Am. J. Trop. Med. Hyg., 92(6), 2015, pp. 1265–1270
doi:10.4269/ajtmh.14-0570

Trichinellosis in Vietnam

Nguyen Van De, Vu Thi Nga, Pierre Dorny, Nguyen Vu Trung, Pham Ngoc Minh, Do Trung Dung, and Edoardo Pozio*

Hanoi Medical University of Vietnam, Hanoi, Vietnam; Parasitology Section, National Centre for Veterinary Diagnosis, Hanoi, Vietnam; Department of Biomedical Sciences, Institute of Tropical Medicine, Antwerp, Belgium; National Hospital of Tropical Diseases, Hanoi, Vietnam; National Institute of Malariology, Parasitology and Entomology, Hanoi, Vietnam; European Union Reference Laboratory for Parasites, Department of Infectious, Parasitic and Immunomediated Diseases, Istituto Superiore di Sanità, Rome, Italy

Abstract. Trichinellosis is a zoonotic parasitic disease with a worldwide distribution. The aim of this work was to describe the epidemiological and clinical data of five outbreaks of trichinellosis, which affected ethnic minorities living in remote mountainous areas of northwestern Vietnam from 1970 to 2012. Trichinellosis was diagnosed in 126 patients, of which 11 (8.7%) were hospitalized and 8 (6.3%) died. All infected people had consumed raw pork from backyard and roaming pigs or wild boar at wedding, funeral, or New Year parties. The short incubation period (average of 9.5 days), the severity of the symptoms, which were characterized by diarrhea, abdominal pain, fever, myalgia, edema, weight loss, itch, and lisping, and the high mortality, suggest that patients had ingested a high number of larvae. The larval burden in pigs examined in one of the outbreaks ranged from 70 to 879 larvae/g. These larvae and those collected from a muscle biopsy taken from a patient from the 2012 outbreak were identified as *Trichinella spiralis*. Data presented in this work show that the northern regions of Vietnam are endemic areas for *Trichinella* infections in domestic pigs and humans.

INTRODUCTION

Trichinellosis is a human disease caused by zoonotic nematodes of the genus *Trichinella*, which show a cosmopolitan distribution.[1] This infection has been documented in 55 (27.8%) countries around the world.[2] From 1986 to 2009, there were 65,818 cases and 42 deaths reported from 41 countries; 87% of these cases were documented in the European World Health Organization (WHO) region.[3]

In Asia, *Trichinella* spp. infection has been documented in humans in 18 countries, domestic animals (mainly pigs) in 9 countries, and wildlife in 14 countries.[2]

These zoonotic parasites have been detected in most southeast Asian countries (Lao People's Democratic Republic, Malaysia, Thailand, and Vietnam), but the recorded data are fragmentary.[2,4–9]

In Vietnam, *Trichinella* sp. was detected for the first time in 1923 in two (0.04%) of 4,952 pigs tested in Hanoi.[10] Then, *Trichinella* sp. was detected in a pig at the slaughterhouse in Saigon in 1929 and two pigs at the slaughterhouse in Hanoi in 1952.[11] More recently, *T. spiralis* larvae were detected in 11 free-roaming pigs of the Chim Van and Lang Cheu municipalities of the Bac Yen district (Son La Province) where an outbreak of trichinellosis occurred.[8] Trichinellosis was diagnosed among six soldiers in Saigon, two of whom died, in 1953; the source of infection was a wild pig.[11,12]

The aim of this work was to review the epidemiological and clinical aspects of trichinellosis in Vietnam from 1970 to 2012.

MATERIALS AND METHODS

After the alert of the healthcare centers of the villages where people became sick, the public health services of Vietnam collected clinical and epidemiological data, drew blood (only in the course of the 2004, 2008, and 2012 outbreaks), made the diagnosis, and treated the infected people.[13–18] In addition, clinical and laboratory investigations were carried out of persons from two villages where trichinellosis outbreaks had been documented in 2004 and 2008 and persons without a confirmed diagnosis hospitalized in two provincial hospitals from 2010 to 2012.[19]

A commercial enzyme-linked immunosorbent assay (ELISA) kit (NovaTec; Immunodiagnostica GmbH, Dietzenbach, Germany) or an in-house ELISA was used to detect anti-*Trichinella* immunoglobulin G (IgG) in the serum samples of people in the course of the 2008–2012 outbreaks. An in-house ELISA followed by a confirmatory Western blot according to the work by Gómez-Morales and others[20] were used in the course of the study carried out during the 2012 outbreak and the clinical–epidemiological investigation carried out from 2010 to 2012.[18,19] Laboratory data were available for five people hospitalized in the course of the 2008 outbreak and six people hospitalized in the course of the 2012 outbreak.

