To assess the global incidence and clinical effects of human trichinellosis, we analyzed outbreak report data for 1986–2009. Searches of 6 international databases yielded 494 reports. After applying strict criteria for relevance and reliability, we selected 261 reports for data extraction. From 1986 through 2009, there were 65,818 cases and 42 deaths reported from 41 countries. The World Health Organization European Region accounted for 87% of cases; 50% of those occurred in Romania, mainly during 1990–1999. Incidence in the region ranged from 1.1 to 8.5 cases per 100,000 population. Trichinellosis affected primarily adults (median age 33.1 years) and about equally affected men (51%) and women. Major clinical effects, according to 5,377 well-described cases, were myalgia, diarrhea, fever, facial edema, and headaches. Pork was the major source of infection; wild game sources were also frequently reported. These data will be valuable for estimating the illness worldwide.

Since the mid-19th century, trichinellosis has been a well-recognized meat-borne zoonosis; however, despite concerted control efforts, it remains a threat in many countries. Veterinary control over the slaughter of food animals to ensure food safety, particularly meat inspection, was introduced in Germany in 1866 specifically to prevent trichinellosis from pork infected with the muscle larvae of *Trichinella spiralis* (1). In the European Union, the estimated annual cost incurred from meat inspection of 167 million pigs (2) ranges from €25 million to €400 million (3). Even in countries without mandatory meat inspection (e.g., United States), the economic cost of selling pork in international and national markets is substantial (4).
The epidemiology and systematics (i.e., the study of the diversification) of this zoonosis are now recognized to involve, in addition to *T. spiralis*, 7 other species in 4 genotypes, all of which are more commonly found in wild animals than in domestic pigs (5). *Trichinella* spp. have been found in domestic and wild animals in 66 countries (6). Human trichinellosis has been documented in 55 countries, particularly those with well-established food behavior that includes consuming meat dishes with raw or undercooked meat (6). Whether trichinellosis is a low-prevalence disease or is frequently misdiagnosed is not clearly understood; its detection can be difficult in low-level infections and its clinical manifestations overlap those of other diseases, such as influenza and chronic fatigue syndrome (7). Human infection is classically characterized by gastroenteritis; myalgia; malaise; facial edema; headache; subungual or conjunctival hemorrhages; and increased eosinophils, leukocytes, and muscle enzymes (7).

Reliable estimates of the incidence of trichinellosis among humans and its effect on health are not available; these estimates are necessary for setting priorities. In the 1990s, the global prevalence of trichinellosis was ≈10 million, and a recent incidence estimate suggested ≈10,000 infections per year (6). However, because of problems related to incomplete data from some regions and to the quality of diagnostic criteria for infection, the Foodborne Disease Burden Epidemiology Reference Group of the World Health Organization (WHO) requested a systematic review of the global incidence, burden of disease, and major sources of infection that used strict criteria for data selection and extraction. Our analyses and summaries of the epidemiologic and clinical data selected provide a basis for an assessment of trichinellosis as a public health problem.

**Data Sources and Selection Criteria**

We retrospectively reviewed trichinellosis outbreak investigations conducted worldwide during 1986–2009. The data analysis focused on incidence, age and sex of patients, infection rates, major clinical aspects including sequelae, and meat sources of infection. The database we developed was geographically organized according to the WHO regions (www.who.int/choice/demography/regions/en): African Region, 46 countries; Region of the Americas, 12 countries; Eastern Mediterranean Region, 22 north African and Middle Eastern countries; European Region, 44 European and 6 Asian countries; South-East Asian Region, 11 east Asian countries; and Western Pacific Region, 27 countries. Data searches of literature included PubMed, Centres for Agricultural Bioscience International (CABI) abstracts, WHO library, System for Information on Gray Literature, Pan America Health Organization Virtual Library, and Index Medicus for South-East Asian Region.

The search terms used were trichinosis, trichinellosis, trichinelliasis, and trichinella. These were combined with the terms prevalence, outbreaks, epidemiology, clinical symptoms, and duration. The search terms were also combined with pork, pig, wild boar, wild pig, warthog, horse, badger, jackal, cougar, walrus, armadillo, turtle, and bear meat. Published abstracts were screened for retention by using the criteria of relevance to human outbreaks or single cases occurring from 1986 through 2009 and by determining whether the report was based on original data (primary source or unpublished data managed by national government agencies). The full paper versions of selected abstracts were then obtained where possible and further screened and evaluated. Outbreak reports published >1 time were occasionally encountered, and care was taken to prevent duplication of data in the database; preference was given to published international, peer-reviewed versions. In some instances, data were obtained through contact with scientists in countries of interest who had access to unpublished and detailed information about outbreaks; these sources are indicated in the reference lists in the online Technical Appendix (wwwnc.cdc.gov/EID/pdfs/11-0896-Techapp.pdf). In addition, information about isolated outbreaks maintained by a national health system was obtained for some countries through personal contacts (see Acknowledgments). For reports in which English versions were not available, translations were obtained through the generous help of colleagues (see Acknowledgments).

