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Factors Associated with Intestinal Parasites among Households in Ratchaburi Province, Thai-Myanmar Border Area

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Abstract

Intestinal parasitic infections are still widely distributed in tropical and subtropical regions. This analytical cross-sectional study was conducted on the Thai-Myanmar border, and focused on factors associated with intestinal parasites among households. The formalin-ether concentration technique was employed to identify parasites from 1,953 stool samples; structured questionnaires were also used. The generalized estimation equation method was used to determine correlated risk factors and infections at the household level, to account for household members sharing the same environment.

It was found that the older age group had a higher risk of *E. histolytica/E. dispar*, *T. trichiura* and hookworm infections; this might be associated with immunosuppression, in contrast, *A. lumbricoides* and *G. lamblia* infections had lower risk, which might be due to raised immunologic status. Gender was significantly associated with hookworm infection. Infections found in different areas of residences may probably be due to geographical differences in the contaminated source. Improper personal hygiene, dirty nails and lack of water treatment, implied higher risk of infection. The structural material of the house, an indirect indicator of economic status, was related to infection risk.

Keywords: intestinal parasites, Thai-Myanmar Border, households, stool samples, Ratchaburi

Introduction

Intestinal parasitic infections continue to affect human health [1] and are widely distributed in tropical and subtropical regions. The most common soil-transmitted helminths, *A. duodenale*, *N. americanus*, *A. lumbricoides* and *T. trichiura*, have been reported among several hundred millions of people worldwide [2]. In Southeast Asia, using Geographical Information System and remote sensing satellite technology, these soil-transmitted helminths were found to be abundant in the environment [3]. In Thailand, the 2001 national survey by the Department of Communicable Disease Control, Ministry of Public Health, revealed that the overall helminth prevalence was 22.3% [4]. Most cases were hookworm (11.3%) and *O. viverrini* (9.5%), whereas the other species were *T. trichiura* (1.6%), *A. lumbricoides* (1.0%), *Echinostoma* spp (0.6%), *S. stercoralis* (0.5%), *T. saginata* (0.5%) and *E. vermicularis* (0.1%). In

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addition, a study in Southern Thailand reported a high prevalence of soil-transmitted helminthiases among primary school children and villagers for many years [5].

Several studies have reported the association of intestinal parasitic infections with other sets of risk factors. In particular, risk factors for soil-transmitted helminth infections related to host-specific and environmental factors, were reviewed. Many risk factors associated with heavy intensities were found–genetics, behavior, household clustering and occupation, poverty, poor sanitation and lack of clean water, climate and season [6], and health education and sanitation in the control of helminth infections [7]. A study of risk factors explained gender differences among hospitalized patients infected with intestinal helminths on the Thai-Myanmar border [8]. A study in Kenya identified risk factors for infection with intestinal helminths and combined qualitative methods [9]; it revealed that absence of latrine, household without soap, the presence or absence of children aged 5 years, were significant predictors of these worms. The results of the qualitative part of the study suggested that latrines and hygienic personnel were important prevention measures. In southern Thailand, the statistically significant protective factor for hookworm infection was wearing shoes [10]. Infections with *A. lumbricoides* and *T. trichiura* were found to be associated with socio-demographic variables in Honduran communities [11]. Furthermore, for the high-risk group, *ie* school-aged children, a guide for managers of control programs for soil-transmitted helminthiasis and schistosomiasis emphasized the importance of intensive learning, awareness of good personal hygiene, and adequate nutrition [12]. Strategies for reducing morbidity and transmission include drug treatment, improved sanitation, and health education. Another high-risk group, Teheran primary-school students with intestinal parasitic infections, and the relation to socio-economic factors and hygienic habits, were studied [13].

