Tropical Biomedicine 35(2): 453–463 (2018)

Opisthorchis viverrini infection among migrant workers in Nakhon Ratchasima province, Thailand, indicates continued need for active surveillance

Kaewpitoon, S.J.[1,2,3*], Sangwalee, W.[1,4], Kujapun, J.[1,4], Norkaew, J.[1,4], Wakkhuwatapong, P.[1], Chuatanam, J.[1,4], Loyd, R.A.[1,2,3], Pontip, K.[1,4], Ponphimai, S.[1,4], Chavengkun, W.[1,4], Padchasuwan, N.[1,5], Meererksom, T.[1,6], Tongtawee, T.[1,3], Matrakool, L.[1,3], Panpimanmas, S.[1,3] and Kaewpitoon, N.[1,3,4]

[1]Parasitic Disease Research Center, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand
[2]Family Medicine and Community Medicine, Institute of Medicine, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand
[3]Suranaree University of Technology Hospital, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand
[4]Faculty of Public Health, Vongchavalitkul University, Nakhon Ratchasima 30000, Thailand
[5]Faculty of Public Health, Khon Kaen University, Khon Kaen 40002, Thailand
[6]Business Computer, Faculty of Management Science, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima 30000, Thailand
[*]Corresponding author e-mail: soraya.k@sut.ac.th
Received 22 October 2017; received in revised form 18 December 2017; accepted 19 December 2017

Abstract. *Opisthorchis viverrini* is a serious problem in Thailand, Cambodia, the Lao People's Democratic Republic and Vietnam. Active surveillance and eradication of *O. viverrini* is required. A cross-sectional study of 403 immigrant workers was conducted between October 2016 and June 2017 in Nakhon Ratchasima, Thailand. Stool samples were analysed via the formalin-ether concentration technique, with subsequent data analysis performed using descriptive statistics and logistic regression. Overall infection was 24.1% and the results reveals an *O. viverrini* infection rate was 11.9%. *O. viverrini* infection was identified in 25.6% of Cambodians, 15.3% of Laotians and 3.6% workers from Myanmar sampled. The majority of infections were found in males, aged e"40 years and working as labourers. Raw or undercooked cyprinoid fish consumption was associated with an elevated risk for *O. viverrini* infection (OR_{adj} = 2.2, 95% CI = 1.2–4.0). Other intestinal helminthic infections were hookworm (5.5%), *Trichuris trichiura* (5.2%), *Strongyloid stercoralis* (0.5%), *Ascaris lumbricoides* (0.5%) and *Taenia* spp. (0.5%), respectively. This is the first study to report *O. viverrini* among immigrant workers in Thailand; therefore, active surveillance is needed among migrant workers to identify and treat *O. viverrini* infection.

INTRODUCTION

Opisthorchiasis caused by *Opisthorchis viverrini* is still a major health concern in many parts of Asia, particularly in parts of Southeast Asia, including the Lao People's Democratic Republic (PDR), Thailand, Cambodia and Vietnam (Jongsuksuntigul & Imsomboon, 2003; Sithithaworn *et al.*, 2012). Recent, estimates suggest that 9.3 million people suffer from liver fluke infections throughout the region (39.0% of the global number of cases), with opisthorchiasis accounting for 8.0 million – predominantly in the Lao PDR and Thailand – and clonorchiasis 1.3 million cases, almost exclusively in Vietnam (Furst *et al.*, 2012; Hotez *et al.*, 2015). *O. viverrini* infection is associated with hepatobiliary diseases, associated with mainly hepatomegaly, cholecystitis, gallstones and cholangitis (Thamavit *et al.*, 1978; Harinasuta *et al.*, 1984). Epidemiological and animal studies have demonstrated that *O. viverrini* infection

is strongly correlated with cholangiocarcinoma (CCA); with bile duct cancer affecting the intra-, extra-hepatic and distal bile duct (Sripa *et al*., 2007; Sripa *et al*., 2008; Shin & Oh, 2010). Recently, *O. viverrini* infection has classified by the International Agency for Research on Cancer, World Health Organization (2011), as a Type 1 carcinogen. There is a particularly high incidence of CCA in the northeast and northern region of Thailand, which is responsible for a significant burden of disease and mortality (Andrews *et al*., 2008). There are some evidence that suggests that fluke infections, are risk factors for CCA. Most of the incidence rates are found in Thailand (85/100,000 versus <0.5/100,000 in the Western world) (Hotez *et al*., 2015). An epidemiological study by Haswell-Elkins *et al.* (1994) describe an innovative strategy to quantify the risk of cancer associated with varying levels of exposure to chronic parasitic infection through the identification of asymptomatic cases of CCA within a population-based survey of *O. viverrini* infection. Fifteen preclinical cases of CCA were diagnosed from a total of 1,807 people based on ultrasonographic evidence with confirmation by endoscopy where possible. The prevalence odds of the diagnosis of CCA increased gradually within the light and moderate intensity groups. In contrast, sharply elevated prevalence odds (14.1, $p < 0.05$) were observed within the most heavily liver fluke-infected groups compared with the uninfected groups. Miwa *et al.* (2014) confirmed that the presence of the antibody against *O. viverrini* significantly increased the risk for CCA; odds ratio (OR) = 27.1 [95% CI: 6.3-116.6]. *O. viverrini*-induced CCA ranks first in mortality among cancers for men and second in women in the Mekong Basin sub-region (Andrew *et al*., 2008; Sithithaworn *et al*., 2012; Sripa *et al*., 2012). In animal model it indicates that *O. viverrini*-induced CCA. Occur after 12 weeks of infection with *O. viverrini*, the biliary epithelium of the hamster is markedly inflamed and displays fibrosis advancing along its length; and, more importantly, there is fibrotic deposition in the biliary epithelium that leads to CCA (Bhamarapravati *et al*., 1978; Chernrungroj 2000; Loilome *et al*., 2006; Nithikathkul *et al*., 2007; Sripa *et al*., 2012).

