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The prevalence of intestinal helminth infection in rural subdistricts of northeastern Thailand

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Abstract. This study aimed to determine the prevalence and intensity of intestinal helminth infections (IHIs) among rural villagers in Waeng Noi district, Khon Kaen Province, northeastern Thailand. A cross-sectional study was conducted between March 1 and July 30, 2018, among rural villagers from 30 rural villages in 2 subdistricts. The participants were selected from the village enrollment list after proportional allocation of the total sample size. The background characteristic data were collected using a structured questionnaire. Specimens from patients with IHIs were prepared by concentration with a Faecal Parasite Concentrator–Solvent-Free (Mini Parasep® SF), and helminths were then detected using a light microscope. Of the 400 faecal specimens examined, 23 were positive for at least one intestinal helminth, resulting in a prevalence of 5.75%. The most prevalent helminths were *Taenia* spp., 10 (2.50%); followed by hookworm, 5 (1.25%); *Trichuris trichiura*, 4 (1.0%); *Ascaris lumbricoides*, 3(0.50%); and *Opisthorchis viverrini*, 1 (0.25%). All infected participants had a light intensity of IHI. Location (adjusted OR=2.52; 95% CI=1.30–3.52; P =0.042) showed a significant association with the prevalence of intestinal helminths. This study reveals that IHIs, particularly those with food-borne and soil-transmitted species of helminths, are prevalent in adults in rural subdistricts. A greater focus on interventions to improve personal hygiene and sanitation to prevent the spread of IHIs is required. Further studies should be performed to implement interdisciplinary research approaches in the study area.

INTRODUCTION

Intestinal helminth infections are considered neglected tropical diseases (NTDs). Statistics indicate that more than 1.5 billion people, or 24% of the world's population, are infected with soil-transmitted helminths (STHs). Infections are widely distributed in tropical and subtropical areas, with the greatest numbers occurring in sub-Saharan Africa, the Americas, China and East Asia (World Health Organization, 2018). In the ASEAN countries, it is estimated that 300 million people are infected with IHIs caused by STHs that are also known as geohelminths; specifically, 126.7 million people are infected with *Ascaris lumbricoides*, 115.3 million are infected with *Trichuris trichiura*, and 77.0 million have hookworm infections (Hotez *et al.*, 2015). Humans become infected by the accidental ingestion of eggs at infective stages or through the penetration of the skin by infected larvae in soil, depending on the nematode species. People with infections of heavier intensity can exhibit a range of symptoms, including intestinal manifestations, abdominal pain and diarrhea, general malaise and weakness, malnutrition, and impaired growth and physical development. Infections of very high intensity can cause intestinal obstruction that should be treated surgically. Patients with a light infection intensity usually do not suffer from the infection (World Health Organization, 2018). The global target is to eliminate morbidity due to STHs in children by 2020. This goal will be attained by regularly treating at least 75% of children in endemic areas (an estimated 836 million in 2016) (World Health Organization, 2018). More than 10 million people in ASEAN countries (particularly Thailand, Lao's People Democratic Republic, Cambodia, and Vietnam) suffer from either liver or intestinal fluke infections caused by foodborne helminths (FBHs) (Hotez *et al.*, 2015). The liver flukes *Opisthorchis viverrini* and *Clonorchis sinensis* are classified as group 1 carcinogens by the World Health Organization's International Agency for Research on Cancer (International Agency for Research on Cancer, 2011). *O. viverrini* infection is associated with cholangitis, gallstones, hepatomegaly, cholecystitis, and cholangiocarcinoma (CCA) (Thamavit *et al.*, 1978; Harinasuta *et al.*, 1984; Jongsuksuntigul and Imsomboon, 2003; Sripa *et al.*, 2007; Sripa, 2008; Shin *et al.*, 2010; Feng and Cheng, 2017). Infection by these liver flukes is rarely diagnosed in early stages and is thus frequently asymptomatic. Persistent and chronic infection can cause severe cancer complications, particularly CCA and other gastroenterological diseases (Wongsaroj *et al.*, 2014).

In 2014, the national prevalence rate of IHIs was 18.1% among 15,555 Thais, with a high prevalence rate of liver fluke and hookworm infections in certain areas of the country. There is an urgent need to expand surveillance activities in rural areas of Thailand and to ensure that mass drug administration is provided to populations at risk for intestinal helminth and fluke infections. With prominent research institutions and universities and their regional offices, participating organizations could implement important public health improvements through NTD control and elimination in the coming decade (Suntaravitun and Dokmaikaw, 2014; Hotez *et al.*, 2015).

Various parts of the country still have a high prevalence of intestinal helminth and fluke infections, especially *O. viverrini* infection, which is high in northeast Thailand, where the traditional practice of eating raw or undercooked cyprinoid fish products continues. Meanwhile, penetrating hookworm and *Strongyloides stercoralis* infection remains high in southern Thailand, particularly in wetland rural areas, where a large proportion of the community works in agriculture. Previous studies have assessed the prevalence of *O. viverrini* infection among villagers in the border areas of three provinces in northeastern Thailand. In the 978 participants screened, *O. viverrini* infection was found in 1.74%, and the majority of positive cases were found in participants who lived in the Khon Sawan district (8.43%). There was no infection in Waeng Noi district, Khon Kaen Province (Kaewpitoon *et al.*, 2016). From this updated report, no information was available regarding the prevalence and intensity of IHIs among the residents at the subdistrict level in Waeng Noi district, Khon Kaen Province. Consequently, this study was undertaken to determine the prevalence and intensity of IHIs among people living in the Lahan Na and Kan Lueang subdistricts, Waeng Noi district, Khon Kaen Province, in the northern region of Thailand. These data are useful for further intervention and research approaches in the study area.

