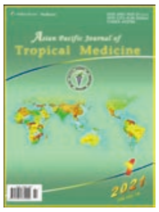

Original Article

Asian Pacific Journal of Tropical Medicine

apjtm.org

doi:10.4103/1995-7645.304297

Impact Factor: 1.94

Intestinal parasitic infections and risk factors among Myanmar migrant workers in northeast Thailand

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ABSTRACT

Objective: To determine the prevalence and associated factors of intestinal parasitic infections in migrant workers in Nakhon Ratchasima Province, Northeast Thailand.

Methods: A cross-sectional study was conducted from August 2017 to July 2018 in 600 Myanmar migrant workers. Questionnaires were employed for collecting the demographic data of participants. Stool samples were collected and examined using the formalin-ether concentration technique. Risk factors for intestinal parasitic infections were determined using multiple logistic regressions analyses.

Results: The overall infection rate of intestinal parasitic infections was 27.67% (166/600). Among the intestinal helminthes observed, hookworm was most abundant (8.67%) followed by *Trichuris trichiura* (8.50%), *Opisthorchis viverrini*(4.17%), *Ascaris lumbricoides*(1.50%), *Strogyloides stercoralis*(1.17%) and *Hymenolepis nana*(0.5%). Meanwhile, *Entamoeba coli* was the most prevalent intestinal protozoa (4.33%, 26/600) followed by *Endolimax nana* (1.33%), *Entamoeba histolytica* complex (1.17%), *Blastocystis* sp. (1.0%) and *Giardia duodenalis* (0.17%). The study found significant associations between gender and *Strogyloides stercoralis* infection (OR_{adj}=5.61, 95% *CI*=1.18–26.70, *P*=0.03), workers aged 30 years old were likely to have a lower risk of the *T. trichiura* infection (OR_{adj}=0.45, 95% *CI*= 0.23–0.89). Moreover, the history of consuming raw or undercooked cyprinoid fish was a risk factor of *Opisthorchis viverrini* infection (OR_{adj}=2.82, 95% *CI*=1.22–6.49, *P*=0.015).

Conclusions: There remains a high prevalence of intestinal parasitic infections among Myanmar migrant workers in the study area and therefore health screenings for all migrant workers in Thailand are required.

KEYWORDS: Intestinal parasite; Infections; Risk factors; Myanmar migrant workers; Thailand

1. Introduction

Urbanization and extensive industrialization of more developed or developing countries have caused mass migration from less developed countries[1]. Due to the open borders policy in 2015 for the Association of Southeast Asian Nations Economic Community (AEC), millions of migrants from the neighboring countries of Myanmar, Cambodia and Lao PDR travelling to major urban cities of Thailand, with Myanmar migrant workers constituting the largest proportion (1.2 million or 65.17%) of the workforce in the country[1]. The majority of migrants are low-skilled workers mostly employed in construction, manufacturing, agriculture, fishery and domestic services[2]. The major contributor to intestinal parasite transmission is poor sanitation such as living at areas that lack of available potable water and lack of toilets based on sanitation system[3,4]. Despite compulsory medical screening for foreigners prior to entering the Thai workforce, screening for parasitic infections is often lacking or inadequate.

Intestinal parasitic infections (IPIs) remain a serious public health problem in many countries across the world. The highest prevalence of intestinal worm infections reported in recent decades were in Southeast Asian countries[5], particularly in Myanmar[6]. Almost

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How to cite this article: Sangwalee W, Rattanapitoon N, Thanchomnang T. Intestinal parasitic infections and risk factors among Myanmar migrant workers in northeast Thailand. Asian Pac J Trop Med 2021; 14(1): 17-26.

Article history: Received 12 September 2019 Revision 15 April 2020 Accepted 19 May 2020 Available online 5 January 2021

200 million people live in extreme poverty in ASEAN countries are affected by neglected helminth and protozoa infections[7]. And more than 10 million people in Southeast Asian Region suffer from either liver and intestinal fluke infections[8]. A myriad of socioeconomic factors are responsible for the high prevalence of IPIs, such as poverty, poor sanitation, poor food hygiene, inadequate water resources, the presence of animal reservoirs in close proximity to communities, poor housing and congested living conditions, difficulty in access to healthcare services, and cultural food habits[4,5,7]

Previous studies showed that about 11.3 million people in Myanmar were infected with intestinal helminthes[7,9]. Another study on molecular identification of *Opisthorchis (O.) viverrini* infection in humans from Lower Myanmar during 2015–2016 revealed that the prevalence of *O. viverrini* infection was 9.3%, 18.9% in Bago, 5% in Mon and 3.6% in Yangon[10]. Additionally, among Myanmar migrant workers living in Malaysia during 2014–2015, the prevalence of helminthes and protozoa was 43.5% (95% *CI* 24.66–63.98) and 21.7% (95% *CI* 8.99–43.34), respectively[11].