**Definitions**

Reports, published or unpublished, were excluded from the database if the diagnosis of *Trichinella* spp. infection was not based on a diagnostic procedure that we defined as confirmatory. Although direct demonstration of muscle larvae infection in biopsy samples is now infrequent, reliance solely on serologic testing to confirm infection can be problematic (8). Therefore, a serologically positive case was included in the database only if the sample was confirmed by a Western blot test or if the patient’s illness could be classified as highly probable according to the clinical diagnostic algorithm published by Dupouy-Camet and Bruschi (7), in which a patient with a positive serologic test result must also exhibit ≥1 classical trichinellosis signs and symptoms (e.g., myalgia, facial edema, headaches, diarrhea, eosinophilia).

We took a conservative approach in extracting clinical data for the analysis of frequency of major signs and symptoms in patients with *Trichinella* spp. infections and excluded report data if there was lack of clarity and reliability of clinical procedures and laboratory tests used to confirm infection. However, in some instances of inadequate clinical descriptions, the report was retained if it otherwise presented useful epidemiologic data.
Consequently, the total number of human infections (Tables 1–3) exceeds the number of cases used to summarize the frequency of major signs and symptoms (Table 4). Except in rare cases, clinical data were extracted from outbreak reports only if the data were from multiple cases that met these criteria; exceptions were reports of single cases from countries with rare occurrences of trichinellosis but that had good clinical and laboratory confirmation data (e.g., Korea, Japan, India).

From the original 494 abstracts identified from literature searches, 378 were judged to potentially meet the criteria for data extraction, and full articles were obtained for most abstracts. From these, 261 reports were retained for data extraction and inclusion. A major reason for rejection of articles was failure to meet the criteria for confirmation of infection, especially interpretation of serologic results.

**Incidence**

In Table 2, the incidence (100,000 person-years) is reported for specific periods because the data were obtained over a shorter period than the formal study interval (1986–2009). For some countries, when incidence figures were not reported in published papers or national health reports, we calculated incidence from data available in the referenced reports by using the WHO World Population Prospects (the 2008 revision) (http://esa.un.org/wpp/unpp/p2k0data.asp). Overall, from 1986 through 2009, there were 65,818 cases and 42 deaths from trichinellosis reported from 41 countries (Tables 1–3). The European Region accounted for 86% of cases (56,912), of which 28,564 (50%) occurred in Romania, mainly during 1990–1999. The full references for specific countries reported summarized in Tables 2–5 are available in the online Technical Appendix.

Of 46 countries in the African Region, trichinellosis has been documented only among soldiers in the Gojam region and policemen in the Arsi region of Ethiopia, a country where the Christian population accounts for ≈60% of the total population. In the Eastern Mediterranean Region, trichinellosis was documented only in the Christian population of Lebanon and in Iran from the consumption of wild boar meat (Table 2). In Algeria and Senegal, where most of the population is Muslim, trichinellosis has been documented only in Europeans (6).

In the European Region, 4 epidemiologic patterns are discernable: 1) countries of eastern Europe where incidence rates are >1 case/100,000 inhabitants (Bosnia-Herzegovina, 4.1; Bulgaria, 2.4–2.9; Croatia, 1.7–4.8; Latvia, 1.1–1.3; Lithuania, 1.2–6.6; Romania, 2.9–8.5; and Serbia, 5.0); 2) countries with a low number of inhabitants where the occurrence of a large outbreak results in a high incidence rate (e.g., Israel, 3.0; Slovakia, 6.2; and Slovenia, 10.5); 3) 19 countries with a low incidence rate caused either by sporadic infections or by a large general population that reduces the incidence per 100,000 inhabitants even when a large outbreak occurs; and 4) 21 countries where no autochthonous infections were reported during the period. Incidence in eastern Europe spiked during the late 1980s and early 1990s and then decreased over the past decade. This pattern may be linked to the political, social, and economic changes that occurred with the breakup of the former Soviet Union as described by Djordjevic et al. (9). The gradual restoration of infrastructure related to food safety (e.g., meat inspection, pig production management, veterinary services) probably contributed substantially to the decrease in incidence in these countries.

The number of cases in the Region of the Americas was comparatively low (Table 1), except in Argentina (Table 2). National incidence estimates are limited for Region of the Americas countries and published only for the United States, Chile, and Argentina; data from Canada, Mexico, and Argentina pertain only to selected states, provinces, or districts that had large outbreaks. In Canada during the period, a few large outbreaks in northern communities among native people who consumed wild game accounted for most of the outbreaks in the country. As an example of the problem of informal or clandestine meat transportation, 2 outbreaks occurred among foreign hunters; in 1 outbreak, the hunters transported infected bear home (France) and unknowingly exposed friends and family (17 total cases). For Canada and Greenland, trichinellosis was caused by consumption of wild game harboring T. nativa, which does not infect swine; no pork-transmitted Trichinella spp. have been recorded in Canada for many years.