The spread of liver fluke infection in the region is due to the increased rate of migration among the Association of Southeast Asian Nations Economic Community (AEC) countries (i.e. Thailand, Lao PDR, Cambodia, Vietnam and Myanmar) and comes about as a result of the open borders policy that began in 2015 (Andrews *et al*., 2008). For this reason, *O. viverrini* constitutes an important health problem in many parts of Southeast Asia; consequently, the eradication of the liver fluke is urgently needed in these areas. A project was conducted among migrant workers in factories in Nakhon Ratchasima province, northeast Thailand. The aim of this study is to investigate the population at risk for *O. viverrini*, to treat the infection and to provide health education.

MATERIALS AND METHODS

Study Areas

A cross-sectional study was conducted among migrant workers located in Nakhon Ratchasima province, in the northeast region of Thailand (Figure 1). This is Thailand's largest province, by area (approx. 20,494 km^2 (7,913 mi^2), with a population of about 2.7 million (Thailand's second highest population). Nakhon Ratchasima is of considerable economic importance to Thailand, contributing about 250 billion baht in GDP, the highest in the northeast region. Nakhon Ratchasima also acts as a gateway to other provinces in the northeast. It is 259 km (161 mi) from Bangkok, the capital of Thailand. The province is divided into 32 districts, which are further subdivided into 263 sub-districts and 3,743 villages (Department of Provincial Affairs, 2015).

Study Population

A total of 7,966 migrant worker from Myanmar (N=4,267), Cambodia (N=2,670) and the Lao PDR (N=1,209), working in Sung Neon, Khon Buri and Pak Chong districts were invited to participate in the study

Figure 1. Study areas; Nakhon Ratchasima province, located in the northeast region of Thailand.

between October 2016 and June 2017. Most of migrant population are working in Thailand approximately 1-3 years. The sample size was calculated using the following formula:

$$n = \frac{Z^2{}_{\alpha/2}\, p(1\text{-}p)d}{e^2}$$

where n = sample size; p = prevalence or proportion of infection in immigrant worker (0.9) (Hotez *et al.*, 2015); $Z_{\alpha/2}$ = normal deviation for two-tailed alternative hypothesis at a level of significance of 1.96; e = precision margin of error (5%; 0.05); and d = design effect (2). After calculating the necessary sample size, 193 participants were identified from the study population of 7,966 potential participants. To ensure a better representation of the study populations, we doubled the number of participants to 403. Participants were selected based on their willingness to participate and the permission granted by their employers (three factories from three districts).

Questionnaire Survey

We also conducted a questionnaire survey of the participants. The questionnaire included questions on sociodemographic characteristics, consumption of dishes of raw cyprinoid fish and past history high-risk behaviours for *O. viverrini* infection (Cronbach's alpha coefficient = 0.8). All questionnaires were translated into Burmese, Cambodian and Laotian languages. Participants completed the questionnaires by themselves. The unbiased answers were quality control by cleared questionnaires and information from researchers and factory's collaborators.

Stool Collection and Examination

Stool specimens were collected in plastic containers and transferred to the laboratory at the Parasitic Disease Research Center, Suranaree University of Technology. The formalin-ether concentration technique (Allen & Ridley, 1970) was used to identify the presence of the *O. viverrini* eggs. Patients who were infected with *O. viverrini* or other known parasites were treated with anti-parasitic drugs and attended a health education session.

Data Analysis

Descriptive statistics were applied to determine the rate of opisthorchiasis infection. The X^2-test was used for computed different infection and characteristics. Unconditional multiple logistic regression was used to evaluate an odds ratio and confidence interval of 95% for participants being egg positive according to various characteristics. Statistical analyses were performed using SPSS WIN 22.0 software.

Ethical Considerations

This study was performed in accordance with the guidelines of the Declaration of Helsinki. The study protocol was approved by the Ethics Committee for Research Involving Human Subjects, Suranaree University of Technology (EC-59-39). All participants provided written informed consent before participating in the study. Permission was accepted from the owner factories. All participants found to be infected were treated

and health education for opisthorchiasis and other known intestinal helminthiasis was provided after examination. In cases of opisthorchiasis, participants were advised to attend for further CCA screening in the government hospital.