Trichinella sp. larvae collected from pigs of the Lang Cheu village, where an outbreak of trichinellosis occurred in 2008,[8] and a muscle biopsy collected from an infected person in the course of the 2012 outbreak,[17] were identified by a multiplex polymerase chain reaction (PCR) according to published protocols.[17,21] Detailed information on *Trichinella* isolates from pigs is available on the International Trichinella Reference Center website.[22]

RESULTS

From 1970 to 2012, five outbreaks of trichinellosis have been documented in four mountainous provinces of north Vietnam (Figure 1). Most of the infected people belonged to the ethnic minorities Thai, Tay, and H'mong; however, people of the main Vietnamese ethnic group, Kinh, also acquired the infection. In the course of the first three outbreaks, which occurred in 1970, 2001, and 2004, the diagnosis of trichinellosis was based on the clinical signs and symptoms of the disease and the isolation of *Trichinella* sp. larvae from pork, which was the source of infection. In the course of the last two outbreaks (2008 and 2012), the diagnosis of trichinellosis was based on the clinical signs and symptoms, serology, and detection of larvae in muscle biopsies of index patients.

The main epidemiological and clinical data are shown in Tables 1–4. Trichinellosis was confirmed in 126 persons, of

*Address correspondence to Edoardo Pozio, European Union Reference Laboratory for Parasites, Department of Infectious, Parasitic and Immunomediated Diseases, Istituto Superiore di Sanità, viale Regina Elena 299, Rome 00161, Italy. E-mail: edoardo.pozio@iss.it

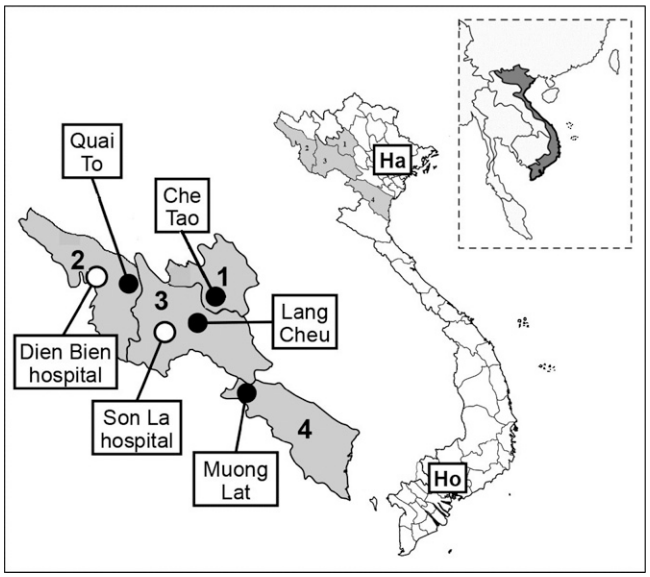

FIGURE 1. Map of Vietnam showing the villages and hospitals where *Trichinella* infections have been documented in humans since 1970. (1) Che Tao village, Mu Cang Chai district, Yen Bai Province, outbreak of 1970. (2) Quai To village, Tuan Giao district, Dien Bien Province, outbreaks of 2001 and 2004 and 2010–2012 survey on people living in the Quai To village and people hospitalized in the Dien Bien Hospital. (3) Lang Cheu village, Bac Yen district, Son La Province, outbreak of 2008 and 2010–2012 survey on people living in the Lang Cheu village and people hospitalized in the Son La Hospital. (4) Muong Lat village, Muong Lat district, Thanh Hoa Province, outbreak of 2012. Ha = Hanoi capital where *Trichinella* sp. was detected in two pigs in 1923[10]; Ho = Ho Chi Minh city (formerly Saigon) where a trichinellosis outbreak from the consumption of pork from a wild boar was documented in 1953.[11,12]

which 11 (8.7%) persons were hospitalized and 8 (6.3%) persons died. None of the patients who died had been treated with albendazole or another anti-*Trichinella* benzimidazole. The average incubation period was 9.5 days (range = 4–17 days) (Table 1). Most of the infected patients were adults of the 41- to 50-year-old age group (35.1%). Only one 6-year-old child acquired the infection in the 2012 outbreak. Males were more infected (84.2%) than females (15.8%) (Table 2). Raw pork from domestic pigs was the source of infection in four outbreaks, whereas both raw and fermented pork (lap and nem chua dishes, respectively) from a wild boar was the source of infection in the 2012 outbreak. All infected people had consumed the infected raw pork at wedding, funeral, or New Year parties (Table 1).