The risk for trichinellosis has decreased markedly in the United States and Chile since the 1990s. The large number of cases associated with Argentina contrasts with

### Table 1. Clinically confirmed cases of trichinellosis in humans documented in World Health Organization regions, 1986–2009

| Region (no. countries) | No. (%) countries with trichinellosis | No. (%) documented human infections | No. (%) deaths |
|------------------------|--------------------------------------|-------------------------------------|----------------|
| African Region (46)    | 1 (2.17)                             | 28 (0.04)                           | 1 (3.57)       |
| Region of the Americas (12) | 5 (42.67)                              | 7,179 (10.90)                        | 10 (0.10)      |
| Eastern Mediterranean Region (22) | 2 (9.09)                               | 50 (0.07)                           | 0              |
| European Region (50)   | 29 (58.00)                            | 56,912 (86.47)                       | 24 (0.04)      |
| South-East Asian Region (11) | 1 (9.69)                               | 219 (0.33)                          | 1 (0.50)       |
| Western Pacific Region (27) | 3 (11.11)                              | 1,344 (2.04)                        | 6 (0.40)       |
| Other*                 | NA                                   | 86 (0.13)                           | 0              |
| Total (168)            | 41 (24)                              | 65,818 (100.00)                     | 42 (0.40)      |

*Infections acquired in countries other than the one in which diagnosis occurred. NA, not applicable.
the situation among other countries in South America. The cases in Argentina may be related to the European origins of persons immigrating there and the risky food behavior they brought with them (10). Although incidence data from Mexico and Argentina are limited, trichinellosis outbreaks are reported frequently in Argentina from domestic pork,

| Region/country                  | Years          | No. cases | Average incidence† |
|---------------------------------|----------------|-----------|--------------------|
| African Region, Ethiopia        | 1986           | 8         | 0.02               |
|                                 | 1990           | 20        | 0.04               |
| Region of the Americas          |                | 7,179     |                    |
| Argentina                       | 1990–2005      | 5,221     | 1.48               |
| Canada                          | 1987–2009      | 257       | 0.03               |
| Chile                           | 1991–2004      | 698       | 0.36               |
| Mexico                          | 1986–2001      | 351       | 0.02               |
| United States                   | 1987–2007      | 652       | 0.016–0.004        |
| Eastern Mediterranean Region    |                | 50        |                    |
| Iran                            | 2007           | 6         | 0.008              |
| Lebanon                         | 1995           | 44        | 1.25               |
| European Region                 |                | 56,912    |                    |
| Belarus                         | 1988, 1989     | 16        | 0.08, 0.55         |
| Bosnia and Herzegovina          | 1993–2003      | 1,600     | 0.1–8.0            |
| Bulgaria                        | 1990–2006      | 4,108     | 2.9                |
| Croatia                         | 1994–2009      | 2,110     | 0.02–12.3          |
| Czech Republic                  | 1986–2009      | 31        | 0.01               |
| Estonia                         | 1986–2009      | 91        | 0.0–2.9            |
| France                          | 1986–2009      | 1,203     | 0.00–0.95          |
| Georgia                         | 1988           | 3         | 0.05               |
| Germany                         | 1986–2009      | 185       | 0.00–0.01          |
| Greece                          | 2009           | 1         | 0.008              |
| Hungary                         | 1986–2009      | 158       | 0.18–0.057         |
| Ireland                         | 2007           | 2         | 0.04               |
| Israel                          | 2002, 2004     | 230       | 0.5, 3.0           |
| Italy                           | 1986–2009      | 1,181     | 0.0–0.9            |
| Kyrgyzstan                      | 1996           | 10        | 0.2                |
| Latvia                          | 1986–2009      | 636       | 0.07–3.8           |
| Lithuania                       | 1989–2009      | 3,979     | 0.4–21.8           |
| Macedonia                       | 1992           | 6         | 0.3                |
| Poland                          | 1986–2007      | 3,084     | 0.05–1.5           |
| Romania                         | 1986–2007      | 28,564    | 1.7–16.1           |
| Russia                          | 1996–2002      | 971       | 0.3–0.6            |
| Serbia                          | 1994–2003      | 5,210     | 1.8–7.8            |
| Slovakia                        | 1986–2008      | 440       | 0.0–6.2            |
| Slovenia                        | 1989–2006      | 203       | 0.00–10.5          |
| Spain                           | 1986–2009      | 1,244     | 0.0–0.4            |
| Switzerland                     | 1994, 2009     | 4         | 0.01, 0.04         |
| Turkey                          | 2003, 2004     | 425       | 0.01, 0.59         |
| United Kingdom                  | 1999           | 7         | 0.01               |
| Ukraine                         | 1986–2009      | 1,210     | 0.00–0.30          |
| South-East Asian Region         |                | 219       |                    |
| India                           | 1996–2002      | 3         | 0.0003             |
| Thailand                        | 1993–2007      | 216       | 0.35               |
| Western Pacific Region          |                | 1,344     |                    |
| Japan                           | 1999–2005      | 4         | NA                 |
| South Korea                     | 1999–2003      | 8         | 0.016              |
| Laos                            | 2004–2006      | 123       | 2.09               |
| People’s Republic of China      | 1995–2009      | 1,137     | NA                 |
| Singapore                       | 1998           | 25        | 0.64               |
| Vietnam                         | 2001–2004      | 47        | 0.058              |

*The detailed data and references for each country are available in the online Technical Appendix (wwwnc.cdc.gov/EID/pdfs/11-0896-Techapp.pdf), section A. NA, insufficient data for incidence calculation.
†Incidence/100,000 person-years. For some countries, incidence was not reported and was calculated from data available in the report referenced.
indicating that a substantial pig husbandry risk persists in that country.