RESULTS

Among the 403 participants surveyed, 48 (11.9%) were found to be positive for *O. viverrini* infection. The rate of positive infection was higher in men (19.8%) than in women (8.7%). The majority of *O. viverrini* infections were found in participants aged ≥40 years (23.8%), uneducated (13.6%), married (13.7%) and working as labourers (12.0%). By nationality, *O. viverrini* infections were detected in Cambodian (25.6%), followed by Lao PDR (15.3%). Categorised according to district, the rate was highest in Pak Chong (27.2%), followed by Sung Neon (3.6%). No infections were found among migrant factory workers in the Khon Buri district. In addition, the rate of *O. viverrini* infection was highest among participants who consumed raw or undercooked cyprinoid fish (18.3%). Participant demographics and *O. viverrini* infections are summarised in Table 1.

Table 1. Positive rate of *O. viverrini* eggs categorised by general characteristics

Characteristics	Total	*O. viverini* Positive *n*(%)	X^2-test	*p*-value
Nationality				
Myanmar	223	8 (3.6)	54.0	0.001
Cambodia	121	31 (25.6)		
Lao PDR	59	9 (15.3)		
Gender				
Female	287	25 (8.7)	25.7	0.001
Male	116	23 (19.8)		
Age				
<40 years old	340	33 (9.7)	9.4	0.007
>40 years old	63	15 (23.8)		
Education				
Primary school	337	39 (11.6)	17.1	0.004
Uneducated	66	9 (13.7)		
Marital status				
Single	88	5 (5.7)	20.9	0.001
Married	315	43 (13.7)		
Occupation				
Housekeeper	19	2 (10.5)	19.5	0.002
Labourer	384	46 (12.0)		
Working periods in Thailand				
1 year	119	8 (6.7)	4.9	0.068
> 1 years	284	40 (14.1)		
Income (TH Baht)				
9000–12000	276	35 (12.7)	0.9	0.666
< 9000	127	13 (10.2)		
Factories site (District)				
Pak Chong district	147	40 (27.2)	52.5	0.001
Sung Neon	223	8 (3.6)		
Khon Buri	33	0		
Residency				
Private dormitory	12	3 (25.0)	20.5	0.001
Factory accommodation	391	45 (11.5)		

Post-data analysis, it was found that being male (OR=2.6; 95% CI=1.4–4.8; p-value= 0.002), aged ≥40 years (OR=2.9; 95% CI= 1.5–5.8; p-value=0.002) (Table 2), and the consumption of raw or undercooked cyprinoid fish (OR=2.2; 95% CI=1.2–4.0; p-value=0.014) were statistically significant risk factors positively associated with *O. viverrini* infection. The majority of raw or undercooked cyprinoid fish that was consumed by participants was eaten raw prickled (4.7%), fermented (4.5%) or medium fried (3.8%), respectively (Table 3).

Table 4 shows the type and frequency of intestinal helminthic eggs found in the faecal samples of the 403 participants. Among all 403 participants, 24.1% (97/403) were found to be infected by one or more helminthic organisms. By species, the detected parasites were *O. viverrini* (11.9%), followed by hookworm (5.5%), *Trichuris trichiura* (5.2%), *Strongyloides stercoralis* (0.5%), *Ascaris lumbricoides* (0.5%) and *Taenia* spp. (0.5%), respectively. Intestinal helminthic eggs were detected among the workers from Myanmar (22.9%), followed by Cambodia (22.3%) and the Lao PDR (22.0%). Soil-transmitted helminth infections (STHs) included *T. trichiura* (9.4%), hookworm (8.5%) and *A. lumbricoides* (0.9%), which was higher among worker from Myanmar than Cambodia or the Lao PDR.

Table 2. Significant risk factors positively associated with *O. viverrini* infection

Categories	Total	*O. viverini* Positive *n*(%)	X^2-test	*p*-value
Perception for opisthorchiasis information				
Yes	6	2 (33.3)	21.7	0.001
No	397	46 (11.6)		
Raw or undercooked cyprinoid fish consumption				
Yes	115	21 (18.3)	22.2	0.001
No	288	27 (9.4)		

Table 3. Behavioural risk for *O. viverrini* infection

Behaviours	Often *n*(%)	Sometimes *n*(%)	Never *n*(%)
Consumption of raw or undercooked cyprinoid fish	15 (3.7)	329 (81.6)	59 (14.6)
Consumption of medium fried cyprinoid fish	15 (3.7)	276 (68.5)	112 (27.8)
Consumption of raw fermented cyprinoid fish	18 (4.5)	327 (81.1)	58 (14.4)
Consumption of raw prickled fish	19 (4.7)	341 (84.6)	43 (10.7)
Consumption of raw minced cyprinoid fish	14 (3.5)	341 (84.6)	48 (11.9)
Consumption of raw cyprinoid fish salad	12 (3.0)	325 (80.7)	66 (16.4)
Raw cyprinoid fish scraps given to cat or dog	46 (11.4)	44 (10.9)	313 77.7)
Consumption of raw cyprinoid fish entrails	15 (3.7)	48 (11.9)	340 (84.4)
Defecation in sanitary latrine	369 (91.6)	17 (4.2)	17 (4.2)
Annual stool examination more than 3 years ago	37 (9.2)	27 (6.7)	339 (84.1)
Praziquantel used for liver fluke treatment	287 (71.2)	23 (5.7)	93 (23.1)
Hand washing after cooking cyprinoid fish	111 (27.5)	269 (66.8)	23 (5.7)
Raw cyprinoid fish scraps dumped in sanitary bin	77 (19.1)	308 (76.4)	18 (4.5)
Praziquantel used for cat and dog treatment	3 (0.7)	22 (5.5)	378 (93.8)
Participated liver fluke campaign	21 (5.2)	44 (10.9)	338 (83.6)