MATERIALS AND METHODS

Ethics statements

This study was approved by the Ethics Committee for Research Involving Human Subjects of Suranaree University of Technology, Thailand (EC- 59-38).

Study design and area

A cross-sectional survey was carried out from March to July 2018 and included people living in 30 rural villages located in the Lahan

Na (16 villages) and Kan Lueang (14 villages) subdistricts, Waeng Noi district, Khon Kaen province, northeastern Thailand. The study area is located 377 km northeast of Bangkok and covers an area of 99.30 km^2, with a geographical location of 15°482133 N, 102°242573 E (Figure 1). Participants were selected from each village using a voluntary sampling method. A total of 400 volunteers were recruited. Data on sociodemographic characteristics were collected using a questionnaire. All participants provided their own written consent before submitting stool specimens.

Faecal collection and examination

Clean plastic containers were distributed to the participants at enrollment with detailed instructions about the procedure for faecal specimen collection. All faecal samples were collected early in the morning and stored in coolers before transportation to the laboratory at the Parasitic Disease Research Center (PDRC), Institute of Medicine, Suranaree University of Technology. Each specimen was prepared and examined for the presence of intestinal helminth organisms by a Faecal Parasite Concentrator–Solvent-Free (Mini Parasep® SF) (Kaewpitoon *et al.*, 2016; Kaewpitoon *et al.*, 2018). Each specimen was examined under a microscope and initially screened with a 10× objective; the magnification of the low, medium, and high power objectives was 4×, 10×, and 40×, respectively. Suspected intestinal helminth objects were subsequently examined under a high-power objective. All samples were examined by two laboratory technologists from the PDRC. Patients who were infected with intestinal helminths and other known parasites were treated with anti-intestinal helminthic drugs and asked to attend health education sessions.

Statistical analysis

Statistical analyses were performed using the computer program STATA for Windows, version 13 (StataCorp LLC, Lakeway Drive, College Station, Texas, USA). The socio-demographic characteristics of the participants are presented as frequencies and percentages for categorical variables. The number of eggs per gram of feces (epg) was calculated as follows: (number of eggs/drop

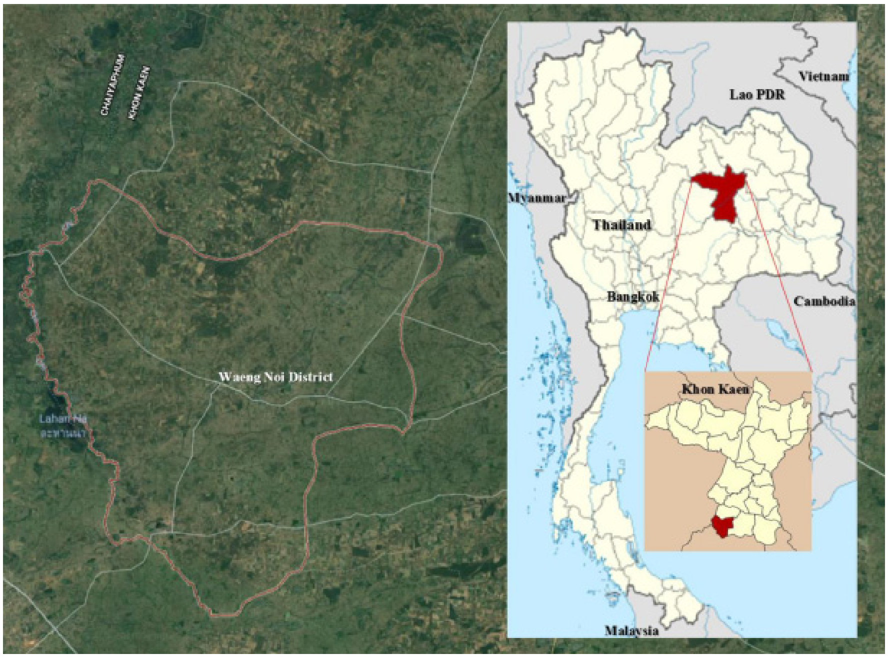

Figure 1. Map of Thailand showing the study area in Waeng Noi district, Khon Kaen Province, Thailand.

× total number of drops of fecal solution)/(g of feces). The intensity of infection was expressed as eggs per gram (epg) of feces for each participant. According to the WHO guidelines, the intensity of infection was classified as "light", "moderate" or "heavy" on the basis of fecal egg count (Elkins *et al.*, 1991; Montresor *et al.*, 1998). The differences in infection between the categorical variables were assessed using the Chi-square test. Multivariable logistic regression analysis was performed to estimate the odds ratios (OR) and 95% confidence intervals (95% CI) to assess the associations between potential risk factors and the prevalence of IHIs. A *P*-value of <0.05 was considered statistically significant.

RESULTS

A total of 400 participants (169 male, 231 female) were included. The overall prevalence of IHIs was 5.75% (23/400). The overall prevalence rate was 8.23% (14/169) in males and 3.9% (9/231) in females. Participants aged 51–60 years had a higher prevalence rate, 7.31% (12/164), than participants in the other age groups. When the participants were classified by education level, the highest prevalence rate was 7.14% (1/14), in those with an academic education. When the participants were classified by occupation, IHIs were most frequent among employed workers, at 19.3% (11/57). A high prevalence of intestinal helminths was found in participants with an income of less than 5,000 Baht/month (7.23%, 22/304). The influence of sociodemographic characteristics on the prevalence of intestinal helminths is shown in Table 1.