In the five outbreaks, the intestinal phase of the disease, characterized by abdominal pain and/or diarrhea, was symptomatic in about 50% of the patients (Table 3). In the parenteral phase (i.e., when newborn larvae invade the human body and penetrate in the striated muscle cell), all patients were symptomatic with fever and muscular pain. Periocular and/or facial edema occurred in 87.3% of patients. Difficulty in moving, swallowing, and breathing, which is caused by myalgia, was observed in 61.9–88.9% of patients. Other signs were weight loss (76.2%), lisping (60.3%), and itch (58.7%) (Table 3). Data on eosinophilia and increased lymphocyte count for 11 patients hospitalized in the course of the last two outbreaks are shown in Table 4. A moderate to high eosinophilia was detected in 25 (83.3%) outpatients in the course of the 2012 outbreak.

In 1970, 22 persons were treated with diethylcarbamazine (6 mg/kg daily for 12 days), because benzimidazoles were not available in Yen Bai Province at that time. Four patients died without any treatment because of the delayed diagnosis. In the course of the 2001 and 2004 outbreaks, 40 people with clinical signs and/or symptoms of the disease were treated with albendazole (400 mg/day for 7 days). Only two patients did not received the specific treatment, because they died before diagnosis was made in the 2001 outbreak. No symptomatic treatment was used in the course of the 2001 and 2004 outbreaks. In 2008, five hospitalized patients were successfully treated with albendazole (400 mg daily for 14 days) and methylprednisolone (80 mg daily for 5 days). Fifteen outpatients received the antihelminthic treatment only. The two patients who died did not receive any antihelminthic treatment before their death because of delayed diagnosis. Six hospitalized patients of the 2012 outbreak were treated with albendazole (800 mg daily for 10 days) and they recovered within 1 month. Thirty outpatients of the 2012 outbreak were successfully treated with albendazole (15 mg/kg body weight daily for 14 days).

Encapsulated *Trichinella* sp. larvae were observed in histological sections of muscle biopsies collected from five hospitalized

TABLE 2

Age and gender of 114 symptomatic people who acquired trichinellosis in the course of five outbreaks in Vietnam from 1970 to 2012

Age group (years)	Number of patients (%)		
	Male	Female	Total
5–9	1 (1)	0	1 (0.9)
10–19	1 (1)	0	1 (0.9)
20–30	15 (15.6)	2 (11.1)	17 (14.9)
31–40	27 (28.1)	5 (27.7)	32 (28.0)
41–50	32 (33.3)	8 (44.4)	40 (35.0)
51–60	13 (13.5)	2 (11.1)	15 (13.1)
> 60	7 (7.3)	1 (5.5)	8 (7.0)
Total	96 (84.2)	18 (15.8)	114 (100)

No information is available for the age and gender of 12 other people who acquired trichinellosis in the course of the 2012 outbreak.

TABLE 1

Summary of trichinellosis outbreaks that occurred in Vietnam between 1970 and 2012

Locality, district, and province of the outbreak	Year	Number of infected people	Incubation range (average), days	Number of deaths (%)	Source of infection (dish)	Event	Reference
Che Tao, Mu Cang Chai, Yen Bai	1970	26	7–14 (10)	4 (15.4)	Raw pork	Wedding	11
Quai To, Tuan Giao, Dien Bien*	2001	22	6–14 (12)	2 (9.0)	Raw pork (lap)	Wedding	12
Quai To, Tuan Giao, Dien Bien	2004	20	4–15 (8)	0	Raw pork	Funeral	13
Lang Cheu, Bac Yen, Son La	2008	22†	5–16 (9)	2 (9.0)	Raw pork	Wedding	14
Muong Lat, Muong Lat, Thanh Hoa	2012	36	4–17 (9)	0	Wild boar (lap, nem chua)	New Year Tet	15,16

*Former Lai Châu Province.
† An additional 20 people became sick, but no information is available on their clinical patterns.[14]

patients in the course of the 2008 outbreak. After this outbreak, *Trichinella* sp. larvae were isolated from 11 pigs reared in the Bac Yen district. All of the larvae isolated from pigs were identified as *T. spiralis* (isolate codes ISS2336, ISS2339, ISS2340, ISS2349, ISS2351, ISS2353, ISS2354, ISS2361, and ISS2362). *Trichinella* sp. larvae were detected by histology in muscle biopsies of six patients hospitalized in the course of the fifth outbreak, which occurred in the Muong Lat town. Then, larvae were isolated from muscle biopsies by artificial digestion and identified as *T. spiralis*.

