Chapter 12
Epidemiology of Cestode and Trematode in Southeast Asian Countries

Zurainee Mohamed-Nor

Abstract Taeniasis/cysticercosis, schistosomiasis, and food-borne trematodiasis have been the major public health problem particularly in Southeast Asia. Data on these diseases for Southeast Asian countries were presented (excluding countries like Brunei Darussalam and Timor-Leste where data was hardly available). Among the countries that indicated high prevalence of such diseases are Lao PDR, Vietnam, Cambodia, Thailand, Indonesia, and the Philippines. Prevalence of taeniasis/cysticercosis (>10 %) was seen in countries like Cambodia, Indonesia, the Philippines, and Vietnam. Schistosomiasis was found highest in Khong Island, Lao PDR (26.8 %). It was also reported in few other countries but with lower prevalence. Vietnam and Thailand demonstrated high prevalence of clonorchiasis, 32.2 % and 23 %, respectively. The prevalence of opisthorchiasis was found very high especially in Lao PDR (85 %) and Thailand (70.8 % in Khon Kaen District and 64 % in central Thailand). Lao PDR was also shown as having the highest prevalence for fascioliasis (13.8 %) and paragonimiasis (51 %) compared to other countries like Vietnam and Thailand.

12.1 Introduction

Parasitic infections (food-borne, water-borne, vector-borne, and soil-borne) are common and widely distributed in the Southeast Asian countries. Basically, their distribution, prevalence, and severity are very much influenced by geography, environment, economic development of the countries, the population's religious and social beliefs, and types of government that rule the country. For example, in countries where increasing economic prosperity and accompanying infrastructure are present, parasitic diseases are almost nonexistent. Religious proscription on

Z. Mohamed-Nor (✉)
Department of Parasitology, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia
e-mail: zurainеemn@um.edu.my

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consumption of certain animals also helped to curb food-borne infection, while culturally deeply rooted habit of eating raw or undercooked foodstuffs, coupled with inadequate hygiene practices and lack of separation between foodstuff and wildlife, have hampered efforts to prevent and control infections effectively.

This chapter provides a brief review on the epidemiology of cestode and trematode infections in Southeast Asian countries.

12.2 Cestode

There are three medically important species of cestode, namely *Taenia saginata* (beef tapeworm), *T. solium* (pork tapeworm), and *T. asiatica* (Asian tapeworm) in Southeast Asia [1–4]. These parasites cause human taeniasis, a disease which is still common and shown as relatively serious public health problem not only in Southeast Asia but worldwide.

Taeniasis in human due to *T. saginata* and *T. asiatica* is caused by eating uncooked or undercooked beef and viscera of swine contaminated with metacestodes of these species, respectively. Metacestodes of *T. asiatica* may develop not only in pigs but also in cattle and goats [5, 6]. *Taenia solium* taeniasis in human is caused by eating uncooked or undercooked pork contaminated with the metacestodes of this species. Persons who do not eat raw or undercooked beef or pork are not likely to get taeniasis. Symptoms are usually mild or nonexistent causing many people with taeniasis to be unaware of the infection.

Taeniasis due to *T. solium* is more prevalent especially in underdeveloped communities due to practice of eating raw or undercooked pork, uncooked vegetables, poor sanitation, and free roaming of pigs due to poor pig husbandry practice. It is therefore widespread in Asia, including China, Indonesia, Nepal, India, South Korea, Thailand, Cambodia, Lao PDR, and Vietnam [1, 2, 7–12].

Taenia solium taeniasis can also lead to a parasitic tissue infection caused by the larval cysts of this tapeworm known as cysticercosis. Cysticercosis is regarded as one of the most important zoonotic diseases in the world affecting approximately 50 million people worldwide. Some 50,000 of those infected die of cysticercosis annually [13, 14] making pork seemed unsafe to consume. It usually occurs when sanitation is poor, meat inspection is not performed or inadequate, and proper pig farming is not implemented.

When eggs that are released from *T. solium* are ingested by humans, pigs, or dogs, the hatched oncospheres develop into cysticerci in many tissues and organs and cause various types of cysticercosis. This larval cyst may form in the brain causing neurocysticercosis leading to seizures, epilepsy, neurological sequelae, or death [15–17]. Another relatively serious type of cysticercosis is ophthalmic cysticercosis which often causes a high degree of visual impairment. An asymptomatic type of cysticercosis is subcutaneous or muscle cysticercosis.