Recently, a growing body of scientific evidence has indicated a high prevalence of IPIs in Myanmar migrant workers residing in Thailand[12,13]. However, there is limited information on the prevalence of IPIs among Myanmar migrant workers residing in Nakhon Ratchasima Province, in which the number of the workers constitutes the highest percentage of the workforce in the northeastern region. Therefore, health screening and surveillance of the workers for IPIs in this area is urgently required. Thus, this study aimed to determine the prevalence and associated factors of IPIs among Myanmar migrant workers residing Nakhon Ratchasima Province, Northeast Thailand.

2. Subjects and methods

2.1. Ethics statement

This study was approved by the Ethics Committee for Research Involving Human Subjects of Mahasarakham University, Thailand (090/2561). An advanced notice was provided to the owners of the factories prior to sample collection. The required information pertaining to the purpose of the research was provided to all participants. Written consent forms were only given to those who agreed to participate in the study. The identity and personal particular were strictly kept confidential. The participants infected with helminths and protozoa were treated with anti-parasitic drugs under the observation of researchers and medical officers. There were no complaints from the participants during the medication administration.

2.2. Study area and sampling

This study was conducted in Nakhon Ratchasima Province, one of the 20 provinces of Northeast Thailand, which extends over an area of 20 494 km^2 and has an estimated population of 1 722 365. It is recognized as the largest province in the northeastern with 150-300 m above sea level, surrounded with mountains, acting as a gateway to other provinces in the northeastern region. The climate of the province is typically tropical with an average annual minimum and maximum temperature of about 24 ℃ and 32 ℃ respectively, and the annual precipitation of 16–463 mm.

This cross-sectional study was conducted from August 2017 to July 2018 among 600 Myanmar migrant workers residing in Nakhon Ratchasima Province, Northeast Thailand. The workers selected for this study were recruited by simple random sampling by randomly drawing workers' identification numbers from a total of 6 658 workers in the study area[1]. The sample size was calculated to estimate the population ratio. In the case of known population size, the sample size is calculated using the equation: $n=[N(Z_{\alpha/2})^2P(1-P)]/[e^2(N-1)+(Z_{\alpha/2})^2P(1-P)]$, where n=sample size, N=population, P=prevalence or proportion of infection in Myanmar workers (0.14)[13], $Z_{\alpha/2}$=normal deviation for two-tailed alternative hypothesis at a level of significance of 1.96, e=precision margin of error (5%; 0.05). After calculating the necessary sample size, 180 participants were identified from the study population of 6 658 potential participants. To ensure a better representation of the study populations, we have doubled the participants for the best representative populations. There were another 240 migrant workers interested in participating in this screening project. Therefore, we included them in the study. Consequently, the total population of this study was 600 migrant workers. Purposive sampling of the participants was according to those who were interested and the factories' permission.

2.3. Data and stool sample collection

Questionnaires in Burmese language were employed as the tool for collecting the workers' demographics and personal particulars. The questionnaires were distributed to all the participants to collect socio-demographic and clinical data.

After collecting the workers' demographics and personal particulars, each of the participants were provided with labelled plastic containers. The stool preparation method, the collected stool samples were pickled with the formalin 10% and the formalin–ether concentration technique was used to identify the presence of the intestinal parasites. The deposit was then examined microscopically using physiological saline and iodine for the cysts of protozoan and eggs, larvae of helminthes. For quality control reason, from all of the slides confirmed by an expert parasitologist[14].

2.4. Statistical analysis

Statistical analysis was performed using SPSS 20.0 for Windows. Descriptive statistics was used to analyze the data and the prevalence of IPIs was expressed as the percentage and 95% confidence interval (95% *CI*). Bivariate and multivariate analysis was used to analyze the associations between the intestinal parasitic infections status and potential risk factors. Variables with $P < 0.25$ level were included for multivariate analysis. Finally, P value less than 0.05 was considered significant at 95% confidence level.