The clinical epidemiological surveys carried out from 2010 to 2012 revealed statistically significant associations of myalgia and facial edema with a *Trichinella*-positive serology (by both ELISA and Western blot) in persons from villages, whereas a statistically significant association of myalgia with a *Trichinella*-positive serology (by both ELISA and Western blot) was observed in persons sampled in hospitals.

DISCUSSION

Northwest Vietnam is located between northern Lao People's Democratic Republic and southeastern China (Yunnan Province), which are two areas with a high prevalence of *T. spiralis* infection in domestic pigs.[4,23,24] In the course of the last 50 years, there was an active animal black market between the borders of these countries, which favored the spread of *Trichinella*-infected pigs in the area. In Vietnam, excluding the outbreak of trichinellosis in the Saigon area caused by the consumption of pork from a wild boar,[11,12] *Trichinella* infections were documented only in domestic pigs and humans of the north Vietnamese provinces.[8,10,16,19]

All of the five outbreaks described in this work occurred in mountainous districts where the hygienic conditions and breeding practices are very poor. Backyard and roaming pigs eat *Trichinella*-infected pork scraps scattered in the environment after slaughtering as well as carcasses of dogs and cats, and they prey on rodents or other animals, because quite frequently, the pig diet is poor in protein.

Wedding, funeral, and New Year parties were the social events that favored the occurrence of trichinellosis outbreaks. A consistent number of people was involved each time. The high number of patients alerted the local healthcare centers of the villages where people became sick, allowing the public health services of Vietnam to collect clinical and epidemiological data. At the beginning of the outbreaks, most of trichinellosis cases were misdiagnosed as leptospirosis, because this bacterial disease is quite common in Vietnam, and it shows clinical symptoms similar to those of trichinellosis.[25,26] This was one of the reasons why eight people died in three outbreaks. Indeed, physicians first suspected leptospirosis, and many people suffering from trichinellosis were inappropriately treated with antibiotics.

In the course of the first outbreak, which occurred in 1970, 22 persons were treated with diethylcarbamazine and recovered from trichinellosis, whereas 4 untreated persons died. It is difficult to state if the 22 treated persons recovered because of the efficacy of the antihelminthic drug or the fact that they did not ingest a very high number of larvae. In fact, contrasting results exist in the literature on the efficacy of diethylcarbamazine in experimental animals and humans with trichinellosis.[27]

Albendazole was used to treat the patients of the 2001–2012 outbreaks, and four patients who did not receive any treatment died. The efficacy of albendazole against *Trichinella* adults worms in the gut, migrating newborn larvae, and larvae in striated muscles has been clearly shown in either experimental animals or humans.[28] However, the efficacy of the benzimidazoles against larvae in the muscles reduces with the increasing time between infection and treatment because of the development of the collagen capsule around the larva.[29]

TABLE 4

Main laboratory parameters of hospitalized people at admission to the hospital in the course of the outbreaks that occurred in Vietnam in 2008 and 2012[16,17]

	Patient					
Parameter	1	2	3	4	5	6
2008 outbreak						
Lymphocyte (%)	25.7	14.8	15.6	11.6	3.7	
Eosinophils (%)	17.2	3.9	5.7	6.5	2.2	
Muscle biopsy	+	+	+	+	+	
ELISA	+	+	+	+	+	
2012 outbreak						
Lymphocyte (%)	17.0	13.6	12.4	12.4	11.1	10.2
Eosinophils (%)	51.8	18.6	5.1	15.9	28.4	18.5
Muscle biopsy	+	+	+	+	+	+
ELISA	+	+	+	+	+	+

TABLE 3

Main clinical signs and symptoms of people in the course of five outbreaks, which occurred in Vietnam from 1970 to 2012