Five species of intestinal helminths were identified from the fecal specimens of the study participants; 3 species were identified as STHs, and the other 2 species were FBHs (Figure 2). The prevalence of intestinal helminths was 5.7% (23/400). STHs were among the most common intestinal helminths, including hookworms, at 1.25% (5/400); *T. trichiura*, at 1.0% (4/400); and *A. lumbricoides*, at 0.75% (3/400). FBHs were identified as *Taenia* spp., at 2.50% (10/400); and *O. viverrini*, at 0.25% (1/400); respectively. The types of IHIs are shown in Table 2. The summary of IHI intensity in Table 3 shows that there were no heavy or moderate infections. Of the 23 infected participants, all had light infection with *T. trichiura*, *A. lumbricoides*, *Taenia* spp. or *O. viverrini*.

The socio-demographic characteristics of the participants and IHIs were analyzed for each variable using the Chi-square test; there were no significant differences between the prevalence of intestinal helminths for each characteristic (Table 1). However, sociodemographic characteristics associated with IHIs were analyzed using multivariable logistic regression analysis, as shown in Table 4. No significant association was found between IHIs and the participants' sex, age, educational level, job status, or monthly income (P >0.05). However, one factor, namely, Location (adjusted OR=2.52; 95% CI=1.30–3.52; P =0.042), showed a significant association with the prevalence of intestinal helminths.

DISCUSSION

IHIs are an important public health problem in tropical countries. Unlike in developed countries, where efficient control, urbanization and other socioeconomic factors have created conditions favoring a decline in the prevalence of IHIs, these infections, particularly STHs, which have been recognized as important public health problems in many developing countries, continue to be a major health problem in the third world countries (Chan *et al.*, 1994; Tefera *et al.*, 2017). The public health problems caused by IHIs have been neglected in rural areas of Thailand, where there remains a lack of hygiene and an inadequate supply of sanitary water (Boonjaraspinyo *et al.*, 2013). Studies conducted with participants living throughout Thailand during a national survey of IHIs in Thailand have reported that the overall prevalence of IHIs was 18.1% (Wongsaroj *et*

Table 1. Positive rate of intestinal helminthic eggs categorized by general characteristics (n=400)

Variable	No. Samples, n (%)	No. positive, n (%)	Infection rate (%)	P-value	95% CI
Sex					
Male	169 (42.25)	14 (8.30)	3.50	0.218	1.20-2.33
Female	231(57.75)	9 (3.90)	2.25		
Age (yr)					
21–30	9 (2.25)	2 (22.22)	0.50	0.725	0.26-7.50
31–40	45 (11.25)	3 (6.66)	0.75		
41–50	100 (25.00)	4 (4.00)	1.00		
51–60	164 (41.00)	12 (7.31)	3.00		
> 60	82 (20.50)	2 (2.43)	0.50		
Illiterate					
Education	15 (3.75)	0 (0.00)	0.00		
Primary	282 (70.50)	16 (5.67)	4.00	0.058	0.23-2.37
Secondary	89 (22.25)	6 (6.74)	1.50		
Academic	14 (3.5)	1 (7.14)	0.25		
Job Status					
Employed	57 (14.25)	11 (19.30)	2.75		
Farmer	321 (80.25)	10 (3.11)	2.50	0.548	0.221-2.014
Trade	9 (2.25)	1 (11.11)	0.25		
Housewife	8 (2.00)	0 (0.00)	0.00		
Government officer	1 (0.25)	1 (100.00)	0.25		
Other	4 (1.00)	0 (0.00)	0.00		
Family Income ($, per month)					
≤5,000	304 (76.00)	22 (7.23)	5.5		
5,001-10,000	57 (14.25)	0 (0.00)	0.00	0.832	0.401-4.00
10,001-15,000	10 (2.50)	0 (0.00)	0.00		
15,001-20,000	3 (0.75)	0 (0.00)	0.00		
>20,000	6 (1.5)	1 (16.66)	0.25		
Unknown	20 (5.00)	0 (0.00)	0.00		
Location					
Lahan Na	240 (60.00)	13 (5.41)	3.25	0.332	0.06-2.57
Kan Lueang	160 (40.00)	10 (6.25)	2.50		

Table 2. Intestinal helminth infection among 400 rural villagers in Khon Kaen province, northeastern Thailand. (n=400)

Type of Intestinal Helminth	No. positive	Prevalence (%)
Taenia spp.	10	2.50
Hookworm	5	1.25
Trichuris trichiura	4	1.00
Ascaris lumbricoides	3	0.75
Opisthorchis viverrini	1	0.25
Total	23	5.75

Table 3. Egg counts (eggs per gram of feces) used to describe the intensity of infection (n=400)

Type of Intestinal Helminth	Intensity of infection (egg count per gram)	Level of intensity
Ascaris lumbricoides	73.33	Light
Hookworm	70.40	Light
Taenia spp.	47.20	Light
Opisthorchis viverrini	40.00	Light
Trichuris trichiura	38.50	Light