Table 4. Intestinal helminthic infection of 403 immigrant workers in Nakhon Ratchasima province, Northeastern Thailand

Nationality	No. Examined	No. Infection (%)	Intestinal Helminthic Infection (No. Infection (%))					
			O. viverrini	Hook-worm	*T. trichiura*	*S. stercoralis*	*A. lumbricoides*	*Taenia* spp.
Myanmar	223	51 (22.9)	8 (3.6)	19 (8.5)	21 (9.4)	1 (0.5)	2 (0.9)	0 (0)
Cambodia	121	33 (27.3)	31 (25.6)	1 (0.8)	0 (0)	1 (0.8)	0 (0)	0 (0)
Lao PDR	59	13 (22.0)	9 (15.3)	2 (3.4)	0 (0)	0 (0)	0 (0)	2 (3.4)
Total	**403**	**97 (24.1)**	**48 (11.9)**	**22 (5.5)**	**21 (5.2)**	**2 (0.5)**	**2 (0.5)**	**2 (0.5)**

DISCUSSION

This study investigated the population at risk for *O. viverrini* and was conducted among migrant workers in factories in Nakhon Ratchasima province, northeast Thailand. A recent study on migrant workers from Myanmar, Cambodia and the Lao PDR working in Nakhon Ratchasima, Thailand, showed a high rate (11.9%) of opisthorchiasis infection, for *O. viverrini*. In relation to nationality of migrant workers, *O. viverrini* infections were detected more commonly among in workers from Cambodia (25.6%), followed by the Lao PDR (15.3%) and Myanmar (3.4%). Opisthorchiasis has also been reported in Cambodia and the Lao PDR. *O. viverrini* is a common parasite found in central and southern Laos and constitutes a major public health problem in that country. Nonetheless, the people of Laos continue to habitually consume raw or half-cooked fish, which are the intermediate hosts for *O. viverrini*. Vonghachack *et al*. (2017), reported that the transmission rate of *O. viverrini* in the Mekong islands versus Southern Lao PDR, reported heavy intensity infections at a rate of 60.7% vs. 4.2%, respectively. Nakamura (2017) reported on the present situation of opisthorchiasis in the Lao capital of Vientiane. Stool samples 296 persons living in Phailom Village (population=1545 in 1999) were examined from 2011 to 2012, with the intestinal parasitism rate to be very high, from 54.0 to 59.0%. Among the intestinal infections, *O. viverrini* infection was observed at highest rate, from 51.0% to 53.0%. Saiyachak *et al*. (2016), in reported a prevalence of *O. viverrini* infection among the 237 population of Thakek district, Khammouane Province, Lao PDR, found an infection rate of 54.8%. In addition, field survey focused on *O. viverrini* infection in 55 villages in five Cambodian provinces. A total of 16,082 stool samples from the 55 villages were examined, 1,232 of which were egg positive. In 15 villages with egg-positive rates greater than 10.0%, eggs were found in 998 of 3,585 stool samples, for a total egg-positive rate of 27.8%.

In Cambodia, another study identified four Cambodian provinces as endemic areas for *O. viverrini* infection (Miyamoto *et al*., 2014). The prevalence of *O. viverrini* infection among people in seven riparian villages along the Mekong River, Kratie Province, has reported. The average *O. viverrini* egg-positive rate was 4.6%, the results provide evidence that the surveyed areas of Kratie Province are endemic with *O. viverrini* infection (Sohn *et al*., 2012). A similarly high prevalence of *O. viverrini* infection was reported among the riparian population of Takeo Province. The positive *O. viverrini* rate in the order of 46.4–50.6% (47.5%). These results confirm Cambodia as a region in which human *O. viverrini* infection is endemic.

Few studies have considered the prevalence of *O. viverrini* infection in Myanmar. A recent study by Aung *et al*. (2017) may be the first report of *O. viverrini* infection in human communities in Lower Myanmar. In this study, Aung *et al*. (2017) surveyed the stool samples of rural populations in three regions of Lower Myanmar, finding *Opisthorchis*-like eggs in 34 out of 364 (9.3%) participants, using a modified formalin-ether concentration

technique. Therefore, while our study might represent the second report of human *O. viverrini* infection in Myanmar, it is the first report concerning migrant workers from Myanmar living in Thailand. Our findings indicate that immigrants from Cambodia, the Lao PDR and Myanmar should be routinely screened for liver fluke infection, following which they should be provided with appropriate treatment and health education to offset the progression of disease, particularly CCA.