The literature reviewed above clearly showed that intestinal parasitic infections were associated with personal and environmental risk factors. However, very few studies have been reported for people within the same family, who share genetic factors and household environments. Morales-Espinoza *et al* (2003) used the generalized estimation equation (GEE) method to determine the association of intestinal parasitic infection with correlated risk factors among children within the family in a highly deprived population of Mexico. It was found that age and speaking an indigenous language were significantly associated with the presence of *E. histolytica/dispar* and *G. lamblia*. Source of water and lack of refrigerator and electricity were associated with ascariasis. The Department of Tropical Hygiene, Faculty of Tropical Medicine, Mahidol University, has been conducting epidemiological research studies in Ratchaburi Province, on the Thai-Myanmar border, for several years. In 2001, the Department, with the local health center, collected blood and stool specimens from two villages. The preliminary report was covered prevalence, parasite intensity, and some basic factors associated with malaria and soil-transmitted helminths [14]. Based on this preliminary report, we added the correlation of risk factors for individuals within the same family, and the most prevalent helminth and protozoan infections. It was assumed that family members share genetics and household environments (*eg*, sanitation and hygiene behavioral patterns).

Materials and methods

Study design

The study was of analytical cross-sectional design; the survey was conducted January to April 2001.

Study area and study population

The study sites were located in Tanowsri Subdistrict, Suan Phueng District, Ratchaburi Province, Thailand, on the Myanmar border. The study area has long mountain range and plateau areas. Villages A and B, about 10 km apart, were selected in this subdistrict. Village A had 189 households and a population of 978, while Village B had 477 households and a population of 2,405.

Most villagers were of Karen ethnicity, and worked in agriculture. The villagers usually resided in small houses and bamboo shelters with thatched roofs.

Data collection

The study team, from the Departments of Tropical Hygiene and Social and Environmental Medicine, Faculty of Tropical Medicine, Mahidol University, collaborated with health volunteers in the study villages. Interviewers were trained to conduct the survey using standardized questionnaires based on a review of the literature on the prevention and control of intestinal parasitic infections. Single stool samples were collected and examined by formalin-ether concentration technique.

Data analysis

Descriptive statistics were used to determine the proportion of infected households where at least one household member was infected with an intestinal parasite was the numerator among households. The epidemiologically important intestinal parasites (*A. lumbricoides*, *T. trichiura*, hookworm, *E. histolytica/E. dispar* and *G. lamblia*) were identified using analytical statistics. The Chi-square test was used to determine bivariate relationships between infection and risk factors. Statistically and epidemiologically significant factors in the bivariate analysis were then included simultaneously in multivariate analysis by General Estimation Equation (GEE) technique, which is also known as regression analysis for correlated data [15]. Exchangeable correlation structure was used to fix the correlation between persons within a household. The STATA version 8 program (License: serial number 198049310) was used for all analyses.

Results

The stool-examination results, matched with the completed questionnaires, were obtained from 1,953 villagers in 556 households. Of all households studied, 88.67% had at least one kind of intestinal parasitic infection.

Tables 1 and 2 show the associations between personal and environmental risk factors with different kinds of intestinal parasitic infections (*A. lumbricoides, T. trichiura,* hookworm*, E. histolytica/ E. dispar* and *G. lamblia*). Age was a significant factor for all parasitic infections in this study. Occupation, education level, latrine type, and residential area, were significantly associated with *A. lumbricoides* and *T. trichiura* infections. Eating practices were associated with ascariasis, whereas dirty nails were associated with trichuriasis. Hookworm infection was significantly associated with gender, occupation, residential area, material of house, latrine type, and footwear use. *E. histolytica* or *E. dispar* infections were significantly associated with water treatment, material of house, and source of drinking water, whereas *G. lamblia* was significantly associated with occupation and household size.