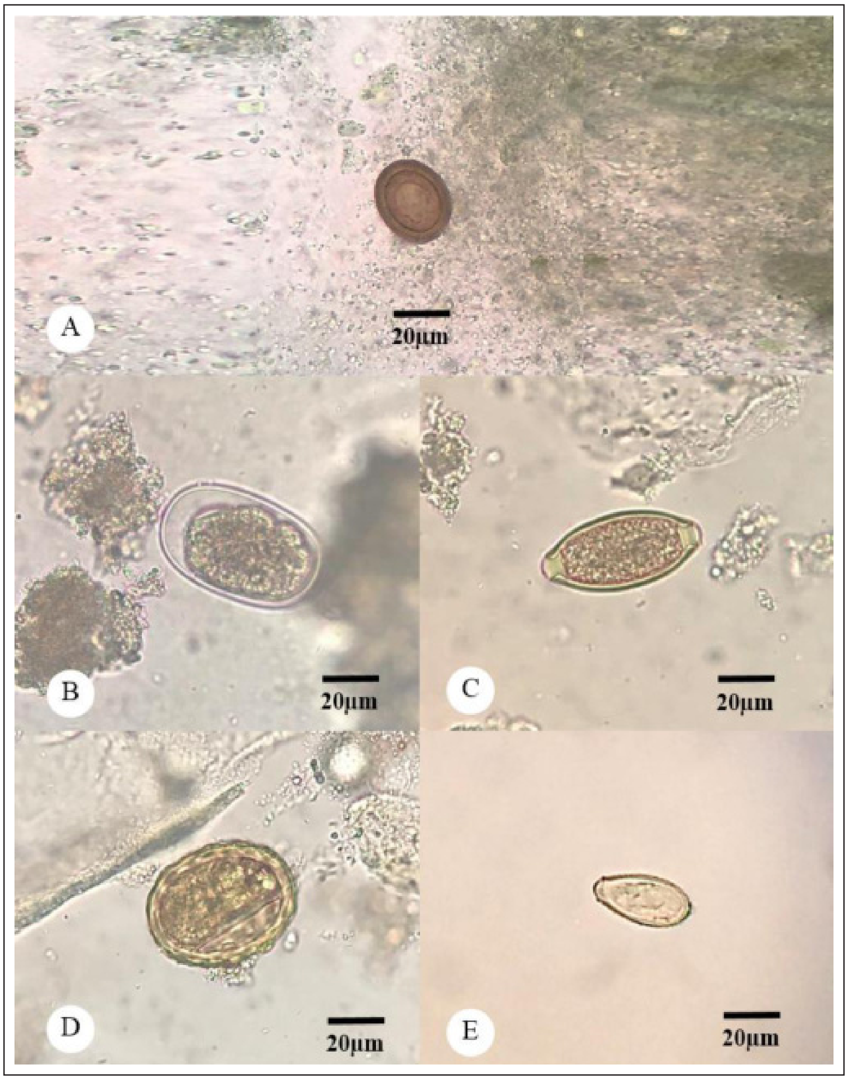

Figure 2. Morphology of intestinal helminth eggs identified by light microscopy in faecal samples. (A) *Taenia* spp. egg (×400). (B) Hookworm egg (×400). (C) *Trichuris trichiura* egg (×400). (D) *Ascaris lumbricoides* egg (×400). (E) *Opisthorchis viverrini* egg (×400).

Table 4. Factors associated with intestinal helminth infection in the multivariable logistic regression analysis

Variables	No. Samples n (%)	No. positive n (%)	Infection rate (%)	*OR	95% CI	*P*-value	**ORadj	95% CI	*P*-value
Sex					0.121			0.060	
Male	169 (42.25)	14 (8.30)	3.50	1.00			1.00		
Female	231 (57.75)	9 (3.90)	2.25	1.51	1.00-2.09		1.65	1.02-2.46	
Age (yr)						0.245			0.411
21 – 30	9 (2.25)	2 (22.22)	0.50	1.00			1.00		
31 – 40	45 (11.25)	3 (6.66)	0.75	0.55	0.56-1.21		0.33	0.03-2.57	
41 – 50	100 (25.00)	4 (4.00)	3.00	1.55	0.06-1.75		3.20	1.05-9.48	
51 – 60	164 (41.00)	12 (7.31)	3.00	1.25	0.03-6.26		3.71	2.50-5.43	
> 60	82 (20.50)	2 (2.43)	2.90	1.49	0.91-1.25		2.10	1.45-2.95	
Education						0.027			0.014
Illiterate	15 (3.75)	0 (0.00)	0.00	1.00			1.00		
Primary	282 (70.50)	16 (5.67)	4.00	0.94	0.59-1.50		4.96	0.65-2.25	
Secondary	89 (22.25)	6 (6.74)	1.50	1.33	0.96-1.75		1.60	0.71-2.41	
Academic	14 (3.5)	1 (7.14)	1.25	0.99	0.77-1.35		1.98	0.23-3.47	
Family Income ($, per month)					0.169			0.141	
≤5,000	304 (76.00)	22 (7.23)	5.5	1.00			1.00		
5,001–10,000	57 (14.25)	0 (0.00)	0.00	0.30	0.03-2.52		0.40	0.14-1.79	
10,001–15,000	10 (2.50)	0 (0.00)	0.00	0.40	0.92-1.21		0.41	0.47-2.09	
15,001–20,000	3 (0.75)	0 (0.00)	0.00	0.21	0.05-1.48		0.23	0.23-2.27	
>20,000	6 (1.5)	1 (16.66)	0.25	3.50	2.35-4.86		3.90	2.65-4.48	
Unknown	20 (5.00)	0 (0.00)	0.00	0.32	0.02-1.28		0.37	0.08-3.15	
Location						0.013			0.042
Lahanna	240 (60.00)	13(5.41)	3.25	1.00			1.00		
Kanlaeng	160 (40.00)	10(6.25)	2.50	2.70	1.02-6.22		2.52	1.30-3.52	