Table 12.1 Prevalence data of taeniasis/cysticercosis in Southeast Asian countries

Country	Prevalence of taeniasis/cysticercosis	Year reported	Reference
Cambodia	21.7 %	2009	[24]
Indonesia	8–51 % (Papua)	2003	[25]
	23.5–56.9 % (central highlands of Papua)	2009	[26]
Lao PDR	0–14 %	2008	[18]
	1.1 % (Northern Lao PDR)	2009	[24]
	2.2 % (cysticercosis), 8.4 % (taeniasis)	2011	[27]
Malaysia	2.2 % (Ranau, East Malaysia)	2006	[28]
Myanmar	6 %	1981	[29]
Philippines	24.6 %	2011	[27]
Thailand	0.2–7.0 %	2007	[1, 2]
Vietnam	5.7 %	2000	[30]
	2.2–7.2 % (cysticercosis), 1.0–12.6 % (taeniasis) (in Bac Kan and Bac Ninh)	2002	[31]
	15.8 % (cysticercosis), 30 % (taeniasis) (in Hanoi)	2003	[12]

Cysticercosis is not only confined to people who raise or consume pork since people are also at risk if they ingest *T. solium* eggs after coming into direct or indirect contact with tapeworm carriers.

Together, taeniasis and cysticercosis occur globally. Many studies have been conducted in the Asian countries, which clearly indicated that the disease is spreading widely in the region [7, 9, 12, 18–23]. Wide variation in the prevalence was observed in association with poverty, pork consumption, and poor pig husbandry. Cysticercosis therefore has been confirmed as a serious threat to human health in many areas of the Southeast Asia region. Table 12.1 showed the prevalence data of taeniasis/cysticercosis in Southeast Asian countries.

12.3 Cambodia

Based on a survey performed from 2007 to 2008, the prevalence of taeniasis in Cambodia was 21.7 % [24].

12.4 Indonesia

Indonesia is one of the countries in Southeast Asia that is endemic with all three species of human *Taenia* tapeworms [32]. *Taenia solium* taeniasis/cysticercosis has been found in several areas of Indonesia mainly in Bali, Papua, and North Sumatra.

Bali is also found to be endemic for *T. saginata* taeniasis [33–35]. Other areas reported of having *T. solium* cysticercosis were Lampung, Jakarta, East Java, West Kalimantan, East Kalimantan, North Sulawesi, South Sulawesi, and Southeast Sulawesi [36–39]. There were also reports that indicated *T. asiatica* endemicity in North Sumatra [21, 22, 34, 35, 40].

Although Indonesia is known for its largest number of Muslim population (88 %) in the world, it was in the regions where most people are Christians or Hindus; hence, higher incidence of *T. solium* taeniasis and cysticercosis were detected [15, 16, 34, 35, 39]. Here, improper cooking of infected pork and reliance upon traditional sanitary are practiced. People generally defecate in their house yards and garden and allow free roaming of pigs to clear the excrement at night time, the use of human feces for fertilizer, inadequate meat inspection coupled with poor control of infected carcasses, and poor hygiene expose human populations to these infections.

In Bali, although the transmission and prevalence have been reported as decreasing dramatically over the years [21, 22, 33–35], recent study showed that taeniasis is still endemic based on a survey conducted from 2002 to 2009 that demonstrated sizable number of *T. saginata* taeniasis cases, dual (*T. saginata*/*T. solium*) infections with *T. solium* metacestodes in the brain, and a dozen of neurocysticercosis (NCC) cases, detected at Sanglah Hospital, Denpasar [41]. A case of ocular cysticercosis was also reported [42]. Here, the traditional dish "lavar," made of minced raw pork mixed with coconut and spices, is commonly consumed.

Cysticercosis and taeniasis in Papua could still be considered as one of the highest in the world. With earlier studies by various workers showed intestinal *T. solium* infection was found varied from 8 to 51 % [25, 34, 35, 43, 44], later study still demonstrated high prevalence of cysticercosis (23.5–56.9 %) in the central highlands of Papua [26]. In fact, these researchers believed that based on the data they observed, the prevalence of cysticercosis and taeniasis here was unchanged from that reported nearly 35 years ago at the beginning of cysticercosis/taeniasis epidemics in Papua.