The multivariate analysis model, adjusting for confounders for each parasite, is shown in Table 3. Older age seemed to correlate with higher risk of trichuriasis, hookworm, and *E. histolytica/ dispar* infections. In contrast, older age groups had a lower risk of infection with ascariasis and *G. lamblia*. Gender differences were found among households with hookworm infections. Education level was significant among the kindergarten group. It was hypothesized that lower education levels meant comparatively less education about hygiene than the higher-educated groups, resulting in more infections. Area of residence was significant for ascariasis and trichuriasis in Village A, and hookworm infections in Village B. In addition, the residential area in Village A was a less likely soil-transmitted disease area than Village B. Households lacking a pit latrine were at higher risk of trichuriasis and hookworm infections, while those with a pit latrine were at lower risk of ascariasis infection. Dirty nails were associated with trichuriasis. Natural house material, as an indirect indicator of economic status, was a significant risk factor for hookworm infection and a borderline risk factor for *E. histolytica/dispar*. Treated water implied a lower risk of *E. histolytica/ dispar* infection. People were in of lower economic

Table 1 Proportion and association of *A. lumbricoides* and *T. trichiura* and hookworm infections.

Variables	N	*A. lumbricoides*			*T. trichiura*			Hookworm		
		n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)
Age										
< 5	238	38	(15.97)	1	9	(3.78)	1	35	(14.71)	1
5-9	338	57	(16.86)	1.07 (0.68-1.67)	43	(12.72)	3.71 (1.77-7.76)*	108	(31.95)	2.72 (1.78-4.17)*
10-14	263	21	(7.98)	0.46 (0.26-0.80)*	39	(14.83)	4.43 (2.10-9.35)*	100	(38.02)	3.56 (2.30-5.51)*
15-24	322	26	(8.07)	0.46 (0.27-0.79)*	62	(19.25)	6.07 (2.95-12.45)*	159	(49.38)	5.66 (3.72-8.61)*
25-34	319	35	(10.97)	0.65 (0.40-1.26)	54	(16.93)	5.18 (2.50-10.73)*	148	(46.39)	5.02 (3.30-7.65)*
35-44	209	10	(4.78)	0.26 (0.13-0.55)*	32	(15.31)	4.60 (2.14-9.89)*	85	(40.67)	3.98 (2.53-6.25)*
45-54	151	12	(7.95)	0.45 (0.23-0.90)*	19	(12.58)	3.66 (1.61-8.33)*	71	(47.02)	5.15 (3.18-8.32)*
≥ 55	113	4	(3.54)	0.19 (0.07-0.56)*	19	(16.81)	5.14 (2.25-11.78)*	56	(49.56)	5.70 (3.41-9.53)*
Gender										
Female	1,019	110	(10.79)	1	152	(14.92)	1	367	(36.02)	1
Male	934	93	(9.96)	0.91 (0.68-1.22)	125	(13.38)	0.88 (0.68-1.14)	395	(42.23)	1.30 (1.09-1.56)*
Occupation										
Non-agriculture	1,028	124	(12.06)	1	120	(11.67)	1	326	(31.71)	1
Agriculture	925	79	(8.54)	0.68 (0.51-0.92)*	157	(16.97)	1.55 (1.20-2.20)*	436	(47.14)	1.92 (1.60-2.31)*
Education level										
Secondary school	75	5	(6.67)	1	5	(6.67)	1	28	(37.33)	1
No education	1,031	93	(6.67)	1.39 (0.55-3.52)	151	(14.65)	2.40 (0.95-6.05)	380	(36.86)	0.98 (0.60-1.59)
Primary school	698	65	(9.31)	1.44 (0.56-3.69)	102	(14.61)	2.40 (0.94-6.08)	305	(43.70)	1.30 0.80-2.13)
Kindergarten	149	40	(26.85)	5.14 (1.93-3.65)*	19	(12.75)	2.05 (0.73-5.71)*	49	(32.89)	0.82 (0.46-1.47)
Area of residence										
Village A	665	103	(15.49)	1	127	(19.10)	1	223	(33.53)	1
Village B	1,288	100	(7.76)	0.46 (0.34-0.62)*	150	(11.65)	0.56 (0.43-0.72)*	539	(41.85)	1.43 (1.17-1.73)*
Eating practices										
Spoon	519	74	(14.26)	1	74	(14.26)	1		-	-
Spoon and finger	491	56	(11.41)	0.77 (0.53-1.12)	70	(14.26)	1.00 (0.70-1.42)		-	-
Finger	943	73	(7.74)	0.50 (0.36-0.71)*	133	(14.10)	0.99 (0.73-1.34)		-	-
Handwashing practice before eating										
Usually	1,827	193	(10.56)	1	263	(14.40)	1		-	-
Sometime	72	8	(11.11)	1.06 (0.50-2.24)	11	(15.28)	1.07 (0.56-2.06)		-	-
Never	54	2	(3.70)	0.33 (0.08-1.35)	3	(5.56)	0.35 (0.11-1.13)		-	-
Eating uncooked vegetables										
Never	876	80	(9.13)	1	122	(13.93)	1		-	-
Sometime	649	74	(11.40)	1.28 (0.92-1.79)	88	(13.56)	0.97 (0.72-1.30)		-	-
Usually	428	49	(11.45)	1.29 (0.88-1.87)	67	(15.65)	1.15 (0.83-1.58)		-	-