	Number of patients (%)					
Outbreak	1970	2001	2004	2008	2012	Total
Number of symptomatic patients	26	22	20	22	36	126
Intestinal phase						
Abdominal pain	13 (50.0)	11 (55.0)	10 (50.0)	14 (63.6)	11 (30.5)	59 (46.8)
Diarrhea	11 (42.3)	15 (75.0)	8 (40.0)	10 (45.5)	12 (33.3)	56 (44.4)
Parenteral phase						
Fever	26 (100)	22 (100)	20 (100)	22 (100)	33 (91.6)	123 (97.6)
Muscular pain	26 (100)	22 (100)	20 (100)	22 (100)	32 (88.9)	122 (96.8)
Edema	26 (100)	20 (90.9)	19 (95)	18 (81.8)	25 (69.4)	110 (87.3)
Difficulty						
Movement	26 (100)	20 (90.9)	20 (100)	22 (100)	24 (66.7)	112 (88.9)
Swallowing	3 (11.5)	20 (90.9)	18 (90.0)	19 (86.4)	23 (63.9)	83 (65.8)
Breathing	18 (69.2)	11 (55.0)	16 (80.0)	13 (59.1)	20 (55.5)	78 (61.9)
Weight loss	20 (76.9)	20 (90.9)	18 (90.0)	18 (81.8)	20 (55.5)	96 (76.2)
Itch	20 (76.9)	19 (95.0)	17 (85.0)	17 (77.2)	18 (50.0)	74 (58.7)
Lisping	26 (100)	12 (60.0)	7 (35.0)	17 (77.2)	14 (38.9)	76 (60.3)

It follows that, in delayed diagnosis, the amount of drug should be increased as well as the length of treatment.

In three of five outbreaks, the local healthcare centers contacted the national health services, which properly diagnosed the disease as trichinellosis but only after the death of some patients. However, we cannot exclude that the reports of these five outbreaks are only the tip of the iceberg and that outbreaks occur with a higher frequency among minorities living in the northwestern mountainous areas of Vietnam. It is likely that outbreaks characterized by a few patients and/or mild signs and symptoms are not correctly diagnosed, and consequently, the public health services are not informed. This hypothesis is confirmed by the clinical–epidemiological surveys carried out in Dien Bien and Son La Provinces, which consistently show the occurrence of undiagnosed cases of trichinellosis in people living in villages and hospitalized persons without a confirmed diagnosis.[19]

We have to keep in mind that the public health services of Vietnam were alerted and started the investigation several weeks after the infection; consequently, a number of infected persons with mild or moderate infections could have been ignored by the investigators.[18] This could represent a bias when the clinical and epidemiological data of these five outbreaks are compared with the literature data.[30,31]

In a review investigation on 5,377 cases of trichinellosis, which occurred worldwide from 1986 to 2009, diarrhea was documented in 27% of patients, fever was documented in 53% of patients, myalgia was documented in 67.0% of patients, and edema was documented in 55.0% of patients.[3] The short incubation period (average = 9.5 days) and the severity of the clinical picture of 126 symptomatic Vietnamese patients suggest that they ingested a high number of larvae. The severity of the disease is also stressed by the high number of deaths (8; 6.3%) observed in the five outbreaks compared with the average number of deaths at the world level, which was 1.0%.[3]

In the five outbreaks described in this work, the enteral phase of the disease has been documented in about 45% of the patients, all of which had a moderate to severe infection. Furthermore, we cannot exclude that abdominal pain and diarrhea could have had another etiology because of the poor living conditions of infected persons. This is in agreement with most of literature data and stresses how the clinical signs and symptoms developed by patients in the course of the enteral phase of trichinellosis are not of any diagnostic support. Only fever, myalgia, and/or edema, which generally appear suddenly, can address the physician to suspect trichinellosis.[32]

In Thailand, most infected patients were in the 35- to 44-year-old age group, and the disease occurred more frequently in men than women during 1962–2003, with no significant sex difference during 2004–2006.[7] In Lao People's Democratic Republic, most of the patients were in the range of 28–33 years of age, and only 17 (12.3%) patient were in the pediatric age.[4] At the world level, trichinellosis affected primarily adults (median age = 33.1 years) and about equally affected men (51%) and women.[3]

The identification of *Trichinella* larvae isolated from human biopsies and pigs from the 2012 outbreak as *T. spiralis* is in agreement with literature data that show that this species is the most widespread species infecting domestic pigs in southeast Asia, China, and most of the other world regions.[4,8,24,33–35] The identification of the etiological agent as *T. spiralis* is also in agreement with the severity of the clinical picture, which resulted in the death of eight patients in the course of three of five outbreaks.

In southeast Asia, Vietnam is the most eastern country of the Indochina Peninsula, and with its 90 million inhabitants (census of 2012), it ranks as the world's 13th most populous country. More than 70% of the population live in rural areas and depend on agriculture. Ethnic minorities living in northern Vietnam have a lower income (estimated US$50 per person per month) than ethnic minorities in other Vietnamese regions. Their income is mainly from crops and livestock.[36] They often consume raw meat and are unaware of the risks as well as basic precautions to prevent *Trichinella* infection, because more than 60% of this population is illiterate.[37] Furthermore, in northern Vietnam, where most outbreaks of human trichinellosis occurred, up to 80% of pigs are raised in traditional smallholder production conditions characterized by free roaming and feeding on raw foodstuffs.[38] In these provinces, no veterinary service exists.