As far as North Sumatra is concerned, *T. asiatica* is the only species reported specifically from Samosir Island in Lake Toba [45]. Survey conducted 30 years later showed a dramatic reduction of *T. asiatica* taeniasis cases and the reason for that significant reduction was the change of practice in the preparation of pork-based dishes as part of public health education where pork was no longer consumed uncooked. Pigs were also kept indoor, distant away from human feces [20]. Based on latest studies, *T. asiatica* is still found endemic in North Sumatra [21, 22, 34, 35].

12.5 Lao PDR

Despite of limited data available, there is a high degree of spatial and some evidence of temporal variation in taeniasis prevalence in Lao PDR based on several studies conducted between 1989 and 2004 [46–49]. The prevalence was found to

vary from 0 to 14 % [18]. These studies however did not provide enough information to determine the cause of infection although old data ([50] cited by Dorny et al. [7]) indicated *T. solium* and *T. saginata* as the common causes. During the nationwide survey conducted between 2000 and 2008, *T. solium* infection was revealed as 1.1 % in Luangprabang province in northern Lao PDR [24]. In the same year, 15 specimens from Savannakhet and Khammouane were confirmed as being *T. saginata* analyzed by Cox1 sequence and multiplex PCR [40].

There was hardly any data on prevalence and incidence of human cysticercosis apart from a case report on a 43-year-old lady from Xiengkhouang Province seen at Mahosot Hospital in Vientiane Capital which was confirmed positive for cysticercosis after brain CT scan demonstrated radiological features compatible with neurocysticercosis [51]. Another case of a male patient with neurocysticercosis was reported from Oudomxay in the northern territory [24].

Several other patients presenting similar neurological condition could not be confirmed since serological confirmation were not performed to rule out tuberculosis since these patients live in *M. tuberculosis* endemic area [52]. Only recently, by the utilization of antigen capture ELISA, cysticercosis prevalence in Lao PDR was determined to be 2.2 %. They also estimated the prevalence of taeniasis to be 8.4 % with *T. saginata* as the dominant species (94 %) detected using PCR method [27].

Taenia solium has only been reported in the northern part of Lao PDR, whereas *T. saginata* was reported in central Lao PDR [53]. *Taenia asiatica* taeniasis has not yet been detected in Lao PDR. Nonetheless, with *T. asiatica* known to be present in the neighboring countries (Thailand and Vietnam and Yunnan province of China), *T. asiatica* is suspected to exist in Lao PDR [24], and detection should be possible if more sensitive method such as molecular method is employed.

12.6 Malaysia

Cysticercosis has been said to be rare in Malaysia since most Malaysians are Muslim. There was however considerable consumption of pork among Malaysian particularly among the Chinese population [54].

Few cysticercosis cases detected in Malaysia were among the migrants [55, 56]. There was however a case of neurocysticercosis involving a Malaysian Muslim who denied ever eating or in contact with pork [57]. Such infection could be attributed to the transmission of *T. solium* eggs via infected immigrant workers employed as food handlers. A case of Malaysian lady having subretinal cysticercosis was also reported and most likely infection was obtained during her visit to China [58].

A survey done on Malaysian population in Ranau, Sabah demonstrated 2.2 % positive for cysticercosis antibody out of 135 samples tested [28]. According to

Conlan et al. [27], however, this study may have underestimated the seroprevalence in Ranau which was believed to be greater than 10 %.

12.7 Myanmar

The only published study could be found pertaining to cysticercosis in Myanmar was dated more than 20 years ago based on serological study in a local population. Six percent of the population was found positive for cysticercosis antibodies [29].

12.8 Philippines

Not much data on human cysticercosis was available from the Philippines. A seroprevalence survey in the Macanip community indicated a presence of 24.6 % cysticercosis antibody [27].

12.9 Singapore

There has been no documented data found on taeniasis/cysticercosis in Singapore thus far. Nonetheless, due to the influx and efflux of tourists, Singapore is considered "at risk" for taeniasis/cysticercosis. Interestingly, its economic prosperity and up-to-date infrastructure seem to have made not only cysticercosis/taeniasis but other parasitic diseases almost nonexistent in this country.

12.10 Thailand

In Thailand, taeniasis caused by *T. saginata* and *T. solium* is common with infection rate as shown by the national data to be between 0.2 and 7.0 % [1, 2]. High infection rates came from the north [59–61] and the northeast areas [60, 62, 63] of the country where consumption of raw and undercooked meat is a custom in these regions. According to the data, infection rates in other regions (the central and the south) were found to be relatively low compared to the north and the northeast regions.