The Asian countries of the Western Pacific Region and the South-East Asian Region reported few outbreaks during the period (Tables 1, 2). Although large outbreaks in the People’s Republic of China have been reported (11), the criteria for selection of reports and data extraction eliminated some reports because of insufficient diagnostic detail to meet the confirmation criteria. Most of the outbreaks reported from Thailand, Laos, and Vietnam, occurred in the northern mountainous regions among the indigenous people who practice free-roaming pig husbandry (12–14). After a 30-year period of no reports of trichinellosis cases, Laos recently experienced several outbreaks (12). The estimated incidence in rural areas of that country is high, which suggests a possible emerging problem there.

Globally, reporting of trichinellosis varies greatly. A major factor affecting the collection of epidemiologic and clinical data is an absent or inadequate national reporting system. For example, in some countries of eastern Europe (e.g., Bosnia-Herzegovina, Byelorussia, Georgia, Moldavia, Romania, Russia, Ukraine) trichinellosis occurs frequently in villages during the winter, and infection might not be diagnosed and subsequently reported unless infection is sufficiently severe to require hospitalization or the cases are part of a larger outbreak that requires attention from public health authorities (A. Marinculic, M.C. Cretu, W. Kociecka, N. Iashvili, N. Bogatko, pers. comm.). For example, in Romania, most of the 20,059 cases documented during 1990–1999 pertain to hospitalized persons only. However, for each hospitalized person, there are probably others in whom a moderate or mild infection developed that did not justify the travel and costs that would be incurred in seeking attention for diagnosis and treatment. Consequently, they are not usually officially recorded as having trichinellosis (M.C. Cretu, pers. comm.). In countries where most of the population is Muslim, Trichinella spp. infection is rare and may not be reported at all because of a scarcity of physicians, lack of good diagnostic tools, and occurrence in remote areas. In contrast, in industrialized countries such as those of Western Europe, United States, and Canada, nearly all cases are more likely to be detected and recorded, including asymptomatic cases associated with large outbreaks. For these reasons, the data we present may underrepresent the incidence of trichinellosis in lesser developed countries in comparison to that in industrialized and affluent countries.

### Sex- and Age-specific Infection

Data from clinical reports (Table 5) demonstrate that trichinellosis is a disease primarily of adults, occurring about equally among both sexes (2,631 [51%] of 5,154 infections occurred in male patients). Infection in male patients did occur more frequently, however, in Ethiopia (100%), Vietnam (91%), Japan and South Korea (75%), Thailand (64%), and China (57%). Age-specific infection data (Table 5) show the highest proportion of cases, for both sexes, was among persons 20–50 years of age (median 33.1 years). Data on age-specific prevalence rates were rarely reported; however, recent improvements in diagnosis of trichinellosis, particularly immunodiagnostic methods, may encourage more human prevalence surveys

### Table 4. Frequency of major clinical signs associated with trichinellosis among World Health Organization regions, 1986–2009*

| Region                        | Total no. cases† | Diarrhea | Myalgia | Fever | Facial and/or eyelid edema | Headache | Eosinophilia | Deaths |
|-------------------------------|-----------------|----------|---------|-------|--------------------------|----------|--------------|--------|
| African Region                | 28              | 28       | 8       | 11    | 8                        | 6        | 6            | 0      |
| Region of the Americas        | 1,229           | 400      | 969     | 821   | 790                      | 410      | 606          | 10     |
| Eastern Mediterranean Region  | 45              | 43       | 42      | 41    | Not reported              | 0        | 30           | 4      |
| European Region               | 3,118           | 798      | 1,971   | 1,387 | 1,617                    | 351      | 1,850        | 24     |
| South-East Asian Region       | 210             | 82       | 206     | 103   | 102                      | 71       | 97           | 1      |
| Western Pacific Region        | 747             | 79       | 409     | 474   | 429                      | 104      | 180          | 8      |

*Report references are available in the online Technical Appendix (wwwnc.cdc.gov/EID/pdfs/11-0896-Techapp.pdf), section C.
†Cases included in this table were selected from all reports on the basis of detailed descriptions of clinical data in the reports.
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and surveillance for trichinellosis that could yield better information about sex- and age-specific rates.

Although infections also occur in children and teenagers, the predominance of infection in adults probably results from culture-driven food behavior. Improperly cooked or prepared meat dishes may be more commonly eaten at adult-oriented events, particularly if alcohol is consumed. There are only a few published studies on the link between food behavior and trichinellosis (15,16), but this potential behavioral risk factor is similar to that that occurs in other foodborne parasites, such as fish-borne parasites (17).