*Crude odds ratio from univariate analysis
**Adjusted odds ratio for all other variables

al., 2014). Here, the overall prevalence of IHIs among the entire tested participant group living in rural communities in the Lahan Na and Kan Lueang subdistricts, Waeng Noi district, Khon Kaen Province was 5.75%. This result was slightly lower or comparable to the findings of a current national survey of IHIs in Thailand. These results were compared to those of other studies, and the recent infection rates reported in these studies were lower than those previously reported among gardeners who were studied in Nakhon Ratchasima (Kaewpitoon *et al.*, 2012), Khon Kaen (Kaewpitoon *et al.*, 2015), and Chachoengsao provinces (Suntaravitun and Dokmaikaw, 2018). Our study demonstrated that STHs and FBHs were found frequently in both sexes. Sex was no significantly associated with the prevalence of intestinal helminths. The infection rate was slightly higher in males than in females. This result was similar to previous findings (Chan *et al.*, 1994; Hotez *et al.*, 2015; Tefera *et al.*, 2017). The sex difference may be due to male-specific behavioral factors (Zuk and Mckean, 1996; Songserm *et al.*, 2012), such as drinking alcohol with colleagues, eating raw meat, and taking risks with their work on the farm (Zuk and Mckean, 1996; Boonjaraspinyo *et al.*, 2013). In our study, the prevalence of IHIs in older people was higher than that in young people (age <51 years). This result is similar to that of previous studies showing that older people need to be screened for IHIs. Suntaravitun and Dokmaikaw (2018) and Boonjaraspinyo *et al.* (2013) reported that the prevalence of IHIs was higher in male participants $\geq$40 years of age than in young people. In addition, Rangsin *et al.* (2009) reported that the prevalence of *O. viverrini* infection was correlated with an age of >60 years. This correlation may arise because older people have poorer education, live in conditions of poor sanitation, and partake in the culturally embedded habit of eating uncooked food (Songserm *et al.*, 2012). Health education programs should target this group and teach the individuals about the benefits of wearing shoes and discontinuing risky eating habits. In the stratification by educational level, the highest prevalence rate was found for those with an academic education. However, many studies indicate that people in the community have a low level of education and a relatively high prevalence of parasites (Chan *et al.*, 1994; Boonjaraspinyo *et al.*, 2013). The highest prevalence rate was found in the academic education group, which may be because of the lower sample size in this group and a lack of credible data. However, health education programs should target this group of individuals with high academic educational levels and teach them about the correct prevention and control of IHIs.

The possible association of IHIs with potential risk factors among the participants was assessed in this study. Location showed a significant association with the prevalence of intestinal helminths. The IHI infection prevalence was higher in the Lahan Na subdistrict than in the Kan Lueang subdistrict. The Lahan Na subdistrict is located on lower land near the Laha Na fresh water reservoir, which covers 11.2 kilometers^2. Our results support the hypothesis that different environmental conditions in the study area favored IHIs, thus influencing the predicted geographical distribution of human infection with these helminth species in Khon Kaen Province, Thailand. Our results indicated that lower elevation was associated with a higher infection rate than higher elevations. Compared to other soil types, loam and clay loam soils are associated with lower odds of *A. lumbricoides* infection, while sandy loam soils are associated with increased odds of *Necator americanus* infection (Wardell *et al.*, 2017). The porosity of sand provides a favorable environment for hookworm survival, offering drainage during wet conditions to prevent hookworm larvae from being waterlogged, while also enabling hookworm larvae to migrate downward to prevent desiccation during hot and dry conditions (Wardell *et al.*, 2017; Brooker and Michael, 2000). Our results are similar to those of previous studies. Villages on higher ground generally had a lower level of opisthorchiasis than those on lower ground, while a significant negative correlation was detected between *O. viverrini* prevalence and farmland with a low water content (P = 0.028), indicating the potential influence of agricultural lands with drought-tolerant crops (Wang *et al.*, 2013). Ribas *et al.* (2017) reported intestinal parasitic infections and environmental water contamination in a rural village of northern Lao's PDR. The level of microbial pathogen contamination was associated with human activity, with greater levels of contamination found at the downstream site than at the village and upstream sites, and the microbial population included several pathogenic microbes that were detected in the local river, a natural water source for consumption in the village. Therefore, more efforts from local administration, particularly health education campaigns for villagers, are required for prevention strategies to minimize IHIs to improve sanitation conditions and consequently the general health of the villagers.