Table 1 Proportion and association of *A. lumbricoides* and *T. trichiura* and hookworm infections (Continued).

Variables	N	*A. lumbricoides*			*T. trichiura*			Hookworm		
		n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)
Dirty nails										
No	719	67	(9.32)	1	80	(11.13)	1		-	-
Yes	1,234	136	(11.02)	1.21 (0.89-1.64)	197	(15.96)	1.52 (1.15-2.00)*		-	-
Household size										
≤ 4	598	58	(9.70)	1	81	(13.55)	1	230	(38.46)	1
> 4	1,355	145	(10.70)	1.12 (0.81-1.54)	196	(14.46)	1.08 (0.82-1.43)	532	(39.02)	1.03 (0.85-1.26)
Material of house										
Non leaf and bamboo	258	22	(8.53)	1	27	(10.47)	1	70	(27.13)	1
Leaf and bamboo	1,695	181	(10.68)	1.28 (0.81-2.03)	250	(14.75)	1.48 (0.97-2.25)	692	(40.83)	1.85 (1.39-2.47)*
Latrine type										
Septic-tank	1,180	140	(11.86)	1	136	(11.53)	1	410	(34.75)	1
Pit	338	15	(4.44)	0.34 (0.20-0.60)*	54	(15.98)	1.46 (1.04-2.05)*	154	(45.56)	1.57 (1.23-2.01)*
No	435	48	(11.03)	0.92 0.65-1.30)	87	(20.00)	1.92 (1.43-2.58)*	198	(45.52)	1.57 (1.25-1.96)*
Footwear use										
Usually	1,409		-	-	-		-	612	(43.44)	1
Sometimes	230		-	-	-		-	67	(29.13)	0.54 (0.40-0.72)*
Never	314		-	-	-		-	83	(26.43)	0.47 (0.36-0.61)*

* statistically significant

Table 2 Proportion and association of *E. histolytic/E. dispar* and *G. lamblia* infections.

Variables	N	*E. histolytic/E. dispar*			*G. lamblia*		
		n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)
Age							
< 5	238	6	(2.52)	1	16	(6.72)	1
5-9	338	27	(7.99)	3.36 (1.36-8.26)*	27	(7.99)	1.20 (0.63-2.29)
10-14	263	21	(7.98)	3.36 (1.33-8.46)*	19	(7.22)	1.08 (0.54-2.15)
15-24	322	19	(23.60)	2.42 (0.95-6.17)	6	(1.86)	0.26 (0.10-0.68)*
25-34	319	29	(9.09)	3.87 (1.58-9.47)*	8	(2.51)	0.36 (0.15-0.85)*
35-44	209	11	(5.26)	2.15 (0.78-5.91)	9	(4.31)	0.62 (0.27-1.44)
45-54	151	5	(3.31)	1.32 (0.40-4.42)	2	(1.32)	0.19 (0.04-0.82)*
≥ 55	113	2	(1.77)	0.70 (0.14-3.55)	1	(0.88)	0.12 (0.02-0.95)*
Gender							
Female	1,019	71	(6.97)	1	40	(3.93)	1
Male	934	49	(5.24)	0.74 (0.51-1.08)	48	(5.14)	1.33 (0.86-2.04)

Table 2 Proportion and association of *E. histolytic/E. dispar* and *G. lamblia* infections (Continued).