A cross-sectional analytic study of urban areas in the northeast of Thailand reveals a similar gender bias toward *O. viverrini* infection in males. In multivariate analysis, being male was found to be significantly and positively associated with *O. viverrini* infection (ORadj=9.8; 95% CI: 34.0–23.6) (Chaiputcha *et al*., 2015). In addition, Thaewnongiew *et al.* (2014), in reporting on the risk factors for opisthorchiasis in the upper northeast of Thailand, found the highest prevalence of infection was among 40–49 year olds. All age groups had a prevalence >20%. The factors related to opisthorchiasis infection were gender, age (especially >50), proximity and duration of living near a water body, and eating raw and/or fermented fish. Meanwhile, Saiyachak *et al*. (2016), in reporting on the factors associated with *O. viverrini* infection among residents of Thakek district, in Khammouane Province, found that the factors positively associated with *O. viverrini* infection were being male, married and older. These results were similar to other studies, mainly Sayasone *et al.* (2011) and Forrer *et al*. (2012). *O. viverrini* infection was also found to be highly prevalent in three riverside villages in the Prey Kabas District, Takeo Province, with infection rates ranging 46.4–50.6% (47.5%). The prevalence of *O. viverrini* eggs appears lower in younger individuals (<20 years) than in the adult population (>20 years). Men (50.4%) are more commonly infected (P=0.02) than women (44.3%).

Yong *et al.* (2012) revealed a particularly high rate of human *O. viverrini* and *C. sinensis* in Cambodia. This may be related to certain cultural practices in Cambodia, in which drinking alcohol and consuming raw cyprinoid fish are more common among men than among women (June *et al*., 2013). Differences among age groups were significant, with those in their 40s showing a somewhat higher positive rate. Because the survival period of *O. viverrini* is over 30 years, if infected persons are not adequately treated, they are likely to experience similar rates of reinfection and complications comparable to *C. sinensis* (Kim *et al*., 2006; June *et al*., 2013). As such, the high positive rate in those over 40 years of age might reflect a history of unsuccessful treatments or repeated reinfections. A positive rate in the order of 16% (approx.) in those with a previous history of infection indicates possible reinfection. Other studies report a higher rate of *C. sinensis* infection among the aged and, as a result of treatment effects, highest among those in their 50s and 60s, but decreasing thereafter (Ju *et al*., 2005; Kim *et al*., 2006; June *et al*., 2013). Categorised according to working factories area, the rate of infection was highest in the Pak Chong district (27.2%), followed by the Sung Neon district (3.6%). These districts are densely populated with factories and several of these factories employ almost entirely immigrant workers. The high rate of infection seems to be influenced by worker habits, number of workers and their risk behaviours.

The results of the logistic analysis consistently reveal that raw cyprinoid fish consumption increases the risk of *O. viverrini* infection. Positive infections were seen in a disproportionate number of participants who had eaten raw fish cyprinoid fish or related dishes. This result is consistent with earlier studies that reveal eating raw and/or fermented fish is related to opisthorchiasis infection (Rangsin *et al*., 2009; Wattanayingcharoenchai *et al*., 2011; Yong *et al*., 2012; Thaewnongiew *et al*., 2014; Saiyachak *et al*., 2016; Vonghachack *et al*., 2017). These results suggest that the process of infection might be difficult to disrupt because the factors that promote infection are so deeply embedded within cultural practices, eating practices having been proven extremely difficult to change. Moreover, the high prevalence of liver fluke in canine and feline reservoir hosts makes

the fluke life cycle virtually impossible to disrupt. While liver fluke infections can be treated with praziquantel, individuals will often become re-infected, and multiple reinfections can be more harmful than a singular, long-term infection (Hughes *et al*., 2017). Opisthorchiasis prevention and control can only be achieved through transdisciplinary, inter-university social engagement and sustainable community participation (Kaewpitoon *et al*., 2017).