Five species of intestinal helminths were identified from the fecal specimens of the study participants; 3 species were identified as STHs, and the other 2 species were FBHs. However, the infection rate of STHs and FBHs was not significantly different. *Taenia* spp. infection had the highest prevalence in this study, and the prevalence of this was is higher than that reported in a previous study. In a total of 199 fecal samples submitted for routine examination in the clinical pathology laboratory of Suranaree University of Technology Hospital, Nakhon Ratchasima Province, Thailand, from August to October 2015, the prevalence of *Taenia* spp. infection was 0.5% (Kaewpitoon *et al.*, 2016). In addition, in 209 fecal samples analyzed in rural areas of Nakhon Ratchasiam Province, Thailand, and the prevalence of *Taenia* spp. infection was 0.48% (Kaewpitoon *et al.*, 2015). These results indicate that people still have the culturally embedded habit of eating uncooked meat and have poor education. Health education programs should target this group and teach the individuals about risky eating habits. The findings from our study demonstrated that the most prevalent STHs found in human feces were hookworms (1.25%), which were also the most prevalent nematode in the studies in Thailand by Suntaravitun and Dokmaikaw[3], Wongsaroj *et al.* (2014), Kaewpitoon *et al.* (2016), and Boonjaraspinyo *et al.* (2013). Punsawad *et al.* (2017) also reported the prevalence of intestinal parasitic infection and associated risk factors among village health volunteers in rural communities of southern Thailand. These studies showed that hookworm infection is more prevalent than other types of STH infection. This STH has a direct life cycle, and the main route of exposure is contact with larvae-contaminated soil due to a lack of footwear (Ribas *et al.*, 2017). Other STHs with significant prevalence were *T. trichiura* (1.0%) and *A. lumbricoides* (0.75%). The prevalence of infection with these prevalent STHs was lower than that reported in other studies in Thailand, mainly Suntaravitun and Dokmaikaw (2018) reported that the most common intestinal parasites were hookworms (6.7%), followed by *Strongyloides stercoralis*, (5.0%), *A. lumbricoides* (1.3%) and *T. trichiura* (1.3%). Comparison of our current data and the national survey of Thailand in 2014 (Wongsaroj *et al.*, 2014) showed that our study found a slightly higher prevalence of *A. lumbricoides* (0.5%) but lower prevalence of *T. trichiura* (1.2%) than that study. Therefore, preventive measures should be taken to improve the health of the people against such helminths. FBHs were also identified as *Taenia* spp. 2.50% and *O. viverrini* 0.25%, which is concerning because *O. viverrini* is a carcinogenic liver fluke and a serious problem in Thailand. Our data showed a lower prevalence of *O. viverrini* infection than data from previous studies in Thailand. Laoraksawong *et al.* (2018) reported the current prevalence of *O. viverrini* infection in rural communities in the Mueang Khon Kaen district in Khon Kaen Province, northeastern Thailand. The prevalence of *O. viverrini* infection was 19.4%. The previous study demonstrated that the most recent prevalence of *O. viverrini* infection is still high in rural communities in northeastern Thailand. In addition, Kaewpitoon *et al.* (2018) reported that the prevalence of *O. viverrini* infection among a rural Thai population of 560 individuals from Nakhon Ratchasima, Khonkaen, and Chaiyaphum provinces was found to be 2.86%. Kaewpitoon *et al.* (2016) also reported that *O. viverrini* infection was found in people in the border areas of three provinces in northeastern Thailand, including Kaeng Sanam Nang district of Nakhon Ratchasima Province, Waeng Noi district of Khon Kaen Province, and Khon Sawan district of Chaiyaphum Province, Thailand. Of the total of 978 participants screened, *O. viverrini* infection was found in 1.74%. These results indicate that *O. viverrini* is still a problem in Thailand; these liver flukes still exist, which raises concerns regarding public health. The intensity of the IHIs shows that there were no heavy or moderate infections. Of the 23 infected participants, all had light infection with *T. trichiura*, *A. lumbricoides*, *Taenia* spp. or *O. viverrini*. These results indicated that the majority of the participants had a light infection by STHs and FBHs. None of the participants had a heavy IHI. The light intensity of IHIs in the present study may be due to differences in the study population, general living conditions, and the accessibility of health services. In general, the majority of people infected with IHIs have a light infection intensity and have no symptoms. The participants who were infected with these IHIs were informed and treated following the Centers for Disease Control and Prevention recommendations regarding the types of IHIs. In Thailand, the cost of anti-parasitic drugs is generally low (Suntaravitun and Dokmaikaw *et al.*, 2018; Boonjaraspinyo *et al.*, 2013; Punsawad *et al.*, 2017).

In this study, we used the Mini Parasep® SF, a new diagnostic tool used to detect intestinal parasitic infections. This method is simple and useful for isolating and identifying helminth eggs and larvae and protozoal cysts. The closed concentration system allows the rapid, reliable, and safe detection of intestinal parasites by inexperienced technologists (Saez *et al.*, 2011; Useh *et al.*, 2011; Zeeshan *et al.*, 2011). A previous study indicated that the Mini Parasep® SF is suitable for intestinal helminths (Kaewpitoon *et al.*, 2016). However, other studies show that this method, which is used in the field in Thailand, exhibits a low quality of detection for some intestinal helminths, particularly *O. viverrini sensu lato* (Laoprom *et al.*, 2016). This detection method may thus affect and be a limitation of this study. Therefore, a large-scale sample is required for *O. viverrini* infection to prove the advantage of this method.

CONCLUSIONS

In conclusion, our results show a prevalence rate of IHIs among adults living in the rural communities of the Lahan Na and Kan Lueang subdistricts, Waeng Noi district, Khon Kaen Province, northeastern Thailand. These infections result mainly from foodborne helminths and skin-penetrating nematodes. Therefore, interventions should concentrate on the personal hygiene of the population and improving sanitation to reduce IHIs in this area. Further studies and works should be performed with an interdisciplinary research approach, namely, One Health, which is implemented in the study area and includes public health officers, local governors of administrative organizations, village leaders, village health volunteers, veterinary parasitologists, environmentalists, and social scientists, for local public health improvement.