Variables	N	*E. histolytic/E. dispar*			*G. lamblia*		
		n	(%)	Odds ratio (95% CI)	n	(%)	Odds ratio (95% CI)
Occupation							
Non-agriculture	1,028	62	(6.03)	1	65	(6.32)	1
Agriculture	925	58	(6.27)	1.04 (0.72-1.51)	23	(2.49)	0.38 (0.23-0.61)*
Education level							
Secondary school	75	3	(4.00)	1	3	(4.00)	1
No education	1,031	54	(5.24)	1.33 (0.00-4.35)	37	(3.59)	0.89 (0.27-2.97)
Primary school	698	52	(7.45)	1.93 (0.59-6.34)	34	(4.87)	1.23 (0.37-4.10)
Kindergarten	149	11	(7.38)	1.91 (0.52-7.08)	14	(9.40)	2.49 (0.69-8.95)
Area of residence							
Village A	665	34	(5.11)	1	31	(4.66)	1
Village B	1,288	86	(6.68)	1.33 (0.88-2.00)	57	(20.57)	0.95 (0.61-1.48)
Eating practices							
Spoon	519	26	(5.01)	1	23	(4.43)	1
Spoon and finger	491	38	(7.74)	1.59 (0.95-2.66)	23	(4.68)	1.06 (0.59-1.51)
Finger	943	56	(5.93)	1.20 (0.74-1.13)	42	(4.45)	1.01 (0.60-1.69)
Handwashing practice before eating							
Usually	1,827	112	(6.13)	1	83	(4.54)	1
Sometime	72	7	(9.72)	1.65 (0.74-3.68)	4	(5.56)	1.24 (0.44-3.47)
Never	54	1	(1.85)	0.09 (0.24-2.11)	1	(1.85)	0.40 (0.05-2.90)
Eating uncooked vegetable							
Never	876	46	(5.25)	1	41	(4.68)	1
Usually	649	46	(7.09)	1.38 (0.90-2.10)	35	(5.39)	1.16 (0.73-1.84)
Sometimes	428	28	(6.54)	1.26 (0.78-2.05)	12	(2.80)	0.59 (0.31-1.13)
Water treatment							
Boiling	973	58	(5.96)	1	37	(3.80)	1
No treatment	980	62	(6.33)	2.35 (1.23-4.49)*	51	(5.20)	0.32 (0.08-1.35)
Dirty nails							
No	719	39	(22.67)	1	29	(4.03)	1
Yes	1,234	81	(6.56)	1.22 (0.83-1.82)	59	(4.78)	1.19 (0.76-1.88)
Household size							
≥ 4	598	34	(5.69)	1	18	(3.01)	1
> 4	1,355	86	(6.35)	1.12 (0.75-1.69)	70	(5.17)	1.76 (1.04-2.97)*
Material of house							
Non leaf and bamboo	258	7	(2.71)	1	9	(3.49)	1
Leaf and bamboo	1,695	113	(6.67)	2.56 (1.18-5.56)*	79	(4.66)	1.35 (0.67-2.73)
Latrine type							
Septic-tank	1,180	70	(5.93)	1	60	(5.08)	1
Pit	338	22	(6.51)	1.10 (0.67-1.81)	15	(4.44)	0.87 (0.49-1.55)
No	435	28	(6.44)	1.09 (0.69-1.72)	13	(2.99)	0.58 (0.31-1.06)
Source of drinking water							
Rain	378	14	(3.70)	1	10	(2.65)	1
Tap water or stream water	1,575	106	(6.73)	1.88 (1.06-3.31)*	78	(4.95)	1.92 (0.98-3.74)

* statistically significant

Table 3 Associations of multivariate analysis of epidemiologically important intestinal parasites.