Cases of cysticercosis have also been reported in Thailand with the number of neurocysticercosis cases being higher compared to the subcutaneous cysticercosis [11]. Studies also showed, like taeniasis cases, cysticercosis cases were also mainly from the northern provinces, followed by central, northeast, east, and the south regions [64, 65].

Later study on taeniasis and cysticercosis performed in Kanchanaburi Province showed that not only *T. solium* and *T. saginata* were causing the infection but for the first time, *T. asiatica* was also detected. The study confirmed sympatrically occurring of *T. solium*, *T. saginata*, and *T. asiatica* in the study area [1, 2, 66]. *Taenia asiatica* has been reported earlier in other Asian countries such as Taiwan, the Republic of Korea, China, the Philippines, Indonesia, and Vietnam [15, 16, 20, 34–36].

12.11 Vietnam

Cysticercosis is widespread in North Vietnam and was concluded to have become a serious health problem in the country [12]. The disease is often seen in male adults but none in children [12, 67]. Serological study performed in North Vietnam showed 5.7 % of its population was positive against cysticercosis [30].

Survey conducted based on fecal and serology in the Bac Kan and Bac Ninh provinces showed 1.0–12.6 % of taeniasis and 2.2–7.2 % of cysticercosis [31].

CT scan of brain on the other hand indicated higher percentage of infection (15.8 %) in Hanoi alone with 30 % of those infected had taeniasis suggesting high rate of autoinfection [12]. In Vietnam, the disease was found to be caused by all *Taenia* species with *T. asiatica* being the highest (55.4 %), followed by T. *saginata* (38.5 %) and *T. solium* (6.2 %) [68].

12.12 Trematode

12.12.1 Schistosome spp.

In Southeast Asia, there are three schistosome species recognized as infecting humans. They are *Schistosoma japonicum*, *S. mekongi*, and *S. malayensis*. The disease, schistosomiasis, poses a public health problem in several Southeast Asian countries. *Schistosoma japonicum* affects millions of people in the Philippines [69] and has also been reported in Indonesia [70, 71]. *Schistosoma mekongi* is endemic in Lao PDR and Cambodia with 60,000 people estimated to be still at risk of infection in Lao PDR and about 80,000 people in Cambodia. Despite satisfactory control measures implemented in both countries, transmission still occurs with prevalence reaching rates of more than 15 % [72]. *Schistosoma malayensis* was first described in 1988 in Peninsular Malaysia and appears to be a zoonotic infection [73].

Schistosomiasis endemic areas are characterized by low socioeconomic conditions, poor sanitary facilities, bad habits of the people as regards urination and defecation in water canals and at the same time exposing themselves to this polluted

water by bathing, swimming for recreation, washing utensils and clothes, and walking barefoot during irrigation for agriculture, and in fishing [74]. Inadequate hygiene and play habits make children especially vulnerable to infection. The building of dams, irrigation systems, and reservoirs and migration to urban areas and refugee movements are introducing and spreading the disease to new areas. Increasing population size and the corresponding needs for power and water often result in development schemes and environmental modifications that also lead to increased transmission. With the rise in ecotourism, increasing numbers of tourists are contracting schistosomiasis.

All species are contracted in the same way, through direct contact with freshwater infested with the free-living form of the parasite known as cercariae. Eggs are excreted in human urine and feces and, in areas with poor sanitation, contaminate freshwater sources. The eggs break open to release a form of the parasite called miracidium. Freshwater snails become infested with the miracidium, which multiply inside the snail and mature into multiple cercariae that the snail ejects into the water. The cercariae quickly penetrate unbroken skin, the lining of the mouth, or the gastrointestinal tract. Once inside the human body, the worms penetrate the wall of the nearest vein and travel to the liver where they grow and sexually mature. Mature male and female worm pair and migrate either to the intestines or the bladder where egg production occurs. One female worm may lay an average of 200–2,000 eggs per day for up to 20 years. Most eggs leave the bloodstream and body through the intestines. Some of the eggs are not excreted and can lodge in the tissues.

Symptoms of schistosomiasis vary with the species of worm and the phase of infection. Heavy infestation may cause fever, chills, lymph node enlargement, and also liver and spleen enlargement. Initial invasion of the skin by cercariae may cause tingling sensation or light rash, commonly referred as “swimmer’s itch,” due to irritation at the point of entrance. Other symptoms can occur which include fever, aching, cough, diarrhea, or gland enlargement. Another primary condition is called “Katayama fever.” Its symptoms include fever, lethargy, the eruption of pale temporary bumps associated with severe itching (urticarial) rash, liver and spleen enlargement, and bronchospasm.