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CONFLICTS OF INTEREST
The authors declare that there are no conflicts of interest.

REFERENCE

Boonjaraspinyo, S., Boonmars, T., Kaewsamut, B., Ekobol, N., Laummaunwai, P., Aukkanimart, R., Wonkchalee, N., Juasook, A. & Sriraj, P. (2013). "A cross-sectional study on intestinal parasitic infections in rural communities, northeast Thailand." *Korean J Parasitol* **51**: 727-734.

Brooker, S. & Michael, E. (2000). "The potential of geographical information systems and remote sensing in the epidemiology and control of human helminth infections In: Hay, S.I., Rogers, D.J. & Randolph, S.E. (2000). Remote sensing and geographical information systems in epidemiology." *Adv Parasitol* **47**: 245-288.

Chan, M.S., Medley, G.F., Jamison, D. & Bundy, D.A. (1994). "The evaluation of potential global morbidity attributable to intestinal nematode infections." *Parasitol* **109**: 373-387.

Elkins, D.B., Sithithaworn, P., Haswell-Elkins, M., Kaewkes, S., Awacharagan, P. & Wongratanacheewin, S. (1991). "*Opisthorchis viverrini*: relationships between egg counts, worms recovered and antibody levels within an endemic community in northeast Thailand." *Parasitol* **102**: 283-288.

Feng, M. & Cheng, X. (2017). "Parasite-associated cancers (blood flukes/liver flukes)." *Adv Exp Med Biol* **1018**: 193-205.

Harinasuta, T., Riganti, M. & Bunnag, D. (1984). "*Opisthorchis viverrini* infection: pathogenesis and clinical features." *Arzneimittelforschung* **34**: 1167-1169.

Hotez, P.J., Bottazzi, M.E., Strych, U., Chang, L.Y., Lim, Y.A., Goodenow, M.M. & AbuBakar, S. (2015). "Neglected tropical diseases among the association of Southeast Asian Nations (ASEAN): Overview and Update.. *PLoS Neglect Trop Dis* **9**: e0003575.

International Agency for Research on Cancer (IARC). "IARC monographs on the evaluation of carcinogenic risks to humans." Lyon: World Health Organization, International Agency for Research on Cancer, 2011.

Jongsuksuntigul, P. & Imsomboon, T. (2003). "Opisthorchiasis control in Thailand." *Acta Trop* **88**: 229-232.

Kaewpitoon, N., Kaewpitoon, S., Meererksom, T., Chan-Aran, S., Sangwalee, W., Norkaew, J., Chuatanam, J., Kujapan, J., Padchasuwan, N., Tongtawee, T., Matrakool, L., Loyd, R. & Wakkhuwatthapong, P. (2018). "Detection of *Opisthorchis viverrini* infection among the ASEAN population in Thailand using a verbal screening test and fecal concentrator kit." *Iran J Parasitol* **13**: 258-266.

Kaewpitoon, N., Kaewpitoon, S., Meererksom, T., Chan-Aran, S., Sangwalee, W., Kujapun, J., Norkaew, J., Chuatanam, J., Ponpimai, S., Pothipim, M., Padchasuwan, N., Tongtawee, T., Matrakool, L., Panpimanmas, S., Loyd, R.A. & Wakkhuwatthapong, P. (2018). "Detection of risk groups for carcinogenic liver fluke infection by verbal screening questionnaire using a mobile application." *Asian Pac J Cancer Prev* **19**: 2013-2019.

Kaewpitoon, S.J., Loyd, R.A. & Kaewpitoon, N. (2015). "A cross-sectional survey of intestinal helminthiases in rural communities of Nakhon Ratchasima province, Thailand." *J Med Assoc Thai* **98**: S27-32.

Kaewpitoon, S.J., Rujirakul, R., Tongtawee, T., Matrakul, L., Panpimanmas, S., Wakkuwattapong, P., Loyd, R.A. & Kaewpitoon, N. (2016). "Detection of the carcinogenic liver fluke *Opisthorchis viverrini* using a mini parasep sf faecal parasite concentrator". *Asian Pac J Cancer Prev* **17**: 373-376.

Kaewpitoon, S.J., Rujirakul, R., Wakkuwattapong, R., Matrakool, L., Tongtawee, T., Panpimanmas, S., Pengsaa, P., Jomkoa, D., Joosiri, A. & Kaewpitoon, N. (2016). "*Opisthorchis viverrini* infection among people in the border areas of three provinces, northeast of Thailand." *Asian Pac J Cancer Prev* **17**: 2973-2977.

Laoraksawong, P., Sanpool, O., Rodpai, R., Thanchomnang, T., Kanarkard, W., Maleewong, W., Kraiklang, R. & Intapan, P.M. (2018). "Current high prevalences of *Strongyloides stercoralis* and *Opisthorchis viverrini* infections in rural communities in northeast Thailand and associated risk factors." *BMC Pub Health* **18**: 940.

Montresor, A., Crompton, D.W.T., Hall, A., Gyorkos, T.W. & Lorenzo, S. 1998). "Guidelines for The evaluation of soil-transmitted helminthiasis and schistosomiasis at community level." Geneva: World Health Organization; 1998. WHO document WHO/CDS/SIP/98. 1 (available from the program parasitic diseases and vector control, World Health Organization, CH1211Geneva 27, Switzerland).