3. Results

3.1. Baseline characteristics

Of the 600 Myanmar migrant workers selected for this study, 528 were female workers accounting for 88.0%. The average age of workers was 23.83 years old (SD=7.39) ranging from 18 to 54 years old. Most of them migrated from West Myanmar (41.00%, 246/600) and Lower Myanmar (28.17%, 169/600), with the average work experience in Thailand of 3.16 years (SD=2.32). According to the educational background, the workers with primary education background accounted for 67.17%. Of all the workers participated, 99.0% were Buddhist, 49.67% were single, and agriculture was their major occupation (61.67%) in their region/city in country of origin. Additionally, 96.17% of the workers resided in the worker's houses provided by the employers. From the questionnaires, 82.17% of the workers did not have any history of stool examination for helminth eggs in the past one year and 97.67% did not undergo any medications to treat intestinal parasitic infections (IPIs) as presented in Table 1.

3.2. Prevalence of intestinal parasitic infections (IPIs) in Myanmar migrant workers

Among the 600 participants surveyed, 27.67% (95% *CI*=24.08–31.26) were infected with all parasites, 22.17% (95% *CI*=18.83–25.50) were infected with helminthes and 7.0 % (95% *CI*=4.95–9.05) were infected with protozoa. When classified by the region/city in country of origin, the highest prevalence of IPIs (all parasites) was found in the workers migrating from Mon State (8/10, 80.0%) as shown in Table 1. Of all the intestinal helminthes studied, hookworm was most prevalent (8.67%, 52/600) as presented in Table 2.

3.3. Factors associated with parasitic infections

Table 3 and 4 shows bivariate and multivariate analysis results for the association between risk factors and intestinal parasitic infections among the Myanmar migrant workers. It was observed that there was a significant association between the male workers and the *S. stercoralis* infection (OR_{adj}=5.61, 95% *CI*=1.18–26.70). The workers aged$\geqslant$30 years old were likely to have a lower risk of the *T. trichiura* infection (OR_{adj}=0.45, 95% *CI*= 0.23–0.89). Moreover, the history of consuming raw or undercooked cyprinoid fish (OR_{adj}=2.82, 95% *CI*=1.22–6.49) was found to be a statistically significant risk factor, positively associated with the *O. viverrini* infection.

4. Discussion

This high parasite infection rate in this study and previously studies among migrant workers is an obvious public health hazard. The impact of intestinal parasitic infections on public health is well known; it can be spread from infected migrant areas to uninfected areas via close contact and fecal-oral transmission from contaminated food and water. The extent of intestinal parasitic infections and the high infection prevalence with a host of helminthes, most importantly hookworm, *T. trichiura*, *A. lumbricoides*, *S. stercoralis* and *O. viverrini* are a public health problem. Consequently, a chemotherapy-based morbidity control program should be re-implemented immediately. To consolidate progress and ascertain long-term sustainability, other control measures such as health education, improving access to clean water and sanitation in an intersectional fashion must be considered. In this study, it was found that 166 (27.67%) out of 600 Myanmar migrant workers residing in Nakhon Ratchasima Province, Northeast Thailand were infected with intestinal parasites. Among the helminths identified, hookworm infection was most prevalent. From the study of O'Connell *et al.*[15] evaluated the epidemiology of hookworm infection among Myanmar refugees living in 3 camps along the Thailand-Myanmar border from 2012 to 2015 for 1 839 samples. This study found that prevalence of Necator americanus was 25.4% and Ancylostoma ceylanicum (a zoonosis) was 5.4%. This prevalence of hookworm infection was quite high because Myanmar refugees who migrated to the camps lived in poor sanitation system such as lack of sources of clean drinking water, lack of toilets based on sanitation system, these factors were factors that promoted to hookworm infection via soil[4,16,17]. Moreover, living in areas that located unclean water sources increased risks of hookworm infection *via* soil[18]. In addition, Myanmar refugees living in the border camps might not get services of health insurance system where as workers who migrant to work in Thai industrial area received basic health screening service and had been registered health insurance from employers and the government. Most workers who migrant to work in Thai industrial area lived in dormitory in factories that organized good sanitation system to prevent distribution

Table 1. The prevalence (%) of intestinal parasitic infections among the Myanmar migrant workers (*n*=600) residing in Nakhon Ratchasima Province, Northeast Thailand, classified by baseline characteristics.