In terms of control on the short term, educational actions should be targeted at the local population by public health workers and veterinary/agricultural extension workers. Public health actions should aim at informing the people of the risks of acquiring trichinellosis and other meat-borne diseases through consumption of dishes prepared with raw and undercooked meat from locally produced pigs, dogs, and wildlife and showing appropriate and locally adapted methods for inactivating *Trichinella* sp. larvae and other pathogens in meat. Cooking and freezing are the primary methods for achieving larval inactivation,[39] but in the case of the absence of electricity, which is common in remote villages in Vietnam, other methods for processing the meat, such as fermentation, drying, or salting, could be recommended if these are properly applied.[40] Public health workers should also inform the people of the clinical presentation of trichinellosis so that they will seek medical help when clinical signs and symptoms appear that are compatible with trichinellosis. Veterinary/agricultural extension workers should assist the local farmers in improving the livestock husbandry conditions to reduce *Trichinella* sp. infection. These improvements include construction of pigpens using local materials, avoidance of free roaming of pigs, feeding animals with locally produced feed, cooking kitchen leftovers before feeding these to the animals, and controlling the rodent populations in and around the farms. Village and community heads can play a role in implementing and monitoring these measures.

On the longer term, farmers should be encouraged to adopt adequate breeding practices. Slaughterhouses should be constructed in the northern provinces of Vietnam, where meat inspection should be implemented based on legislation on food safety. If the artificial digestion method is difficult to implement because of limited resources, trichinoscopy is still a useful method to prevent outbreaks where encapsulated species, such as *T. spiralis*, are circulating.[33]

In conclusion, trichinellosis occurs where there is the comixture of consumption of dishes based on raw or undercooked meat, poverty, ignorance, lack of veterinary controls and consumer education, and black markets. Public health services should be aware of the circulation of these zoonotic parasites in northwest Vietnam and the clinical signs and symptoms of the disease, which are not pathognomonic and need laboratory support for the diagnosis confirmation.

Received September 12, 2014. Accepted for publication November 22, 2014.

Published online April 6, 2015.

Financial support: This work was funded by National Foundation for Science and Technology Development (NAFOSTED), Vietnam Grant 106-YS.05-2014.08 (to N.V.D.) and the National Hospital of Tropical Diseases, Bach Mai Hospital, National Centre for Veterinary Diagnosis, Hanoi, Vietnam. Furthermore, this work was funded by the Institute of Tropical Medicine, Antwerp, Belgium, and the Directorate General for Health and Consumers of the European Commission for the European Union Reference Laboratory, Istituto Superiore di Sanità.

Authors' addresses: Nguyen Van De and Pham Ngoc Minh, Hanoi Medical University of Vietnam, Hanoi, Vietnam, E-mails: ngvdeyhn@gmail.com and phamngocminhyhn@yahoo.com. Vu Thi Nga, Parasitology Section, National Centre for Veterinary Diagnosis, Hanoi, Vietnam, E-mail: ngancvd@gmail.com. Pierre Dorny, Department of Biomedical Sciences, Institute of Tropical Medicine, Antwerp, Belgium, E-mail: pdorny@itg.be. Nguyen Vu Trung, National Hospital of Tropical Diseases, Hanoi, Vietnam, E-mail: nvutrung@fpt.vn. Do Trung Dung, National Institute of Malariology, Parasitology and Entomology, Hanoi, Vietnam, E-mail: dotrungdung.nimpe.vn@gmail.com. Edoardo Pozio, European Union Reference Laboratory for Parasites, Department of Infectious, Parasitic and Immunomediated Diseases, Istituto Superiore di Sanità, Rome, Italy, E-mail: edoardo.pozio@iss.it.

