmission of this group of parasites occurs via consumption of soil-contaminated food that contains infective parasites or via skin penetration of parasite larvae. Remarkably, school RC is a boarding school that has the largest student population of all of the 4 included schools. Student overcrowding may contribute to a high rate of infection and/or reinfection. Important preventative measures include training students to wash their hands regularly and to wear clean, properly washed clothing. Other measures include the training of food preparation staff to wash fruits and vegetables thoroughly, and to cook meats and other food dishes well in order to kill any existing helminthic organisms.

We also observed a significant association between helminthic infection and anemia, but no correlation was observed between infection and low BMI.

This study has some mentionable limitations. First, parasitic infection intensity measurement by Kato Katz or other methods was not performed in any of the samples collected in this study. Second, other confounding factors that could affect hematocrit level, such as nutritional status (ferrous, folic, and B12 levels) and parasite infection intensity, were not adjusted for in our analysis. It was, therefore, possible that anemia found in helminth-infected individuals might not be directly related to helminth infection. Third, the results of this study were based on a single stool examination which gave a sensitivity around 76%.[18,19] However, examination of 2 to 3 specimens on alternate days can increase the sensitivity of detection up to 92%.[18,19] The sensitivity of detection might have been improved if stool examination had been performed more than one time. Fourth, no significant association was observed between multiple parasitic infections and anemic status or BMI. It is possible that parasitic infection intensity or chronicity in this population was not high enough to effectuate serious effect on the hosts. However, it is difficult to arrive at a conclusion regarding this matter, because parasitic burden (parasites/gram of feces) was not assessed in this study. Further study assessing risk factors that contribute to parasitic infection, such as personal sanitation and food hygiene, should be performed.

Intestinal parasitic infection continues to be a problem in school children in Satun Province, Thailand. STH infection was found to be significantly associated with anemia. The majority of parasite types detected at each school varied substantially, which may indicate distinctly different sanitation-related problems at each school. Therefore, improvement in personal sanitation and health education should be emphasized at every school in the area to prevent parasitic infection.

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Conflict of Interest Declaration

The authors hereby declare no personal or professional conflicts of interest regarding any aspect of this study.

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REFERENCES

1. World Health Organization. Soil-transmitted Helminth Infections; 2017. Available from: http://www.who.int/mediacentre/factsheets/fs366/en/
2. Brooker S, Clements AC, Bundy DA. Global epidemiology, ecology and control of soil-transmitted helminth infections. Adv Parasitol 2006;62:221-61.
3. Anantaphruti MT, Jongsuksuntigul P, Imsomboon T, Nagai N, Muennoo C, Saguankiat S, et al. School-based helminthiases control: I. A baseline study of soil-transmitted helminthiases in Nakhon Si Thammarat Province, Thailand. Southeast Asian J Trop Med Public Health 2002;33 Suppl 3:113-9.
4. Anantaphruti MT, Waikagul J, Maipanich W, Nuamtanong S, Pubampen S. Soil-transmitted helminthiases and health behaviors among schoolchildren and community members in a west-central border area of Thailand. Southeast Asian J Trop Med Public Health 2004;35(2):260-6.
5. Brooker S, Singhasivanon P, Waikagul J, Supavej S, Kojima S, Takeuchi T, et al. Mapping soil-transmitted helminths in Southeast Asia and implications for parasite control. Southeast Asian J Trop Med Public Health 2003;34(1):24-36.
6. Warunee N, Choomanee L, Sataporn P, Rapeeporn Y, Nuttapong W, Sompong S, et al. Intestinal parasitic infections among school children in Thailand. Trop Biomed 2007;24(2):83-8.
7. Boonjaraspinyo S, Boonmars T, Kaewsamut B, Ekobol N, Laummaunwai P, Aukkanimart R, et al. A cross-sectional study on intestinal parasitic infections in rural communities, northeast Thailand. Korean J Parasitol 2013;51(6):727-34.
8. Kaewpitoon SJ, Loyd RA, Kaewpitoon N. A Cross-Sectional Survey of Intestinal Helminthiases in Rural Communities of Nakhon Ratchasima Province, Thailand. J Med Assoc Thai 2015;98 Suppl 4:S27-32.
9. Anantaphruti MT, Nuamtanong S, Muennoo C, Sanguankiat S, Pubampen S. Strongyloides stercoralis infection and chronological changes of other soil-transmitted helminthiases in an endemic area of southern Thailand. Southeast Asian J Trop Med Public Health 2000;31(2):378-82.

10. Kitvatanachai S, Rhongbutsri P. Intestinal parasitic infections in suburban government schools, Lak Hok subdistrict, Muang Pathum Thani, Thailand. Asian Pac J Trop Med. 2013 Sep;6(9): 699-702.
11. Wongjindanon N, Suksrichavalit T, Subsutti W, Sarachart T, Worapisuttiwong U, Norramatha P. Current infection rate of Giardia lamblia in two provinces of Thailand. Southeast Asian J Trop Med Public Health. 2005;36 Suppl 4:21-5.
12. Saksirisampant W, Boontanom P, Mungthin M, Tan-Ariya P, Lamchuan D, Siripattanapipong S, et al. Prevalence of giardiasis and genotypic characterization of Giardia duodenalis in hilltribe children, Northern Thailand. Trop Biomed 2012;29(3):331-8.
13. Thima K, Mori H, Praevanit R, Mongkhonmu S, Waikagul J, Watthanakulpanich D. Recovery of Cyclospora cayetanensis among asymptomatic rural Thai schoolchildren. Asian Pac J Trop Med 2014;7(2):119-23.
14. Dib HH, Lu SQ, Wen SF. Prevalence of Giardia lamblia with or without diarrhea in South East, South East Asia and the Far East. Parasitol Res 2008;103(2):239-51.
15. Jantermtor S, Pinlaor P, Sawadpanich K, Pinlaor S, Sangka A, Wilailuckana C, et al. Subtype identification of Blastocystis spp. isolated from patients in a major hospital in northeastern Thailand. Parasitol Res 2013;112(4):1781-6.
16. World Health Organization. Iron deficiency anaemia. Geneva, Switzerland; 2011. Available from: http://www.who.int/nutrition/publications/en/ida_assessment_prevention_control.pdf
17. National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion. Girls body mass index-for-age percentiles: 2 to 20 years. Georgia, Atlanta, USA 2002. Available from: http://www.cdc.gov/growthcharts.
18. Cartwright CP. Utility of multiple-stool-specimen ova and parasite examinations in a high-prevalence setting. J Clin Microbiol 1999;37(8):2408-11.
19. Marti H, Koella JC. Multiple stool examinations for ova and parasites and rate of false-negative results. J Clin Microbiol 199331(11):3044-5.