Baseline characteristics		*n* (%)	% (95% Confidence interval)		
			All parasites	Helminthes	Protozoa
Gender	Male	72 (12.0)	26.38 (15.96–36.82)	20.83 (11.22–30.44)	5.56 (0.14–10.98)
	Female	528 (88.0)	27.84 (24.01–31.68)	21.97 (18.43–25.51)	7.76 (5.48–10.06)
Age (year)	18-23	158 (26.33)	27.85 (20.78–34.91)	22.78 (16.17–29.40)	7.59 (3.42–11.77)
	24-27	153 (25.50)	33.99 (26.40–41.58)	26.80 (19.70–33.89)	7.84 (3.53–12.15)
	28-34	149 (24.83)	22.15 (15.40–28.90)	19.46 (13.03–25.89)	5.37 (1.71–9.03)
	35	140 (23.33)	26.43 (19.03–33.82)	19.28 (12.67–25.90)	7.14 (2.82–11.46)
Religion	Buddhism	594 (99.0)	27.78 (24.16–31.39)	21.89 (18.55–25.22)	7.58 (5.44–9.71)
	Christianity	2 (0.33)	–	–	–
	Islam	4 (0.67)	0.25 (-54.56–104.56)	0.25 (-54.56–104.56)	–
Marital status	Single	298 (49.67)	31.54 (26.24–36.85)	23.49 (18.65–28.33)	11.07 (7.49–14.66)
	Married	274 (45.67)	21.53 (16.64–26.43)	17.88 (13.32–22.45)	4.01 (1.67–6.35)
	Divorced/widowed	28 (4.67)	46.43 (26.73–66.12)	42.86 (23.32–62.40)	3.57 (-3.75–10.90)
Education	Uneducated	64 (10.67)	25.00 (14.10–35.90)	18.75 (8.92–28.58)	6.25 (0.16–12.34)
	Primary school	403 (67.17)	27.05 (22.69–31.40)	21.84 (17.78–25.89)	7.20 (4.66–9.73)
	Secondary school	116 (19.33)	31.03 (22.49–39.58)	22.41 (14.71–30.12)	10.34 (4.72–15.97)
	Bachelor's degree	17 (2.83)	29.41 (5.26–53.56)	29.41 (5.26–53.56)	–
Years of living in Thailand	1–2	307 (51.17)	23.78 (18.99–28.57)	19.22 (14.79–23.65)	6.51 (3.74–9.29)
	Over 2	293 (48.83)	31.74 (26.38–37.10)	24.57 (19.61–29.53)	8.53 (5.31–11.75)
Recent returns to country of origin	Never	458 (76.33)	26.86 (22.78–30.93)	20.74 (17.01–24.47)	7.86 (5.39–10.33)
	Less than 1 year	26 (4.33)	30.77 (11.76–49.78)	26.92 (8.65–45.19)	3.85 (-4.07–11.77)
	1–2 year(s) ago	84 (14.0)	29.76 (19.78–39.74)	25.00 (15.55–34.45)	7.14 (1.52–12.77)
	3–5 years ago	32 (5.33)	31.25 (14.27–48.23)	25.00 (9.14–40.86)	6.25 (-2.62–15.12)
Current residence	Worker's house	577 (96.17)	27.38 (23.73–31.03)	21.84 (18.45–25.22)	7.10 (5.00–9.21)
	House for rent/dormitory	23 (3.83)	34.78 (13.72–55.84)	21.74 (3.50–39.98)	17.39 (0.63–34.15)
Current occupations/positions	General worker	591 (98.50)	27.75 (24.13–31.37)	22.00 (18.65–25.34)	7.44 (05.32–09.57)
	Assistant housekeeper	9 (1.50)	22.22 (-11.67–56.12)	11.11 (-14.51–36.73)	11.11 (-14.51–36.73)
Previous occupations/positions in country of origin	Unemployed	100 (16.67)	26.00 (17.25–34.75)	21.00 (12.88–29.13)	5.00 (0.65–9.35)
	Agriculture	370 (61.67)	27.30 (22.74–31.86)	21.35 (17.16–25.55)	7.84 (5.09–10.59)
	Hired worker	76 (12.67)	31.58 (20.89–42.27)	22.37 (12.78–31.95)	11.84 (4.41–19.27)
	Fisheries	7 (1.17)	–	–	–
	Trading	47 (7.83)	31.91 (18.08–45.75)	29.79 (16.21–43.36)	4.26 (-1.74–10.24)
History of stool examination for helminth eggs in the past one year	No	493 (82.17)	26.57 (22.66–30.48)	20.69 (17.10–24.28)	7.51 (5.17–9.84)
	Yes	107 (17.83)	32.71 (23.68–41.74)	27.10 (18.54–35.66)	7.48 (2.41–12.54)
History of using drugs for helminth treatment in the past one year	No	586 (97.67)	28.16 (24.50–31.81)	22.18 (18.81–25.56)	7.68 (5.52–9.84)
	Yes	14 (2.33)	7.14 (-8.29–22.57)	7.14 (-8.29–22.57)	–
Water resources for utilization and consumption	Bottled water/tap water	573 (95.50)	27.75 (24.07–31.42)	21.82 (18.42–25.23)	7.50 (5.34–9.67)
	Natural water resources*	27 (4.50)	25.92 (8.26–43.59)	22.22 (5.46–38.98)	7.41 (-3.15–17.96)
Hand-washing before eating meals and after using the toilet	No	53 (8.83)	15.09 (5.13–25.06)	9.43 (1.30–17.57)	5.66 (-0.77–12.09)
	Yes	547 (91.17)	28.88 (25.07–32.69)	23.03 (19.50–26.57)	7.68 (5.44–9.92)
History of consuming raw or undercooked cyprinoid fish	No	472 (78.67)	27.54 (23.50–31.59)	22.03 (18.28–25.79)	7.20 (4.86–9.54)
	Yes	128 (21.33)	28.12 (20.23–36.02)	21.09 (13.93–28.26)	8.59 (3.67–13.52)
Being informed of the prevention and control of helminthes	No	266 (44.33)	24.44 (19.24–29.63)	19.17 (14.41–23.93)	7.14 (4.03–10.26)
	Yes	334 (55.67)	30.24 (25.29–35.19)	23.95 (19.35–28.55)	7.78 (4.89–10.67)
Total		600	27.67 (24.08–31.26)	22.17 (18.83–25.50)	7.00 (4.95–9.05)