Intestinal symptoms include abdominal pain and diarrhea which may be bloody. When eggs become lodged in the intestinal wall, it causes an immune system reaction called granulomatous reaction that can lead to obstruction of the colon and blood loss. The infected individual may have what appears to be a potbelly. Eggs can also become lodged in the liver, leading to high blood pressure through the liver, enlarged spleen, the buildup of fluid in the abdomen (ascites), and potentially life-threatening dilations or swollen areas in the esophagus or gastrointestinal tract that can tear and bleed profusely (esophageal varices).

Urinary symptoms may include frequent urination, painful urination (dysuria), and blood in the urine (hematuria). The loss of blood can lead to iron deficiency anemia. A large percentage of persons, especially children, who are moderately to heavily infected experience urinary tract damage that can lead to blocking of the urinary tract and bladder cancer. Table 12.2 showed the prevalence data of schistosomiasis in Southeast Asian countries.

Table 12.2 Prevalence data of schistosomiasis in Southeast Asian countries

Country	Prevalence of schistosomiasis	Year reported	Reference
Cambodia and Lao PDR	77 % (1995), 1 % (2003)	2010	[75]
	26.8 % (Khong Island), 2 % (Sadao)	2007	[76]
Indonesia	0.49 % (2005 and 2006) (Lindu Valley)	2008	[77]
	0.79 % (2005), 1.08 % (2006) (Napu Valley)		
Malaysia	13.3 % (Police personnel)	1996	[78]
	6.8 % (Sarawak)	2001	[79]
Philippines	18.9 % (1975), 10 % (2008) (Maguindanao)	2008	[80]
	1.8 % (2012) (Maguindanao)	2012	[81]
Thailand	0.03 % (Ubon Ratchathani province)	1999	[82]

12.13 Cambodia and Lao PDR

Found in the Mekongi river that runs through Cambodia and parts of Lao PDR, *S. mekongi* has posed a persistent public health problem since its discovery in 1957 [72, 83]. In the 1990s, up to three quarters of the population in some areas of Cambodia were infected with schistosomiasis. Cambodia then launched an integrated control program to people residing in schistosomiasis endemic areas, and in the late 1994 and since the implementation of these control measures, the percentage of persons with schistosomiasis has dropped significantly from about 77 % in 1995 to less than 1 % in 2003 [75]. While this integrated control program has been extremely effective in lowering the prevalence of schistosomiasis, there have been many concerns regarding the sustainability of these intervention efforts. For example, the prevalence in Hat-Xai-Khoun village, Khong Island, although has decreased significantly, it only came down to 26.8 % (from 80 % in 1989), while at Sadao in Cambodia, it was detected to be around 2 % in 2005 when there was none in 2004 [76].

The role of reservoir hosts in the persistence of transmission has been demonstrated [84, 85]. In addition, it has been shown that prevalence of infection in the snails at Khong Island [86] and Sadao [87] has not declined as significantly as in the case of infection in the human population. In 2004, 11 new snail populations were recorded, occurring in six river systems of Lao PDR and Cambodia. As a result, the potential human population at risk has risen from 150,000 to over 1.5 million following the discovery of these new snail populations. Such observations suggest that control of this disease clearly is a task that is not easy to maintain [88].

12.14 Indonesia

Schistosomiasis in Indonesia is only endemic in the province of Sulawesi. It is only *S. japonicum* that has been reported in Indonesia [70, 71]. It was found limited to two very isolated areas, the Napu and Lindu Valleys [89]. The averaged prevalence was 0.49 % in seven villages in Lindu Valley during 2005 and 2006. In Napu Valley, the average prevalence among 17 villages was 0.79 % in 2005 and increased slightly to 1.08 % in 2006 [77].

12.15 Malaysia

Schistosomiasis in Malaysia is caused by *S. malayensis* which was first described in 1988 in Peninsular Malaysia [73]. Humans and rats are the only known natural hosts [90]. Several studies have indicated that humans are not an important host for this parasite [91–93] and its infection appears to be zoonotic in nature and was unlikely to become a significant public health problem.