Clinical Signs and Sequelae

For 5,377 cases, the chief clinical signs of trichinellosis were compatible in type and frequency with the classical trichinellosis syndrome (7), i.e., myalgia, diarrhea, fever, facial edema, and headaches that, after treatment, disappeared within 2–8 weeks (Table 4). Their rapid recovery reflects improvements in diagnostic methods, drug therapy, and public health education. The more rapid diagnosis and treatment in recent decades may also account for the low death rate; 42 deaths occurred worldwide during the 24-year period. Determining the disease burden of trichinellosis, however, is hampered by lack of data on the long-term sequelae of infection; few clinical reports included posttreatment follow-up evaluations, particularly beyond 1 month. The few studies that included follow-up over a longer time span indicate that myalgia and fatigue can persist for 4 months and, in a substantial proportion of cases, for up to 2 years (18–20). There is a need for internationally recognized epidemiologic and clinical protocols for trichinellosis outbreaks that include follow-up investigations that would facilitate reliable calculations of disease estimates.

Sources of Infection

Domestic pigs and wild boars were the major sources of Trichinella spp. infection for humans, but in recent years new infection sources, particularly from exotic hosts, have emerged (Table 6). An example is the cause of outbreaks in France, where in addition to wild boar sources, most trichinellosis cases for the past 2 decades have resulted from consumption of raw horse meat, a strong food preference in French culture (21). In Italy, human infections from consumption of horse meat have also been documented in 2 areas (Emilia Romagna and Lombardy regions in northern Italy and the Apulia region in southern Italy), where the French fondness for raw horse meat was introduced centuries ago (16). In China and the Slovak Republic, dog meat was the source of infection in several outbreaks (22,23). Although Judaic and Muslim religions forbid the consumption of pork, in Israel, Lebanon, and
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Syria human outbreaks of trichinellosis have occurred after consumption of meat from wild boars among the Christian Arab population and immigrant laborers (24–27). Muslim populations are not entirely protected from acquiring trichinellosis, however, as demonstrated by a large outbreak in Turkey from the consumption of minced beef illegally mixed with pork of unknown origin (Table 2) (28).

The demographic movements of humans with culturally unique food practices, the illegal importation of uncontrolled meat from trichinellosis-endemic to -nonendemic countries, and the introduction of risky new food practices have resulted in cases in Denmark, Germany, Italy, Spain, Sweden, and the United Kingdom (Tables 2, 3) (29–33). Many cases of trichinellosis have occurred among international travelers who acquired Trichinella spp. infections while visiting or hunting in disease-endemic areas and the disease developed after they returned to their home countries (Table 3) (34–38).

Issues Affecting the Effective Control of Trichinellosis

Human behavior is the biggest determinant in the persistence of trichinellosis in the face of increasing regulations directed at ensuring the safety of meat and the enhancement of good management practices in farming, especially in areas in which trichinellosis is highly endemic, such as the European and the Americas regions. Of particular concern is an increase in the association of wild animals with domestic pigs. For example, in the United States, the expansion of the range of feral pigs (wild boars) into major areas of pig production, including free-range systems, may increase the risk for incursion of Trichinella spp. into the human food chain (39). The increased frequency of outbreaks from eating pork from wild boars in Europe is believed to be related to the great increase in wild boar populations (40). As with other foodborne zoonoses, cultural traditions in food behavior and practices in the use of domestic and wild animals are not easily altered, and trichinellosis can be expected to remain a food-safety risk in many areas of the world for the foreseeable future.

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Worldwide Occurrence and Impact of Human Trichinellosis, 1986–2009

Technical Appendix

Section A. Total cases and incidence of human *Trichinella* infections by country and World Health Organization region, 1986–2009*