–: not detected; *Natural water resoures: rain water, surface and underground water.

Table 2. The prevalence (%) of IPIs among the Myanmar migrant workers (n=600) residing in Nakhon Ratchasima Province, Northeast Thailand, classified by the parasites and region/city in country of origin.

Area parts	Region/city in country of origin	Samples examined (n)	Positive samples [n (%)]	Parasites identified										
				Trichuris trichiura	Hookworm	*Opisthorchis viverrini*	*Ascaris lumbricoides*	*Strongyloides stercoralis*	*Hymenolepis nana*	*Endolimax nana*	*Blastocystis* sp.	*Entamoeba histolytica* complex	*Entamoeba coli*	*Giardia duodenalis*
North	Kachin	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Central	Magway	39	8 (20.51)	2 (5.13)	2 (5.13)	1 (2.56)	0 (0.00)	1 (2.56)	1 (2.56)	0 (0.00)	0 (0.00)	0 (0.00)	2 (5.13)	0 (0.00)
	Mandalay	35	16 (45.71)	0 (0.00)	10 (28.57)	1 (2.86)	2 (5.71)	1 (2.86)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (8.57)	0 (0.00)
East	Shan	13	1 (7.69)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Kayah	13	1 (7.69)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Chin	7	2 (28.57)	0 (0.00)	0 (0.00)	1 (14.29)	0 (0.00)	2 (28.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
West	Sagaing	208	40 (19.23)	4 (1.92)	13 (6.25)	5 (2.40)	2 (0.96)	0 (0.00)	1 (0.48)	2 (0.96)	4 (1.92)	4 (1.92)	8 (3.85)	1 (0.48)
	Rakhine	31	15 (48.39)	12 (38.7)	4 (12.90)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (3.23)	0 (0.00)	0 (0.00)	1 (3.23)	0 (0.00)
	Bago	66	33 (50.00)	16 (24.24)	6 (9.09)	10(15.15)	4 (6.06)	2 (3.03)	0 (0.00)	2 (3.03)	1 (1.52)	1 (1.52)	1 (1.52)	0 (0.00)
Lower	Yangon	72	19 (26.39)	7 (9.72)	9 (12.50)	2 (2.78)	1 (1.39)	0 (0.00)	0 (0.00)	1 (1.39)	0 (0.00)	1 (1.39)	3 (4.17)	0 (0.00)
	Ayeyarwady	31	11 (35.48)	7 (22.58)	2 (6.45)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (3.23)	0 (0.00)	0 (0.00)	3 (9.68)	0 (0.00)
	Tanintharyi	57	9 (15.79)	1 (1.75)	2 (3.51)	1 (1.75)	0 (0.00)	0 (0.00)	1 (1.75)	1 (1.75)	0 (0.00)	1 (1.75)	3 (5.26)	0 (0.00)
South	Kayin	12	3 (25.00)	1 (8.33)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (8.33)	0 (0.00)	1 (8.33)	0 (0.00)
	Mon	10	8 (80.00)	1 (10.00)	1 (10.00)	4 (50.00)	0 (0.00)	1 (10.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (10.00)	0 (0.00)
Total		600	166	51	52	25	9	7	3	8	6	7	26	1

Table 3. Bivariate analysis results for the associations between risk factors and helminth infections among the Myanmar migrant workers (n=600) residing in Nakhon Ratchasima Province, Northeast Thailand.