Nonetheless a study done on Police Field Force personnel showed that 13.3 % of participants were positive or borderline for schistosomiasis via serological screening. Stool samples however were negative for schistosome eggs [78]. Another serological study, performed on indigenous interior tribes (Orang Ulu) in upper Rejang River Basin Sarawak Malaysia determined by ELISA method, demonstrated that 6.8 % of the individual surveyed were positive for malayensis schistosomiasis [79]. Unfortunately, stool examination was not done and therefore cannot be concluded that human was involved as agent for propagating the schistosome life cycle in Malaysia.

12.16 Philippines

Schistosoma japonicum is the only trematode affecting humans and has been documented as an important problem in the Philippines [94]. In 1975, it was indicated that five million people lived in schistosomiasis endemic areas and over 700,000 individuals were infected. Maguindanao, a province in the Autonomous Region of Muslim Mindanao, was ranked first in the list of schistosomiasis endemic provinces in the Philippines with a prevalence rate of 18.9 % and in 2005 reduced to 10 % [80].

When prevalence rate was compared between male and female, it was shown to be higher among males than that of females. In Luzon, for example, prevalence rate is almost four times higher in males than in females suggesting the occupational hazard of farming and fishing among the males [80].

In 2006, although it was estimated that the population in the endemic areas had grown to 12 million, the implementation of extensive chemotherapy programs has helped reducing the active infection to around 150,000 [95]. In the most recent survey, the prevalence rate recorded for Maguindanao was at 1.8 % [81].

12.17 Singapore

There is no report of schistosomiasis from Singapore in recent years. There was only one case reported long time ago of an 83-year-old female presented *S. japonicum* infection with bloody diarrhea [96].

12.18 Thailand

In Thailand, *S. japonicum* and *S. mekongi* which cause intestinal schistosomiasis can be seen especially in the northeastern region [97, 98]. Relatively high mekongi schistosomiasis infection rate has been recovered in humans and dogs along the country's borders with neighboring country of both Lao PDR and Cambodia. One of the endemic areas of mekongi schistosomiasis, the Kong Island [99], is in the immediate vicinity of Ubon Ratchathani province, the third most populated city in the northeastern part of Thailand. A study conducted in the province employing indirect- and dot-blot ELISA using a *Schistosoma* heterophile substance, keyhole limpet hemocyanin (KLH) as the antigen, indicated that very small percentage (0.03 %) of Ubon Ratchathani province inhabitants have been exposed to *S. mekongi* [82].

Few hospital cases of urinary schistosomiasis [100, 101] and S. *japonicum* causing eosinophilic appendicitis [102] have been reported in Thailand.

12.18.1 Food-Borne Trematodes

More than 40 million people are infected and more than 10 % of the world's population are at risk of food-borne trematode infections [103–106]. These infections, similar to other infections previously discussed, were also limited to populations living in low-income countries particularly in Southeast Asia and were very much associated with poverty.

In Southeast Asia the clinically important food-borne trematodes include *Opisthorchis viverrini*, *Clonorchis sinensis*, *Fasciola* spp., and *Paragonimus* [105].

The transmission of food-borne trematodes is restricted to areas where the first and second intermediate hosts coexist and where humans have the habit of eating

raw, pickled, or undercooked fish and other aquatic products. Parasite eggs from infected humans or animals reach freshwater bodies through contaminated fecal matter, e.g., through non-hygienic defecating habits of humans or the use of human feces for fertilizer (night soil). Food-borne trematodes have widespread zoonotic reservoirs. Cats, dogs, foxes, pigs, and rodents are definitive hosts for *C. sinensis*, and domestic ruminants serve as reservoirs for *F. hepatica* infections. Once eggs have reached a suitable body of freshwater, they develop and release a miracidium. It enters an aquatic snail, which acts as first intermediate host. Inside the snail, within several weeks, the miracidium transforms into cercariae. They are released into the freshwater environment and attach, penetrate, and encyst as metacercariae in susceptible second intermediate hosts. Infection with food-borne trematodes is accomplished through ingestion of metacercariae by eating raw or insufficiently cooked freshwater fish (*C. sinensis*, *Opisthorchis* spp.), freshwater crab or crayfish (*Paragonimus* spp.), aquatic plants, or by drinking contaminated water (*Fasciola* spp.).This determines the focal distribution of the food-borne trematode infections [103, 105], and endemic areas therefore can be identified as the area where the people eat raw, pickled, and semi-cooked freshwater species of crabs, shrimps, and crayfishes.