Variables	*A. lumbricoides*	*T. trichiura*	Hookworm	*E. histolytica/ E. dispar*	*G. lamblia*
	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)
Age					
< 5	1	1	1	1	1
5-9	0.93 (0.58-1.48)	3.65 (1.73-7.69)*	2.65 (1.71-4.12)*	3.52 (1.44-8.58)*	1.13 (0.60-2.16)
10-14	0.61 (0.34-1.09)	4.96 (2.30-10.69)*	3.35 (2.08-5.38)*	3.37 (1.34-8.43)*	0.99 (0.49-1.99)
15-24	0.79 (0.47-1.34)	6.71 (3.01-14.94)*	4.82 (2.87-8.09)*	2.44 (0.97-6.13)	0.25 (0.08-0.82)*
25-34	0.84 (0.51-1.37)	5.10 (2.20-11.82)*	4.34 (2.49-7.58)*	3.99 (1.65-9.65)*	0.33 (0.09-1.22)
35-44	0.44 (0.23-0.85)*	4.48 (1.88-10.68)*	3.46 (1.93-6.19)*	2.35 (0.86-6.43)	0.54 (0.15-1.95)
45-54	0.69 (0.36-1.33)	3.90 (1.56-9.73)*	4.33 (2.37-7.92)*	1.34 (0.40-4.49)	0.18 (0.03-1.03)*
≥ 55	0.26 (0.10-0.71)*	5.03 (2.10-12.07)*	5.04 (2.77-9.17)*	0.76 (0.15-3.88)	0.12 (0.01-1.03)*
Area of residence					
Village A	1	1	1	-	-
Village B	0.54 (0.35-0.82)*	0.52 (0.39-0.71)*	1.37 (1.09-1.72)*	-	-
Latrine type					
Septic-tank	1	1	1	-	-
Pit	0.40 (0.20-0.79)*	1.61 (1.09-2.39)*	1.50 (1.13-2.00)*	-	-
No	0.80 (0.49-1.30)	2.01 (1.42-2.86)*	1.55 (1.19-2.01)*	-	-
Education level					
Secondary school	1	1	-	-	-
No education	1.01 (0.46-2.23)	2.16 (0.85-5.47)	-	-	-
Primary school	0.95 (0.44-2.05)	2.04 (0.81-5.14)	-	-	-
Kindergarten	3.12 (1.31-7.46)*	2.59 (0.88-7.59)	-	-	-
Eating practices					
Spoon	1	-	-	-	-
Spoon and finger	0.97 (0.64-1.49)	-	-	-	-
Finger	0.81 (0.55-1.21)	-	-	-	-
Occupation					
Non-agriculture	1	-	1	-	1
Agriculture	1.08 (0.69-1.68)	-	1.08 (0.78-1.49)	-	1.08 (0.38-3.07)
Dirty nails					
No	-	1	-	-	-
Yes	-	1.41 (1.04-1.90)*	-	-	-
Gender					
Female	-	-	1	-	-
Male	-	-	1.38 (1.15-1.67)*	-	-
Footwear use					
Usually	-	-	1	-	-
Sometimes	-	-	0.75 (0.54-1.05)	-	-
Never	-	-	0.82 (0.58-1.16)	-	-

Table 3 Associations of multivariate analysis of epidemiologically important intestinal parasites (Continued).

Variables	*A. lumbricoides*	*T. trichiura*	Hookworm	*E. histolytica/ E. dispar*	*G. lamblia*
	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)	adj OR (95% CI)
Material of house					
Non leaf and bamboo	-	-	1	1	-
Leaf and bamboo	-	-	1.56 (1.10-2.20)*	2.31 (0.97-5.47)	-
Water treatment					
Boiling	-	-	-	1	-
No treatment	-	-	-	2.34 (1.16-4.74)*	-
Source of drinking water					
Rain	-	-	-	1	-
Tap water or stream water	-	-	-	1.52 (0.80-2.91)	-
Household size					
≤ 4	-	-	-	-	1
> 4	-	-	-	-	1.45 (0.83-2.52)

*statistically significant

status usually constructed their houses from local plants, *eg* grass, leaves, and bamboo.