Risk factors	*Strongyloides stercoralis*		*Opisthorchis viverrini*		Hookworm		*Ascaris lumbricoides*		*Trichuris trichiura*	
	OR (95% *CI*)	*P* value	*OR* (95% *CI*)	*P* value	*OR* (95% *CI*)	*P* value	*OR* (95% *CI*)	*P* value	*OR* (95% *CI*)	*P* value
Gender										
Female	1		1		1		–	–	1	
Male	5.70 (1.25-25.98)	0.025	0.63 (0.14-2.72)	0.533	1.16 (0.50-2.67)	0.735	–	–	0.43 (0.13-1.43)	0.171
Age (years)										
<30	1		1		1		1		1	
30+	4.09 (0.79-21.25)	0.094	0.90 (0.39-2.07)	0.806	0.84 (0.46-1.52)	0.564	0.80 (0.20-3.24)	0.756	0.47 (0.24-0.91)	0.026
Years of living in Thailand										
1–2 y	1		1		1		1		1	
Over 2 y	1.40 (0.31-6.32)	0.660	0.82 (0.36-1.83)	0.622	0.97 (0.55-1.71)	0.909	0.84 (0.22-3.14)	0.791	2.04 (1.12-3.71)	0.020
Recent returns to country of origin										
Never	1		1		1		1		1	1
Ever	2.45 (0.54-11.08)	0.245	0.80 (0.29-2.17)	0.660	1.34 (0.71-2.53)	0.359	1.63 (0.40-6.59)	0.496	1.24 (0.65-2.37)	0.507
Previous occupations/positions in country of origin										
Unemployed/Hired worker/ Fisheries/Trading	1		1		1		1		1	
Agriculture	0.82 (0.18- 3.73)	0.805	0.78 (0.35-1.76)	0.553	1.44 (0.78-2.66)	0.243	2.20 (0.45- 10.67)	0.329	0.62 (0.35- 1.10)	0.103
History of stool examination for helminth eggs in the past one year										
Yes	1		1		1		1		1	
No	0.54 (0.10- 2.81)	0.462	1.15 (0.38-3.41)	0.807	0.70 (0.35-1.38)	0.303	0.26 (0.07-1.00)	0.050	0.68 (0.34-1.35)	0.269
Water resources for utilization and consumption										
Bottled water/tap water	–	–	1		1		1		1	
Natural water resources (rain water, surface and underground water)	–	–	1.38 (0.65- 2.93)	0.396	0.91 (0.44- 1.91)	0.812	1.65 (0.57- 4.75)	0.355	1.17 (0.63- 2.17)	0.620
Being informed of the prevention and control of helminthes										
Yes	1		1		1		1		1	
No	0.59 (0.13- 2.68)	0.497	2.61 (1.03-6.54)	0.043*	1.30 (0.73-2.34)	0.374	0.63 (0.17- 2.38)	0.498	1.05 (0.59- 1.88)	0.857
History of consuming raw or undercooked cyprinoid fish										
No	1		1		1		1		1	
Yes	2.81 (0.62- 12.71)	0.180	3.08 (1.36-6.95)	0.007*	0.46 (0.19- 1.09)	0.078	0.46 (0.06- 3.68)	0.462	0.77 (0.37- 1.64)	0.503
Hand-washing before eating meals and after using the toilet										
Yes	–	–	–	–	1		1		1	
No	–	–	–	–	0.39 (0.09-1.65)	0.200	1.30 (0.16-10.56)	0.809	0.40 (0.09-1.69)	0.211

Table 4. Bivariate and multivariate analysis results for the associations between risk factors and helminth infections among the Myanmar migrant workers (n=600) residing in Nakhon Ratchasima Province, Northeast Thailand.