STHs are still a major problem in Southeast Asia. Pullan *et al*. (2014) reported that 126.7 million people in Southeast Asia are infected with *Ascaris* roundworms, while 115.3 million are infected with *Trichuris* whipworms and 77.0 million have hookworm infections. Therefore, approximately one-half of the Southeast Asian population living in poverty have one or more STHs. In our study, intestinal helminthic eggs were found in the faecal samples of workers from Myanmar (22.9%), followed by Cambodia (22.3%) and the Lao PDR (22.0%). Overall STH infection was 11.7%, with many infected by one or more helminthic parasites. STHs, including *T. trichiura* (9.4%), hookworm (8.5%) and *A. lumbricoides* (0.9%), where more frequent among workers from Myanmar than Cambodia or the Lao PDR. By species, the detected parasites were hookworm (5.5%), followed by *T. trichiura* (5.2%), *S. stercoralis* (0.5%) and *A. lumbricoides* (0.5%), respectively. Food borne helminthiasis, *Taenia* spp. was found at a rate of 0.5%. This of intestinal helminthic infection among immigrant workers in the northeaster region of Thailand is perhaps the largest study of its kind in Thailand. Active surveillance or screening for intestinal parasitic infection among immigrant workers in Thailand is lacking. Several investigations have surveyed in immigrant populations in central Bangkok. Sagnuankiat *et al*. (2016), in determining the prevalence of intestinal parasitic infections among a sample of 372 immigrant children at eight daycare centres in Samut Sakhon province, central of Thailand, found a 71.0% prevalence for intestinal parasitic infections. These infections comprised both helminths and protozoa: *T. trichiura* (50.8%), *Enterobius vermicularis* (25.2%), *A. lumbricoides* (15.3%), hookworm (11.6%), *Giardia lamblia* (10.2%), *Endolimax nana* (3.5%), *E. coli* (2.7%) and *Blastocystis hominis* (0.5%). Ngrenngarmlert *et al*. (2012), in determining the prevalence of intestinal parasites within a sample of 213 Myanmar migrant workers in Bangkok and Samut Sakhon provinces, found the overall prevalence of intestinal parasitic infections was 13.6%. Helminthes (10.3%) were more commonly found than protozoa (8.50%). Migrant workers in the Ngrenngarmlert *et al*. (2012) study were predominantly infected with the faecal-oral transmitted parasites: *E. histolytica/dispa* (3.8%), *A. lumbricoides* (3.3%) and *T. trichiura* (2.3%). The high prevalence of intestinal parasites (17.2%) was found among migrant workers living in Bangkok. Nuchprayoon *et al*. (2009) performed a study of intestinal parasitic infections in 284 migrant workers from Myanmar working in the Thai food industry in Samut Sakhon province. They found parasites in 177 (62.3%) migrants (29 of 46 males; 148 of 238 females). The majority (89.3%) were infected with parasites transmitted via the faecal-oral route, including *B. hominis* (41.5%), *T. trichiura* (22.2%), *G. lamblia* (14.1%) and *A. lumbricoides* (1.8%). Such a high rate of parasitic infection among migrant workers represents an obvious public health risk. The impact of intestinal parasitic infections on public health is well known, with the potential to spread from infected migrant areas to uninfected areas via close contact and the faecal-oral transmission of contaminated food and water. These results indicate that intestinal helminthic infections are a serious public health problem.

In conclusion, this study is the first report regarding *O. viverrini* in migrant workers in Thailand. *O. viverrini* and other intestinal helminthic infections are endemic among immigrant worker because of various behavioural risk factors, many of which are deeply culturally embedded. Therefore, health education is required in high-risk groups. In addition, active surveillance of migrant workers is needed to promote early disease identification and eradication.

Acknowledgements. The authors are grateful to all participants and owner factories for their corporation. This study was supported by the SUT research and development fund, Suranaree University of Technology (SUT), Thailand.

Conflict of Interest:
The authors declare that they have no conflict of interest.

REFERENCES

Allen, A.V.H. & Ridley, D.S. (1970). Further observations on the formol-ether concentration technique for faecal parasites. *Journal of Clinical Pathology* **23**(6): 545-546.

Andrews, R.H., Sithithaworn, P. & Petney, T.N. (2008). *Opisthorchis viverrini*: an underestimated parasite in world health. *Trends in Parasitology* **24**(11): 497-501.

ASEAN Secretariat hwao. (2014). Association of Southeast Asian Nations. http://www.asean.org/. Accessed February 13, 2017.

Aung, W.P.P., Htoon, T.T., Tin, H.H., Thinn, K.K., Sanpool, O., Jongthawin, J., Sadaow, L., Phosuk, I., Rodpai, R., Intapan, P.M. & Maleewong, W. (2017). First report and molecular identification of *Opisthorchis viverrini* infection in human communities from Lower Myanmar. *PLoS One* **12**(5): e0177130.

Bhamarapravati, N., Thammavit, W. & Vajrasthira, S. (1978). Liver changes in hamsters infected with a liver fluke of man, *Opisthorchis viverrini*. *Am J Trop Med Hyg* **27**(4): 787-794.

Chaiputcha, K., Promthet, S. & Bradshaw, P. (2015). Prevalence and risk factors for infection by *Opisthorchis viverrini* in an urban area of Mahasarakham Province, Northeast Thailand. *Asian Pacific Journal of Cancer Prevention* **16**(10): 4173-4176.

Chernrungroj, G. (2000). Risk factor for cholangiocarcinoma: a case control study: Doctoral Dissertation to the Faculty of the Graduate School, Yale University, Connecticut, USA.

Department of Provincial Affairs (DOPA) Thailand (in Thai). Population of the Kingdom 2014-12-31. Retrieved February 13, 2017.

Feng, M. & Cheng, X. (2017). Parasite-associated cancers (blood flukes/liver flukes). *Advance Experimental Medical Biology* **1018**: 193-205.

Furst, T., Keiser, J. & Utzinger, J. (2012). Global burden of human food-borne trematodiasis: a systematic review and meta-analysis. *Lancet Infectious Disease* **12**(3): 210-221.

Grundy-Warr, C., Andrews, R.H., Sithithaworn, P., Petney, T.N., Sripa, B., Laithavewat, L. & Ziegler, A.D. (2012). Raw attitudes, wetland cultures, life-cycles: socio-cultural dynamics relating to *Opisthorchis viverrini* in the Mekong Basin. *Parasitology International* **61**(1): 65-70.