REFERENCES

1. Gottstein B, Pozio E, Nöckler K, 2009. Epidemiology, diagnosis, treatment, and control of trichinellosis. *Clin Microbiol Rev 22:* 127–145.
2. Pozio E, 2007. World distribution of *Trichinella* spp. infections in animals and humans. *Vet Parasitol 149:* 3–21.
3. Murrell KD, Pozio E, 2011. Worldwide occurrence and impact of human trichinellosis, 1986–2009. *Emerg Infect Dis 17:* 2194–2202.
4. Barennes H, Sayasone S, Odermatt P, De Bruyne A, Hongsakhone S, Newton PN, Vongphrachanh P, Martinez-Aussel B, Strobel M, Dupouy-Camet J, 2008. A major trichinellosis outbreak suggesting a high endemicity of *Trichinella* infection in northern Laos. *Am J Trop Med Hyg 78:* 40–44.
5. Sicard D, Fontan R, Richard-Lenoble D, Gentilini M, 1976. Human trichinosis. A recent epidemic in Vientiane (Laos) (a propos of 32 cases). *Bull Soc Pathol Exot 69:* 521–525.
6. Sayasone S, Odermatt P, Vongphrachanh P, Keoluangkot V, Dupouy-Camet J, Newton PN, Strobel M, 2006. A trichinellosis outbreak in Borikhamxay Province, Lao PDR. *Trans R Soc Trop Med Hyg 100:* 1126–1129.
7. Kaewpitoon N, Kaewpitoon SJ, Pengsaa P, 2008. Food-borne parasitic zoonosis: distribution of trichinosis in Thailand. *World J Gastroenterol 14:* 3471–3475.
8. Vu Thi N, Dorny P, La Rosa G, To Long T, Nguyen Van C, Pozio E, 2010. High prevalence of anti-*Trichinella* IgG in domestic pigs of the Son La province, Vietnam. *Vet Parasitol 168:* 136–140.
9. Intapan PM, Chotmongkol V, Tantrawatpan C, Sanpool O, Morakote N, Maleewong W, 2011. Molecular identification of *Trichinella papuae* from a Thai patient with imported trichinellosis. *Am J Trop Med Hyg 84:* 994–997.
10. Le Louet GM, Broudin L, 1923. Parasites habituels des muscles du porc. *Bull Soc Med Chir Indo-Chin*, November 9.
11. Merle A, 1957. Enquête sur la trichinose. *Bull Off Int Epizoot 48:* 95–103.
12. Blanc F, Collomb H, Armengaud M, 1956. Etude de six cas de trichinose. *Ann Med 57:* 201–261.
13. Lam KT, 1973. First epidemic of *Trichinella spiralis* in North Vietnam. *Bull Sci Res Inst Malar Parasitol* 324–332.
14. Toan ND, Van De N, Son DT, Van Linh P, 2002. Report of an epidemic area of trichinellosis in Tuan Giao district, Lai Chau province. *J Malar Parasit Dis Control 1:* 76–79.
15. Nhan DH, Van De N, 2004. Emergence of trichinellosis in Tuan Giao district, Dien Bien province. *J Malar Parasit Dis Control 6:* 76–79.
16. Taylor WR, Tran GV, Nguyen TQ, Dang DV, Nguyen VK, Nguyen CT, Nguyen LT, Luong CQ, Scott T, Dang TC, Tran TH, Nguyen TD, Pham KT, Fox A, Horby P, Wertheim H, Doan HN, Nguyen HH, Trinh LM, Nguyen TV, Nguyen KV, Nguyen DH, 2009. Acute febrile myalgia in Vietnam due to trichinellosis following the consumption of raw pork. *Clin Infect Dis 49:* 79–83.
17. De NV, Trung NV, Ha NH, Vu Thi N, Ha NM, Thuy PT, Duyet LV, Chai JY, 2012. An outbreak of trichinosis with molecular identification of *Trichinella* sp. in Vietnam. *Korean J Parasitol 50:* 339–343.
18. Vu Thi N, Trung DD, Litzroth A, Praet N, Nguyen Thu H, Nguyen Thu H, Nguyen Manh H, Dorny P, 2013. The hidden burden of trichinellosis in Vietnam: a postoutbreak epidemiological study. *Biomed Res Int 2013:* 149890.
19. Vu Thi N, Pozio E, Van De N, Praet N, Pezzotti P, Gabriël S, Claes M, Thuy NT, Dorny P, 2014. Anti-*Trichinella* IgG in ethnic minorities living in *Trichinella*-endemic areas in northwest Vietnam: study of the predictive value of selected clinical signs and symptoms for the diagnosis of trichinellosis. *Acta Trop 139:* 93–98.
20. Gómez-Morales MA, Ludovisi A, Amati M, Blaga R, Zivojinovic M, Ribicich M, Pozio E, 2012. A distinctive Western blot pattern to recognize *Trichinella* infections in humans and pigs. *Int J Parasitol 42:* 1017–1023.
21. Pozio E, La Rosa G, 2012. Trichinella. Liu D, ed. *Molecular Detection of Human Parasitic Pathogens*. Boca Raton, FL: CRC Press, Taylor & Francis Group, 691–703.
22. International Trichinella Reference Center, 2014. The database of *Trichinella* strains. Available at: http://www.iss.it/site/Trichinella/index.asp. Accessed November 19, 2014.
23. Takahashi Y, Mingyuan L, Waikagul J, 2000. Epidemiology of trichinellosis in Asia and the Pacific Rim. *Vet Parasitol 93:* 227–239.
24. Cui J, Wang ZQ, Xu BL, 2011. The epidemiology of human trichinellosis in China during 2004–2009. *Acta Trop 118:* 1–5.
25. Kociecka W, 2000. Trichinellosis: human disease, diagnosis and treatment. *Vet Parasitol 93:* 365–383.
26. Thai KT, Nga TT, Phuong HL, Giao PT, Hung le Q, Binh TQ, Van Nam N, Hartskeerl RA, de Vries PJ, 2008. Seroepidemiology and serological follow-up of anti-leptospiral IgG in children in southern Vietnam. *Acta Trop 106:* 128–131.
27. Zaiman H, 1970. Drug treatment of trichinosis. Gould SE, ed. *Trichinosis in Man and Animals*. Springfield, IL: Charles C Thomas, 329–347.
28. Dupouy-Camet J, Bruschi F, 2007. Management and diagnosis of human trichinellosis. Dupouy-Camet J, Murrell KD, ed. *FAO/WHO/OIE Guidelines for the Surveillance, Management, Prevention and Control of Trichinellosis*. Paris, France: World Organization for Animal Health, 37–68.
29. Pozio E, Sacchini D, Sacchi L, Tamburrini A, Alberici F, 2001. Failure of mebendazole in the treatment of humans with *Trichinella spiralis* infection at the stage of encapsulating larvae. *Clin Infect Dis 32:* 638–642.
30. Romano F, Motta A, Melino M, Negro M, Gavotto G, Decasteli L, Careddu E, Bianchi C, Bianchi DM, Pozio E, 2011. Investigation on a focus of human trichinellosis revealed by an atypical clinical case after wild-boar (*Sus scrofa*) pork consumption in northern Italy. *Parasite 18:* 85–87.
31. Fichi G, Stefanelli S, Pagani A, Luchi S, De Gennaro M, Gómez-Morales MA, Selmi M, Rovai D, Mari M, Fischetti R, Pozio E, 2015. Trichinellosis outbreak caused by meat from a wild boar hunted in an Italian region considered to be at negligible risk for *Trichinella*. *Zoonoses Public Health 62:* 285–291.
32. Dupouy-Camet J, Kociecka W, Bruschi F, Bolas-Fernandez F, Pozio E, 2002. Opinion on the diagnosis and treatment of human trichinellosis. *Expert Opin Pharmacother 3:* 1117–1130.
33. Pozio E, 2014. Searching for *Trichinella*: not all pigs are created equal. *Trends Parasitol 30:* 4–11.
34. La Rosa G, Marucci G, Rosenthal BM, Pozio E, 2012. Development of a single larva microsatellite analysis to investigate the population structure of *Trichinella spiralis*. *Infect Genet Evol 12:* 369–376.
35. Pozio E, Murrell KD, 2006. Systematics and epidemiology of *Trichinella*. *Adv Parasitol 63:* 367–439.