Symptoms of clonorchiasis include anorexia, indigestion, abdominal pain, weakness, weight loss, diarrhea, jaundice, portal hypertension, ascites, gastrointestinal bleeding, gallstone formation, inflammation, and hyperplasia of the biliary epithelium leading to deposition of fibrous tissue. Invasion of the pancreatic duct occurs in patients with heavy infections.

Many of the signs and symptoms of opisthorchiasis are similar to those described for clonorchiasis. With chronic heavy infections, patients present with enlarged gallbladder, cholecystitis, cholangitis, liver abscess, and gallstones.

Fasciola spp. (*F. gigantica* and *F. hepatica*) infection causes abdominal pain frequently localized to right hypochondrium, anorexia, weight loss, malaise, mild intermittent fever, mild hepatomegaly, jaundice, biliary abnormalities, traumatic and necrotic lesions in hepatic tissue, and fibrosis of biliary ducts.

Paragonimiasis is characterized by the following symptoms: chest pain, cough with rust-colored sputum, fatigue, fever, focal hemorrhagic pneumonia, migrating subcutaneous nodes granuloma formation, and fibrotic encapsulation in the lung parenchyma. Abdominal pain causes decreased appetite and diarrhea. Flukes tend to migrate to ectopic sites and can cause cerebral paragonimiasis which is fatal. Table 12.3 showed the prevalence data of food-borne trematodes in Southeast Asian countries.

(i) *Clonorchis sinensis*

In 2002 it was reported that more than 18 million people were infected with fish-borne trematodes worldwide [124]. In Southeast Asia *C. sinensis* is prevalent especially in Vietnam. During a study conducted on community that eats raw fish, *C. sinensis* was recovered from 51.5 % of the participants [107]. More recent study performed on fish-farming community in Nam Dinh showed that 32.2 % fish farm household members were infected with *C. sinensis* [108].

Table 12.3 Prevalence data of food-borne trematodes in Southeast Asian countries

Country	Prevalence of food-borne trematodes	Year reported	Reference
(i) *Clonorchis sinensis*			
Vietnam	51.5 %	2007	[107]
	32.2 %	2011	[108]
Thailand	23 % (Central)	2009	[109]
(ii) *Opisthorchis viverrini*			
Cambodia	4.6 %	2012	[110]
Lao PDR	50 % (Southern provinces)	2000	[111]
	23 % (Thakhek), 15 % (Vientiane)	2003	[112]
	85 % (Southern region)	2007	[48]
Thailand	9.6–19.3 %	2003	[113]
	2.1–70.8 % (Khon Kaen District)	2004	[114]
	7–13 % (Khukan District)	2004	[115]
	64 % (Central)	2009	[109]
Vietnam	21 %	2004	[116]
(iii) *Fasciola* spp.			
Vietnam	1,350 cases (2008), 3,000 cases (2009)	2001	[117]
Lao PDR	2.4 % (stool examination), 13.8 % (serology)	2008	[118]
(iv) *Paragonimus westermani*			
Lao PDR	51 % (villagers), 14.5 % (school children)	2008	[119]
Vietnam	12.7 % (Sinho district), 3.3 % (Luc Yen district)	2011	[120]
Thailand	10 % (samples of the 1980s), 4.9 % (samples of 2005)	2008	[121]
	15.8 % (samples of 1988)	1988	[122]
	0.51 % (samples of 2000)	2001	[123]

Clonorchis sinensis infection was also reported in central Thailand. Based on analysis of microscopy-positive PCR products, it was revealed that 23 % of individuals were infected with *C. sinensis* [109].

(ii) *Opisthorchis viverrini*

It was estimated that ten million people are infected with *O. viverrini* [125]. In Southeast Asia, *O. viverrini* is endemic in Cambodia, Lao PDR, Thailand, and Vietnam [105].

In Cambodia, the prevalence of this trematode has been reported as 4.6 % based on a study conducted on the residents and school children of Takeo Province. They were found positive for *O. viverrini* egg [110].

World Health Organization (WHO) estimated that over two million people are infected with *O. viverrini* in Lao PDR [126]. In the cities of Thakhek (Khammouane province) and Vientiane capital, infection rates were found to be at 23 % and 15 %, respectively [112]. Highest infection rate was seen in the southern provinces, where it exceeded 50 % in school children [111]. The

infection remains common in Lao PDR with an extensive distribution in the southern region with prevalence detected approaching 85 % [48].