Haswell-Elkins, M.R., Mairiang, E., Mairiang, P., Chaiyakum, J., Chamadol, N., Loapaiboon, V., Sithithaworn, P. & Elkins, D.B. (1994). Cross-sectional study of *Opisthorchis viverrini* infection and cholangiocarcinoma in communities within a high-risk area in northeast Thailand. *Int J Cancer* **59**(4): 505-509.

Harinasuta, T., Riganti, M. & Bunnag, D. (1984). *Opisthorchis viverrini* infection: pathogenesis and clinical features. *Arzneimittelforschung* **34**(9B): 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 Neglected Tropical Disease* **9**(4): e0003575.

Hughes, T., O'Connor, T., Techasen, A., Namwat, N., Loilome, W., Andrews, R.H., Khuntikeo, N., Yongvanit, P., Sithithaworn, P. & Taylor-Robinson, S.D. (2017). Opisthorchiasis and cholangiocarcinoma in Southeast Asia: an unresolved problem. *International Journal of General Medicine* **10**: 227-237.

International Agency for Research on Cancer, World Health Organization. (2011). IARC Working Group on the Evaluation of Carcinogenic Risks to Humans: Infection

with liver flukes (*Opisthorchis viverrini*, *Opisthorchis felineus* and *Clonorchis sinensis*). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans* **61**: 121-175.

Jongsuksuntigul, P. & Imsomboon, T. (2003). Opisthorchiasis control in Thailand. *Acta Tropica* **88**(3): 229-32.

Ju, Y.H., Oh, J.K., Kong, H.J., Sohn, W.M., Kim, J.I., Jung, K.Y., Kim, Y.G. & Shin, H.R. (2005). Epidemiologic study of *Clonorchis sinensis* infestation in a rural area of Kyongsangnam-do, South Korea. *Journal of Prevention Medicine and Public Health* **38**(4): 425-430.

June, K.J., Cho, S.H., Lee, W.J., Kim, C. & Park, K.S. (2013). Prevalence and risk factors of clonorchiasis among the populations served by primary healthcare posts along five major rivers in South Korea. *Osong Public Health and Research Perspectives* **4**(1): 21-26.

Kaewpitoon, S.J., Kaewpitoon, N., Matrakool, L., Tongtawee, T., Panpimanmas, P., Norkaew, J., Kujapun, J., Sangwalee, W., Ponphimai, S., Poochaya, S., Junpirom, S., Kompor, P., Pathisena, T., Eksanti, T., Poolsripradist, P., Chavengkun, W., Udompron, T., Udomporn, P., Prathamyo, J., Pongpanpaenpanga, P., Taangpanich, P., Padchasuwan, N., Chan-Aran, S., Loyd, A.R. & Wakkhuwatapong, P. (2017). Prevention and control of the carcinogenic human liver fluke through transdisciplinary and university community engagement. Proceeding of The Asian Symposium on Healthcare without Borders, which held jointly with the International Conference on Advancing the Life Sciences and Public Health Awareness (ALPHA), 1–3 August 2017 at Hiroshima KKR Hotel, Hiroshima, Japan.

Kim, H.K., Cheun, H.I., Cheung, B.S., Lee, K.Y., Kim, T.S., Lee, S.E., Lee, W.J. & Cho, S.H. (2010). Prevalence of *Clonorchis sinensis* infections along the five major rivers in Republic of Korea in 2007. *Osong Public Health and Research Perspectives* **1**(1): 43-49.

Miwa, M., Honjo, S., You, G., Tanaka, M., Uchida, K., Srivatanakul, P., Khuhaprema, T., Loilome, W., Techasen, A., Wongkham, C., Limpaiboon, T., Yongvanit, P. & Wongkham, S. (204). Genetic and environmental determinants of risk for cholangiocarcinoma in Thailand. *World J Gastrointest Pathophysiol* **5**(4): 570-578.

Loilome, W., Yongvanit, P., Wongkham, C., Tepsiri, N., Sripa, B., Sithithaworn, P., Hanai, S. & Miwa, M. (2006). Altered gene expression in *Opisthorchis viverrini*-associated cholangiocarcinoma in hamster model. *Mol Carcinog* **45**(5): 279-287.

Miyamoto, K., Kirinoki, M., Matsuda, H., Hayashi, N., Chigusa, Y., Sinuon, M., Chuor, C.M. & Kitikoon, V. (2014). Field survey focused on *Opisthorchis viverrini* infection in five provinces of Cambodia. *Parasitology International* **63**(2): 366-373.

Nakamura, S. (2017). Present situation of opisthorchiasis in Vientiane capital, Lao Peoples' Democratic Republic. *Nihon Eiseigaku Zasshi* **72**(2): 101-105.

Ngrenngarmlert, W., Kritsiriwuthinan, K. & Nilmanee, N. (2012). Prevalence of intestinal parasitic infections among Myanmar workers in Bangkok and Samut Sakhon. *Asia Journal of Public Health* **3**(2): 53-58.

Nithikathkul, C., Tesana, S., Sithithaworn, P. & Balakanich, S. (2007). Early stage biliary and intrahepatic migration of *Opisthorchis viverrini* in the golden hamster. *J Helminthol* **81**(1): 39-41.