Discussion

The proportion of households with intestinal parasitic infections was quite high, which could indicate high transmission in the study community households. Regression analysis with a correlated structure model, after controlling for confounders (Table 3), showed that intestinal parasite infections were associated with several risk factors. The results of this study were consistent with some factors found in other studies, but differed from others that used standard regression analysis [4,8,10,11,13,16].

Evidence from endemic areas referred to immunity to parasitic infections and that prevalence declined with age, or succumbed quickly to infection due to their immune-suppressed status, such as those with AIDS [17]. In our study, the older age group had lower risk of infection with *A. lumbricoides* and *G. lamblia* infections. This might be explained by a raised level of immune status, as noted by others. In contrast, the older age group had a higher risk of *E. histolytica/E. dispar*, *T. trichiura* and hookworm infection, which might be due to immunosuppression, since age might be associated with reduced immunity.

Gender: males were more likely to have hookworm infection, which might be due to their biological immunity and/or gender-related habits [8]; among patients from the Thai-Myanmar border admitted to the Hospital for Tropical Diseases, more males harbored hookworm than females. Moreover, males showed a higher risk of *S. stercoralis* infection. These infections might reflect increased non-specific immunity against hookworm among women infected with *Ascaris* and/or *Trichuris* and/or gender-differentiated exposures (*eg*, use of footwear, by gender). Females were more at risk due to their attire, including their footwear.

Education level: school-aged children were at high risk of soil-transmitted helminth infections [4,12]. The kindergarten group appeared to have the highest risk of ascariasis; this may be because of their level of understanding about how to protect themselves from infection. This finding supports a study from a primary school in Tehran, which recommended promoting educational level could be affected for infectious control [13].

The associations were significantly different between intestinal parasitic infections and area of residence; this is likely due to geographic variations and the differences in soil composition, which may be more conducive for *A. lumbricoides*, *T. trichiura,* and hookworm. Other studies found similar results. Brooker *et al* and Hotez *et al* cited different soil and climatic characteristics that affected these 3 helminths. In Mexico, the risk of ascariasis infection increases with closer contact with the soil and harsh environmental conditions [18].

The existence of a septic-tank latrine had a protective effect against trichuriasis and hookworm infections. This finding is consistent with a study in Kenya, where the risk of hookworm infection increased without latrines [11]. However, the risk of ascariasis was found to be higher, even with septic-tank latrines; these cases may have already been infected but remained undiagnosed even before latrines were installed. Improper latrine use and other unhygienic habits could also explain the increased risk [7], as observed in studies in Kenya [9].

Dirty fingernails were associated with trichuriasis, which suggests that the fecal-oral route is still a significant route of infection among the population.

Material used in house construction, as an indirect indicator of a family's economic status, was related to hookworm infection, as also cited in a study in Mexico, which reported the lack of a refrigerator and electricity were associated with ascariasis [18].

Lack of regular water-treatment practices was a risk factor for *E. histolytica/E. dispar* infection; water may be contaminated in the environment and/or during transportation due to unhygienic conditions. During our survey, villagers mentioned drinking water directly from a stream, and often asked their children to bring water from the stream for consumption.

Footwear use was not statistically significant in the final model of hookworm infection, due to its epidemiological importance in the study. This contrasted with other studies, which found footwear practices to be a significant factor for hookworm prevention in Thailand [10]. This study showed that shoe-wearing had an exposure-outcome severity relationship, especially against heavy infections with hookworm and reducing the risk of infection. Moreover, in the current study, people who became infected with hookworm before they used footwear, might affect the statistical significance of any association.

These hygiene practices could be incorporated effectively into the disease prevention and health education program. A well-planned prevention and control program, taking into account these personal and environmental risk factors at the household and/or community level, is a necessary and important measure for solving the problem, especially in such low-resource areas.

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