It was reported that approximately six million people harboring *O. viverrini* in Thailand live in the northern and northeastern regions [127]. An epidemiologic survey showed that the average prevalence of opisthorchiasis in Thailand for 2001 was relatively high, ranging from 9.6 to 19.3 % [113]. Other studies conducted in 2004 showed that the average prevalence of *O. viverrini* infection was 24.5 % (ranging from 2.1 to 70.8 %) in various districts of Khon Kaen [114] while *O. viverrini* infection in Khukan District, Si Sa Ket Province ranging from 7 to 13.6 % [115]. *Opisthorchis viverrini* was also reported in central Thailand where 64 % of individuals were found infected based on analysis of the microscopy-positive PCR products [109].

A survey conducted in Vietnam from 1976 to 2002 on over 30,000 human stool samples from 15 provinces demonstrated average infection rate of *Clonorchis/Opisthorchis* in those provinces was 21 % [116].

(iii) *Fasciola* spp.

Fasciola hepatica and *F. gigantica* are the causative agents of liver fluke disease in domestic animals and humans. *F. hepatica* is common in sheep-raising countries like parts of Europe, the Middle East, and South America, while in Southeast Asia, *F. gigantica* is more commonly found. The two species can coexist in some countries.

In Southeast Asia, Vietnam has reported an increase of *Fasciola* infection. Here, human fascioliasis was distributed mainly in central region and the midland provinces. Based on hospital cases captured, The Vietnamese Ministry of Health reported an approximately 3,000 cases of fascioliasis in 2009 which was an approximate 45 % increase of the same infection reported in 2008. They also confirmed that almost all patients presented hepatic symptoms [117].

Fascioliasis is also found in Lao PDR where the prevalence of human fascioliasis was shown to be 2.4 % based on stool examination but increased to 13.8 % when systematic serology testing was employed [118].

(iv) *Paragonimus westermani*

There are about 15 species of *Paragonimus* known to infect humans. *Paragonimus westermani* is the most common worldwide. More than 20 million people are infected with *Paragonimus* spp. [128]. In Southeast Asia, human paragonimiasis is found in Lao PDR, Vietnam, and Thailand [105, 128].

A field investigation employing intradermal skin tests conducted in Lao PDR between 2003 and 2005 on 308 villagers and 633 school children showed that among the 308 villagers tested, almost 51 % presented positive reaction with male exhibiting a higher positive rate (66.2 %) than the female (37.3 %). As for the school children, the skin test positive reaction rate was 14.5 % [119].

In Vietnam a seroepidemiological surveys showed 12.7 % participants in Sinho district of Laichau province and 3.3 % of participants in Lucyen district

of Yenbai province were antibody positive against the *Paragonimus* antigen [120].

Using serodiagnostic method, IgG-ELISA for paragonimiasis on samples obtained in the 1980s and in 2005 from two villages near Chet Khot Waterfall, Kaeng Khoi District, in Saraburi province, Thailand, it was demonstrated that paragonimiasis occurred in 10 % of the total population of the 1980s and 4.9 % of those of 2005 [121]. Based on this finding, it can be concluded that the prevalence of paragonimiasis has decreased in Thailand (at least in the study area concerned). This conclusion is supported by another report of paragonimiasis in another paragonimiasis endemic area, Noen Maprang District, Phitsanulok Province, where its earlier prevalence of 15.8 % [122] was later dropped to 0.51 % during the follow-up study in 2000 [123].

12.19 Conclusion

Based on the data presented, the parasitic infections caused by cestodes and trematodes in Southeast Asia are clearly still a major burden on public health. With many countries having limited, incomplete, and outdated data, it is very possible to find that the status of these infections occurring currently in these countries differ from what was reviewed. This is because perpetuation and enhancement of these parasitic infections discussed are very much influenced by many factors such as geography, environment, socioeconomic, development, the population's religious and social beliefs, lifestyle, and customs which are not an easy proposition to tackle in order to achieve improvement for the existing situation.

Southeast Asia will remain endemic for these infections if progress pertaining to information and awareness about the extent and burden of the problem, suitable diagnostic and management capacity, and appropriate prevention and control strategies are not forthcoming. All these not only need to be well documented but must be applied in order to bring to the attention of the affected communities and the decision makers. Decision makers' understanding on burden of diseases, its impact on the health and agriculture, and overall development of the population effected is so crucial for any appropriate and relevant policies to be formulated and successfully implemented. Only then sustainability of any control and preventive strategies put in place is guaranteed and situation improved.

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