Nuchprayoon, S., Sanprasert, V., Kaewzaithim, S. & Saksirisampant, W. (2009). Screening for intestinal parasitic infections among Myanmar migrant workers in Thai food industry: a high-risk transmission. *Journal of Immigrant Minority Health* **11**(2): 115-121.

Pullan, R.L., Smith, J.L., Jasrasaria, R. & Brooker, S.J. (2014). Global numbers of infection and disease burden of soil-transmitted helminth infections in 2010. *Parasite Vectors* **7**(37): 1-19.

Rangsin, R., Mungthin, M., Taamasri, P., Mongklon, S., Aimpun, P., Naaglor, T. & Leelayoova, S. (2009). Incidence and risk factors of *Opisthorchis viverrini* infections in rural community in Thailand. *American Journal of Tropical Medicine and Hygiene* **81**(1): 152-155.

Sagnuankiat, S., Wanichsuwan, M., Bhunnachet, E., Jungarat, N., Panraksa, K., Komalamisra, C., Maipanich, W., Yoonuan, T., Pubampen, S., Adisakwattana, P. & Watthanakulpanich, D. (2016). Health status of immigrant children and environmental survey of child daycare centers in Samut Sakhon province, Thailand. *Journal Immigrant Minority Health* **18**(1): 21-27.

Saiyachak, K., Tongsotsang, S., Saenrueang, T., Moore, M.A. & Promthet, S. (2016). Prevalence and factors associated with *Opisthorchis viverrini* infection in Khammouane province, Lao PDR. *Asian Pacific Journal of Cancer Prevention* **17**(3): 1589-1593.

Sayasone, S., Mak, T.K., Vanmany, M., Rasphone, O., Vounatsou, P., Utzinger, J., Akkhavong, K. & Odermatt, P. Helminth and intestinal protozoa infections, multiparasitism and risk factors in Champasack province, Lao People's Democratic Republic. *PLoS Neglected Tropical Disease* **5**(4): e1037.

Shin, H.R., Oh, J.K., Masuyer, E., Curado, M.P., Bouvard, V., Fang, Y.Y., Wiangnon, S., Sripa, B. & Hong, S.T. (2010). Epidemiology of cholangiocarcinoma: an update focusing on risk factors. *Cancer Science* **101**(3): 579-575.

Sithithaworn, P., Andrews, R.H., Nguyen, V.D., Wongsaroj, T., Sinuon, M., Odermatt, P., Nawa, Y., Liang, S., Brindley, P.J. & Sripa, B. (2012). The current status of opisthorchiasis and clonorchiasis in the Mekong Basin. *Parasitology International* **61**(1): 10-16.

Sohn, W.M., Yong, T.S., Eom, K.S., Pyo, K.H., Lee, M.Y., Lim, H., Choe, S., Jeong, H.G., Sinuon, M., Socheat, D. & Chai, J.Y. (2012). Prevalence of *Opisthorchis viverrini* infection in humans and fish in Kratie Province, Cambodia. *Acta Tropica* **124**(3): 215-220.

Sripa, B., Kaewkes, S., Sithithaworn, P., Mairiang, E., Laha, T., Smout, M., 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 Medicine* **4**(7): e201.

Sripa, B. & Pairojkul, C. (2008). Cholangiocarcinoma: lessons from Thailand. *Current Opinion Gastroenterology* **24**(3): 349-56.

Sripa, B. & Brindley, P.J., Mulvenna, J., Laha, T., Smout, M.J., Mairiang, E., Bethony, J.M. & Loukas, A. (2012). The tumorigenic liver fluke *Opisthorchis viverrini*-multiple pathways to cancer. *Trends in Parasitology* **28**(10): 395-407.

Thaewnongiew, K., Singthong, S., Kutchamart, S., Tangsawad, S., Promthet, S., Sailugkum, S. & Wongba, N. (2014). Prevalence and risk factors for *Opisthorchis viverrini* infections in upper Northeast Thailand. *Asian Pacific Journal of Cancer Prevention* **15**(16): 6609-6612.

Thamavit, W., Bhamarapravati, N., Sahaphong, S., Vajrasthira, S. & Angsubhakorn, S. (1978). Effects of dimethylnitrosamine on induction of cholangiocarcinoma in *Opisthorchis viverrini*-infected Syrian golden hamsters. *Cancer Research* **38**(12): 4634-9463.

Vonghachack, Y., Odermatt, P., Taisayyavong, K., Phounsavath, S., Akkhavong, K. & Sayasone, S. (2017). Transmission of *Opisthorchis viverrini*, *Schistosoma mekongi* and soil-transmitted helminthes on the Mekong Islands, Southern Lao PDR. *Infectious Disease Poverty* **6**(1): 131.

Yong, T.S., Shin, E.H., Chai, J.Y., Sohn, W.M., Eom, K.S., Lee, D.M., Park, K., Jeoung, H.G., Hoang, E.H., Lee, Y.H., Woo, H.J., Lee, J.H., Kang, S.I., Cha, J.K., Lee, K.H., Yoon, C.H., Sinuon, M. & Socheat, D. (2012). High prevalence of *Opisthorchis viverrini* infection in a riparian population in Takeo Province, Cambodia. *Korean Journal of Parasitology* **50**(2): 173-176.