| Region/Country                  | Period      | No. cases | Average incidence (range/dates)† | References                                                                 |
|--------------------------------|-------------|-----------|----------------------------------|---------------------------------------------------------------------------|
| **African Region**              |             |           |                                  |                                                                           |
| Ethiopia                        | 1986        | 8         | 0.02                             | Kefenie et al., 1988                                                     |
|                                 | 1990        | 20        | 0.04                             | Kefenie and Bero, 1992                                                   |
| **Region of the Americas**      |             |           |                                  |                                                                           |
| Canada                          | 1987–2009   | 257       | 21.3 for Kewatin region (1989–1995) | Heinzig, 1996                                                            |
|                                 |             |           |                                  | Schellenberg et al., 2003                                               |
|                                 |             |           |                                  | Ancelle et al., 2006                                                    |
|                                 |             |           |                                  | Gaulin et al., 2006                                                     |
|                                 |             |           |                                  | Houzé et al., 2009                                                      |
|                                 |             |           |                                  | Serhir et al., 2001                                                    |
|                                 |             |           |                                  | Moller et al., 2005                                                    |
|                                 |             |           |                                  | McIntyre et al., 2007                                                  |
| **USA**                         | 1987–2007   | 652       | 0.016 (0.01–0.04/1987–1990)       | McAuley et al., 1991                                                  |
|                                 |             |           | 0.014 (0.001–0.03/1991–1996)      | Moorhead et al., 1999                                                 |
|                                 |             |           | 0.005 (0.004–0.005/1997–2001)     | Roy et al., 2003                                                        |
|                                 |             |           | 0.004 (0.001–0.002/2002–2007)     | Kennedy et al., 2009                                                   |
|                                 |             |           |                                  | Smith et al., 2004                                                      |
|                                 |             |           |                                  | Nelson et al., 2003                                                    |
|                                 |             |           |                                  | Madariaga et al., 2007                                                 |
|                                 |             |           |                                  | Centers for Disease Control and Prevention, 1987                        |
|                                 |             |           |                                  | Landry et al., 1992                                                    |
|                                 |             |           |                                  | Petri et al., 1988                                                    |
|                                 |             |           |                                  | Graves et al., 1996                                                   |
|                                 |             |           |                                  | McAuley et al., 1992                                                  |
|                                 |             |           |                                  | Dworkin et al., 1996                                                  |
|                                 |             |           |                                  | Ortega-Pierres et al., 2000                                          |
|                                 |             |           |                                  | Chapa-Ruiz et al., 2001                                               |
| **Mexico**                      | 1986–2001   | 351       | 0.25 for State of Mexico (1986–1997) |                   |
|                                 |             |           |                                  |                                                |
| **Argentina**                   | 1990–2005   | 5,221     | 1.48 (1990–1999)                 | Bolpe and Boffi, 2001                                                   |
|                                 |             |           |                                  | Nunez et al., 2008                                                    |
|                                 |             |           |                                  | Rossi et al., 2007                                                    |
|                                 |             |           |                                  | Schenone et al., 2002                                                 |
| **Chile**                       | 1991–2004   | 698       | 0.36 (1996–2000)                 | Morales et al., 1999                                                  |
|                                 |             |           | 0.2 (2000)                       | Garciá et al., 2005                                                   |
| **Eastern Mediterranean Region**|             |           |                                  |                                                                           |
| **Iran**                        | 2007        | 6         | 0.008                            | Kia et al., 2008                                                       |
| **Lebanon**                     | 1995        | 44        | 1.25                             | Haim et al., 1997                                                    |
| **European Region**             |             |           |                                  |                                                                           |
| **Belarus**                     | 1986–1989   | 16        | 0.08                             | Ivanov et al., 1990                                                  |
| **Bosnia-Herzegovina**          | 1993–2003   | 1,600     | 4.1 (0.1–8.0)                    | Skripova and Kovchur, 1994                                           |
| **Bulgaria**                    | 1990–2006   | 4,108     | 2.9 (0.3–7.4/1990–1999)          | Cuperlovic et al., 2005                                              |
|                                 |             |           | 2.4 (0.7–4.0/2000–2006)          | Kurdova-Mintcheva et al., 2009                                       |
                                 |             |           |                                  | Peklova et al., 2008                                                  |
| Region/Country  | Period       | No. cases | Average incidence (range/dates)† | References                                                                 |
|----------------|--------------|-----------|----------------------------------|---------------------------------------------------------------------------|
| Croatia        | 1994–1999    | 1,350     | 4.8 (2.1–12.3)                   | Aleraj, 2008                                                              |
|                | 2000–2009    | 760       | 1.7 (0.02–3.9)                   | Croatia National Institute of Public Health, 2010                         |
|                |              |           |                                  | Marinculic et al., 2001                                                  |
|                |              |           |                                  | Vojnikovic et al., 2001                                                  |
|                |              |           |                                  | Puljiz et al., 2005                                                      |
|                |              |           |                                  | Cvitovic et al., 2007                                                   |
|                |              |           |                                  | Venetz et al., 2008                                                      |
| Czech Republic | 1986–2009    | 31        | 0.01                             | National Reference Laboratory for Tissue Helminthosis, 2010               |