Risk factors	Crude OR (95%CI)	P value	Adjusted OR (95%CI)	P value
Strongyloides stercoralis				
Gender				
Female	1		1	
Male	5.70 (1.25-25.98)	0.025	5.61 (1.18-26.70)	0.030
Trichuris trichiura				
Age (years)				
<30	1		1	
30+	0.47 (0.24-0.91)	0.026	0.45 (0.23-0.89)	0.022
Opisthorchis viverrini				
History of consuming raw or undercooked cyprinoid fish				
No	1		1	
Yes	3.08 (1.36-6.95)	0.007	2.82 (1.22- 6.49)	0.015

of hookworm infection via soil including tap water management for drinking, using, and toilets in buildings. Therefore, these factors probably helped to decrease risks of hookworm infection via soil. Soil-transmitted helminth infection remains a major public health problem in Southeast Asia, especially in Myanmar[19], with 126.7 million people in Southeast Asia infected with *A. lumbricoides*, 115.3 million infected with *T. trichiura* and 77.0 million infected with hookworms[20]. Soil-transmitted helminth infection causes chronic and insidious impact on nutritional status, physical development and quality of life of those infected rather than to the overt morbidity or mortality[21] and, in particular, hookworms are a leading cause of iron deficiency anemia and protein malnutrition[22]. In an earlier study[12] which screened for IPIs among 284 Myanmar migrant workers in Thai food industry in Samut Sakhon Province, Thail and by examining stool samples for the presence of intestinal parasites, the prevalence of parasitic infection was 62.3% (177/284), in which the prevalence of *B. hominis*, *T. trichiura*, *G. lamblia* and *A. lumbricoides* infections was 41.5%, 22.2%, 14.1% and 1.8%, respectively. Besides, 213 Myanmar workers residing in Bangkok and Samut Sakhon Province, Thailand in 2008 were assessed for the prevalence of IPIs and it was found that the prevalence of IPIs was 13.6%, with the highest abundance of *A. lumbricoides*, followed by *T. trichiura*, *Taenia* spp., *Opisthorchis* spp. and hookworm[13]. This study found that the helminthes which remains as a health problem among migrant workers were hookworm, *T. trichiura*, A. lumbricoides, *S. stercoralis* and *O. viverrini*.

Of the Myanmar migrant workers surveyed in the present study, 25 (4.17%) were infected with *O. viverrini*. The liver fluke *O. viverrini* has been reported to be endemic in Southeast Asia, in which over 10 million people are estimated to be at risk of infection that is associated with several hepatobiliary diseases, including cholangiocarcinoma. Northeast Thailand is in particular a hotspot for *O. viverrini* transmission, and, despite extensive public health prevention campaigns led by the government, the prevalence of *O. viverrini* infection is still at high rates, which is a result of cultural and ecological complexities like wet-rice agrarian habitats and centuries-old raw-food culture[23].

The highest prevalence of the liver fluke *O. viverrini* infection was found in the workers who migrated from Mon State and Bago Region and had a history of consuming raw or undercooked cyprinoid fish, in which the risk of infection was 2.82 fold greater than that in those never consuming raw or undercooked cyprinoid fish. The results obtained from this study were well supported by a previous study of Aung *et al.*[10] which conducted among rural people in Lower Myanmar using molecular methods to identify *O. viverrini* infection. All partial mitochondrial *cox1* gene sequences obtained shared 99.7% similarity with that of *O. viverrini*. And reported that *O. viverrini* was highest in Bago Region, followed by Mon State and Yangon Region. A growing body of scientific evidence has elucidated that consumption of raw or undercooked fish is one of the major risk factors for liver fluke infection[24,25]. One previous study[26] claimed that individuals who consumed raw fish had a 5.22 fold greater risk of the liver fluke *O. viverrini* infection than those who never consumed raw fish (OR_{adj}=5.22, 95% CI=2.05–13.3, P<0.001). Moreover, a statistically significant association between raw fish consumption and the liver fluke *O. viverrini* infection (OR=3.5, 95% CI=2.7–4.5, P<0.001) was also reported in an earlier study[27].

This study did not show relation between *S. stercoralis* infection and elder ages because the majority of workers surveyed in this study were relatively young. The average age of workers was 23.83 years old (SD=7.39), and the most of ages was no more than 40 years old (90.33%), only 9.67% (58/600) were elder than 40 years old. However, the risk of *S. stercoralis* infection in the male workers observed for the current study was 5.61-fold greater than that in the female workers. The result agreed with one previous study[28] which assessed *S. stercoralis* infection and associated risk factors and symptoms on the Mekong islands in Southern Laos and found that men were at higher risk than women (OR=1.97, 95% CI=1.45–2.67). Similarly, in an earlier study[29] which determined the prevalence and risk factors of *S. stercoralis* infection in Takeo Province, Cambodia, it was noted that in all age groups the infection in males was greater than that in females (OR=1.7, 95% CI=1.4–2.0, P<0.001) *S. stercoralis* infection in male may be caused by the nature of their work: more likely to work outside and associate with the soil than females. As well as being less care about cleanliness than women. Therefore, it is a risky opportunity and a risk factor for increasing helminth infections transmitted through the soil in male.