36. General Statistics Office, 2013. Capita income per month at current prices and production of crop and livestock by urban and rural regions. Available at: http://www.gso.gov.vn/default.aspx?tabid=395&idmid=3&ItemID=15175. Accessed November 5, 2014.
37. Epprecht M, 2005. *Geographic Dimensions of Livestock Holdings in Vietnam. Spatial Relationships Among Poverty, Infrastructure and the Environment. PPLPI Working Paper*, Vol. 24. Rome, Italy: FAO.
38. Lemke U, Kaufmann B, Thuy LT, Emrich K, Valle Zárate A, 2007. Evaluation of biological and economic efficiency of smallholder pig production systems in North Vietnam. *Trop Anim Health Prod 39:* 237–254.
39. Murrell KD, 2013. Zoonotic foodborne parasites and their surveillance. *Rev Sci Tech 32*: 559–569.
40. Porto-Fett AC, Call JE, Shoyer BE, Hill DE, Pshebniski C, Cocoma GJ, Luchansky JB, 2010. Evaluation of fermentation, drying, and/or high pressure processing on viability of *Listeria monocytogenes, Escherichia coli* O157:H7, *Salmonella* spp., and *Trichinella spiralis* in raw pork and Genoa salami. *Int J Food Microbiol 140:* 61–75.