| Estonia        | 1986–2009    | 91        | 0.2 (0.0–2.9)                    | Epshtein, 2010                                                           |
| France         | 1986–1989    | 11        | 0.005 (0.0–0.02)                 | Dupouy-Camet et al., 2010                                               |
|                | 1990–1999    | 1,158     | 0.19 (0.0–0.95)                  | Durant et al., 1991                                                     |
|                | 2000–2009    | 34        | 0.006 (0.0–0.02)                 | Roumier et al., 1992                                                    |
|                |              |           |                                  | Soulé, 1992                                                              |
|                |              |           |                                  | Gari-Toussaint et al., 1994                                              |
|                |              |           |                                  | Soulé, 1994                                                              |
|                |              |           |                                  | Basset et al., 1995                                                     |
|                |              |           |                                  | Bernard et al., 1995                                                    |
|                |              |           |                                  | Laurichesse et al., 1997                                                |
|                |              |           |                                  | Mailiot et al., 1997                                                    |
|                |              |           |                                  | Ancelle et al., 1998                                                    |
|                |              |           |                                  | Dupouy-Camet et al., 1998                                               |
|                |              |           |                                  | Haeghebaert et al., 1998                                                |
| Greece         | 1988         | 3         | 0.05                             | Ivanov et al., 1990                                                     |
| Germany        | 1986–1989    | 19        | 0.005 (0.003–0.007)              | Anonymous, 2010                                                         |
|                | 1990–1999    | 105       | 0.009 (0.0–0.01)                 | Robert Koch Institute, 2010                                             |
|                | 2000–2009    | 61        | 0.005 (0.0–0.01)                 | Nothdurft et al., 1995                                                  |
|                |              |           |                                  | Littmann et al., 2006                                                   |
|                |              |           |                                  | Nockler et al., 2007                                                    |
|                |              |           |                                  | Jansen et al., 2008                                                     |
| Greece         | 2009         | 1         | 0.008                            | Boutsini, 2009                                                          |
| Hungary        | 1986–1989    | 74        | 0.18 (0.08–0.32)                 | Glatz et al., 2010                                                      |
|                | 1990–1999    | 27        | 0.027                            |                                                                          |
|                | 2000–2009    | 57        | 0.057 (0.0–0.13)                 |                                                                          |
| Ireland        | 2007         | 2         | 0.04                             | McHugh et al., 2007                                                     |
| Israel         | 2002         | 30        | 0.5                              | Hefer et al., 2004                                                      |
|                | 2004         | 200       | 3.0                              | Marva et al., 2005                                                      |
| Italy          | 1986–1989    | 448       | 0.19 (0.0–0.7)                   | E. Pozio, unpub. data                                                   |
|                | 1990–1999    | 649       | 0.01 (0.0–0.9)                   | Pozio et al., 1986                                                     |
|                | 2000–2009    | 84        | 0.01 (0.0–0.07)                  | Pozio et al., 1987                                                     |
|                |              |           |                                  | Di Barù et al., 1990                                                   |
|                |              |           |                                  | Frongillo et al., 1992                                                 |
|                |              |           |                                  | Pozio et al., 1993                                                     |
|                |              |           |                                  | Pagni et al., 1994                                                     |
|                |              |           |                                  | Pozio et al., 1998                                                     |
|                |              |           |                                  | Pozio et al., 2001                                                     |
|                |              |           |                                  | Pozio and Marucci, 2003                                                |
|                |              |           |                                  | Pozio et al., 2006                                                     |
|                |              |           |                                  | Pozio et al., 2009                                                     |
| Kyrgyzstan     | 1996         | 10        | 0.2                              | Witschi, 2010                                                           |
| Latvia         | 1986–1989    | 22        | 0.20 (0.07–0.34)                 | NRL of Latvia Dr. G. Deksne                                             |
|                | 1990–1999    | 345       | 1.37 (0.60–3.40)                 |                                                                           |
|                | 2000–2009    | 269       | 1.13 (0.20–3.80)                 |                                                                           |
| Lithuania      | 1990–2004    | 3,705     | 6.6 (0.6–21.8)                   | Bartuliene et al., 2005                                                |
|                | 1989         | 75        | 2.0                              | Rockiene, 1996                                                          |
|                | 2005–2009    | 199       | 1.2 (0.4–3.4)                    | EpiNorth, 2010                                                          |
|                |              |           |                                  | Malakauskas, 2002                                                       |
|                |              |           |                                  | Bartuliene et al., 2009                                                |
| Macedonia      | 1992         | 6         | 0.3                              | Hristovski et al., 1992                                                |
| Region/Country | Period       | No. cases | Average incidence (range/dates)† | References                                                                 |
|---------------|--------------|-----------|----------------------------------|---------------------------------------------------------------------------|
| Poland        | 1986–1991   | 955       | 0.4 (0.05–0.8)                   | Adonajlo, 1988–1993                                                       |
|               | 1992         | 219       | 0.6                              | Koncki, 1994                                                              |
|               | 1993–1999    | 1,085     | 0.4 (0.05–1.5)                   | Seroka, 1995–2001                                                         |
|               | 2000–2001    | 88        | 0.1                              | Przybylska, 2002–2003                                                     |
|               | 2002–2007    | 737       | 0.3 (0.1–0.7)                    | Sadkowska-Todys and Golał, 2005–2009                                      |
| Romania       | 1986–1989    | 2,621     | 2.9 (1.7–3.9)                    | Néghina et al., 2010a                                                     |
|               | 1990–1999    | 20,059    | 8.57 (4.1–16.1)                  | Blaga et al., 2007                                                       |
|               | 2000–2007    | 5,884     | 3.3 (1.8–5.9)                    | Néghina et al., 2009a                                                    |
|               |              |           |                                  | Néghina et al., 2009b                                                     |