The prevalence and risk factors of IPIs were examined in rural and remote West Malaysia and it was found that the prevalence displayed an age dependency relationship and the rates of infection in the participants aged 12 years were 2.1-fold higher than that in those older people (OR=2.10, 95% CI=1.43–2.98)[18]. The soil-transmitted helminth infections and risk factors were also assessed in three tribes of Orang Asli (Malaysian aboriginals) in Peninsular Malaysia and participants aged <15 years were observed to have a higher possibility of *T. trichiura* infection (OR=1.90, 95% CI=1.09–3.30) and those aged 30 years had a 50% lower risk of the infection (OR_{adj}=0.45, 95% CI=0.23–0.89)[30]. These findings suggested that IPIs could occur in people of different ages and, in particular, young people were at higher risk of infection due to their poor personal hygiene practices like playing in dirt at young age, walking barefoot or eating foods without washing hands.

The prevalence of IPIs among the Myanmar migrant workers in the present study varied considerably according to the region/city in country of origin, in which the highest prevalence was found in the workers from West Myanmar and Lower Myanmar. This might be due to the difference in geography, temperature, and atmospheric humidity that have an effect on the growth and viability of helminth eggs and larvae, particularly soil-transmitted helminth[31–33]. Moreover, factors that facilitate the infection of helminths include poor sanitation systems in that area, such as lack of clean drinking water and proper toilets[3,4]. Many countries in Southeast Asia are among the poorest countries in the world, without adequate water and sanitation infrastructure and therefore, the parasites prosper in such environments[34,35]. Apart from the aforementioned factors, it was found that the risk factors for the infection of IPIs were the personal behaviors which differed depending on the culture, way of life and living conditions in each region, such as the habit of consuming raw or undercooked foods, hand-washing, untrimmed finger nails, shoe-wearers and use of toilet[35].

This study was a primary screening to perceive prevalence of parasite infection of Myanmar workers in Thailand. The formalin ethyl acetate method was a general laboratory method to discover the infection prevalence. Advantages of this method were high sensitivity and accuracy[36]. However, although the formalin ethyl acetate method is popular, this method is low sensitive to find out some parasites. For discovery of *S. stercoralis* and hookworm infection, Agar Plate Culture technique is more sensitive[37,38]. Moreover, this study found that the prevalence was quite low compared with other studies towards Myanmar workers in Thailand. This point indicated that the method that has low sensitivity might take the negative result. Therefore, for accurate results, researcher should select the method with high sensitivity of testing. In addition, the biomolecule confirmation is important and necessary to confirm the infection type (such as protozoa, hookworms, *Taenia* spp., and *Opisthorcis*/*Clonorchis* eggs), which may have implications for clinical and epidemiological outcomes which might be a worthwhile future research direction.

This research has documented the prevalence of IPIs in the Myanmar migrant workers residing in Nakhon Ratchasima Province, Northeast Thailand. The results showed that the majority of the helminths detected were the species that caused serious public health problems, adversely affecting the health of infected individuals. Thus, it requires relevant agencies pay close attention to health-status screening in migrant workers in order to prevent the transmission and incidence of new IPIs, thereby reduce the prevalence of the diseases. In addition, the risk factor associated with the increased rate of IPIs in the Myanmar migrant workers was those migrating from the region where IPIs in populations were undergoing epidemiological transition, as well as those residing in the area with poor sanitation, thus being at serious risk of spreading the diseases.

Conflict of interest statement

The authors declare no conflict of interests.

Acknowledgements

This research was supported by the Graduate Studies Division, Faculty of Medicine, Mahasarakham University, Maha Sarakham, Thailand; and Distinguished Research Professor Grant, Thailand Research Fund (grant number DPG6280002). The authors gratefully acknowledge the participants and factory owners for their cooperation. Thanks also goes to Prayong Radomyos, Faculty of Medicine, Mahasarakham University, Maha Sarakham, Thiland.

Authors’ contributions

W.S, T.T and N.R designed the study and carried out the study. W.S, T.T conducted laboratory analysis, interpreted the result and data analysis. W.S and T.T drafted and critically revised the manuscript. All the authors contributed to the final version of the manuscript.

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