Laoprom, N., Laithavewat, L., Kopolrat, K., Kiatsopit, N., Kaewkes, S., Chantalux, S., Mongkolsin, C., Chanmaha, B., Andrews, R.H., Petney, T.N. & Sithithaworn, P. (2016). "Evaluation of a commercial stool concentrator kit compared to direct smear and formalin-ethyl acetate concentration methods for diagnosis of parasitic infection with special reference to *Opisthorchis viverrini sensu lato* in Thailand". *Southeast Asian J Trop Med Public Health* **47**: 890-900.

Punsawad, C., Phasuk, N., Bunratsami, S., Thongtup, K., Siripakonuaong, N. & Nongnaul, S. (2017). "Prevalence of intestinal parasitic infection and associated risk factors among village health volunteers in rural communities of southern Thailand." *BMC Public Health* **17**: 564.

Rangsin, R., Mungthin, M., Taamasri, P., Mongklon, S., Aimpun, P., Naaglor, T. & Leelayoova, S. (2009). "Incidence and risk factors of *Opisthorchis viverrini* infections in a rural community in Thailand." *Am J Trop Med Hyg* **81**: 152-155.

Ribas, A., Jollivet, C., Morand, S., Morand, S., Thongmalayvong, B., Somphavong, S., Siew, C.C., Ting, P.J., Suputtamongkol, S., Saensombath, V., Sanguankiat, S., Tan, B.H., Paboriboune, P., Akkhavong, K. & Chaisiri, K. (2017). "Intestinal parasitic infections and environmental water contamination in a rural village of northern Lao PDR." *Korean J Parasitol* **55**: 523-532.

Saez, A.C., Manser, M.M., Andrews, N. & Chiodini, P.L. (2011). "Comparison between the midi parasep and midi parasep solvent free (SF) faecal parasite concentrators". *J Clin Pathol* **64**: 901-904.

Shin, H.R., Oh, J.K. & Masuyer, E. (2010). "Epidemiology of cholangiocarcinoma: an update focusing on risk factors." *Cancer Sci* **101**: 579-585.

Songserm, N., Promthet, S., Wiangnon, S. & Sithithaworn, P. (2012). "Prevalence and co-infection of intestinal parasites among Thai rural residents at high-risk of developing cholangiocarcinoma: a cross-sectional study in a prospective Cohort study." *Asian Pac J Cancer Prev* **13**: 6175-6179.

Sripa, B., Kaewkes, S., Sithithaworn, P., Mairiang, E., Laha, T., Smout, M., Pairojkul, C., Bhudhisawasdi, V., Tesana, S., Thinkamrop, B., Bethony, J.M., Loukas, A. & Brindley, P.J. (2007). "Liver fluke induces cholangiocarcinoma." *PLoS Med* **4**: e201.

Sripa, B. (2008). "Concerted action is needed to tackle liver fluke infections in Asia." *PLoS Negl Trop Dis* **2**: e232.

Suntaravitun, P. & Dokmaikaw, A. (2018). "Prevalence of intestinal parasites and associated risk factors for infection among rural communities of Chachoengsao province, Thailand." *Korean J Parasitol* **56**: 33-39.

Tefera, E., Belay, T. & Mekonnen, S.K. (2017). Prevalence and intensity of soil transmitted helminthes among school children of Mendera Elementary School, Jimma, Southwest Ethiopia. *Pan Afr Med J* **27**: 88.

Thamavit, W., Bhamarapravati, N. & Sahaphong, S. (1978). Effects of dimethylnitrosamine on induction of cholangiocarcinoma in *Opisthorchis viverrini*-infected Syrian golden hamsters. *Cancer Res* **38**: 4634-4639.

Useh, M.F., Asuquo, A.E., Otu-Bassey, I.B. & Ubi, O.L. (2011). "Evaluation of the efficacy of the mini parasep sf faecal parasite concentrator; a new technique against the direct smear and formol ether concentration technique for the detection of intestinal parasites in stool". *J Med Lab Sci* **20**: 37-43.

Wang, Y.C., Feng, C.C. & Sithithaworn, P. (2013). "Environmental determinants of *Opisthorchis viverrini* prevalence in northeast Thailand." *Geospat Health* **8**: 111-123.

Wardell, R., Clements, A.C.A., Lal, A., Summers, D., Llewellyn, S., Campbell, S.J., McCarthy, J., Gray, D.J. & V Nery, S. (2017). "An environmental assessment and risk map of *Ascaris lumbricoides* and *Necator americanus* distributions in Manufahi District, Timor-Leste." *PLoS Negl Trop Dis* **11**: e0005565.

Wongsaroj, T., Nithikathkul, C., Rojkitikul, W., Nakai, W., Royal, L. & Rammasut, P. (2014). National survey of helminthiasis in Thailand. *Asian Biomedicine* **8**: 779-783.

World Health Organization. (2018). "Soil-transmitted helminthic infections". Retrieved May 10, 2018, from http://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections, 2018

Zeeshan, M., Zafar, A., Saeed, Z., Irfan, S., Sobani, Z.A., Shakoor, S. & Beg, M.A. (2011). "Use of parasep filter fecal concentrator tubes for the detection of intestinal parasites in stool samples under routine conditions". *Indian J Pathol Microbiol* **54**: 121-123.

Zuk, M. & McKean, K.A. (1996). "Sex differences in parasite infections: patterns and processes." *Int J Parasitol* **26**: 1009-1023.