|               |              |           |                                  | Némé et al., 2009                                                         |
|               |              |           |                                  | Néghina et al., 2010b                                                     |
| Russia        | 1996–2002    | 971       | 0.48 (0.3–0.6)                   | Ozeretskoykovskaya et al., 2005                                          |
| Serbia        | 1994–2003    | 5,210     | 5.05 (1.8–7.8)                   | Cuperlovic et al., 2005                                                   |
|               |              |           |                                  | Cuperlovic et al., 2001                                                   |
|               |              |           |                                  | Djordjevic et al., 2003                                                   |
| Slovakia      | 1986–1992    | 83        | 0.22 (0.0–0.64)                  | Dubinsky et al., 1993                                                    |
|               | 1998         | 336       | 6.2                              | Dubinsky et al., 2001                                                    |
|               | 2001         | 11        | 0.2                              | Reiterova et al., 2007                                                   |
|               | 2008         | 10        | 0.2                              | Paralićová et al., 2009                                                  |
| Slovenia      | 1989         | 200       | 10.5                             | Brglez, 1996                                                             |
|               | 1995         | 2         | 0.1                              | Saulinger et al., 2007                                                   |
|               | 2006         | 1         | 0.05                             |                                                                            |
| Spain         | 1986–1989    | 233       | 0.15 (0.0–0.3)                   | Anonymous, 2010                                                          |
|               | 1990–1999    | 607       | 0.13 (0.02–0.40)                 | Anonymous, 1986                                                          |
|               | 2000–2009    | 404       | 0.08 (0.0–0.25)                  | Anonymous, 1987                                                          |
|               |              |           |                                  | Anonymous, 1988                                                          |
|               |              |           |                                  | Anonymous, 1987                                                          |
|               |              |           |                                  | de la Torre et al., 1989                                                 |
|               |              |           |                                  | Serrano et al., 1989                                                     |
|               |              |           |                                  | Anonymous, 1990                                                          |
|               |              |           |                                  | Cobo et al., 1991                                                        |
|               |              |           |                                  | Mangas Gallardo and Tello                                               |
|               |              |           |                                  | Anchuela, 1994                                                           |
|               |              |           |                                  | de la Cruz de Julián et al., 1994                                       |
|               |              |           |                                  | Anonymous, 1995                                                          |
|               |              |           |                                  | Tiberio et al., 1995                                                     |
|               |              |           |                                  | Tiberio et al., 1997                                                     |
|               |              |           |                                  | Rodriguez-Osorio et al., 1999                                           |
|               |              |           |                                  | Martinez Corral et al., 2000                                             |
|               |              |           |                                  | Lopez Hernandez et al., 2001                                            |
|               |              |           |                                  | Cortés Bianco et al., 2002                                               |
|               |              |           |                                  | Gomez Garcia et al., 2003                                               |
|               |              |           |                                  | Herrera Garcia et al., 2003                                             |
|               |              |           |                                  | Gallardo et al., 2007                                                    |
|               |              |           |                                  | Arevalo et al., 2009                                                     |
|               |              |           |                                  | J.C. Lozano-Becerra, pers. comm.                                        |
| Switzerland   | 1994         | 3         | 0.04                             | Lupinc et al., 2003                                                      |
| Turkey        | 2003         | 7         | 0.01                             | Heper et al., 2005                                                       |
|               | 2004         | 418       | 0.59                             | Akkoc et al., 2009                                                       |
| United Kingdom| 1999         | 7         | 0.01                             | Milne et al., 2001                                                       |
| Ukraine       | 1986–1989    | 147       | 0.06 (0.04–0.10)                 | Ukraine Ministry of Health, 2010                                         |
|               | 1990–1999    | 955       | 0.18 (0.09–0.3)                  |                                                                            |
|               | 2000–2009    | 108       | 0.018 (0.0–0.08)                 |                                                                            |
| South-East Asia Region | 219  |           |                                  |                                                                            |
| Thailand      | 1993–2007    | 216       | 0.35                             | Limsunwan and Siriprasert 1994                                           |
|               |              |           |                                  | Charkrit, 1998                                                           |
|               |              |           |                                  | Jongwutiwes et al., 1998                                                 |
|               |              |           |                                  | Watt et al., 2000                                                        |
|               |              |           |                                  | Chotmongkul et al., 2005                                                 |
|               |              |           |                                  | Khumjui et al., 2008                                                     |
|               |              |           |                                  | Alipuria et al., 1996                                                   |
|               |              |           |                                  | Handa et al., 2000                                                       |
|               |              |           |                                  | Mohan et al., 2002                                                       |
| India         | 1996–2002    | 3         | 0.0003                           |                                                                            |
| Western Pacific Region | 1,344 |           |                                  |                                                                            |
| Region/Country          | Period   | No. cases | Average incidence (range/dates)† | References                                      |
|------------------------|----------|-----------|----------------------------------|------------------------------------------------|
| People’s Republic of China | 1995–2009 | 1,137     | Yunan, 1.0  
Henan, 0.001  
Tibet, 1.74  
Sichuan, 0.028  
Hubei, 0.03 (2000–2003) | Cui et al., 1997  
Lo et al., 2009  
Wang and Cui, 2001  
Xu et al., 1995  
Gong et al., 2008  
Ye et al., 2003  
Ci et al., 2003 |
| Japan                  | 1999–2005 | 4         | NA                               | Kusuhara et al., 1999  
Shiota et al., 1999  
Nakamura et al., 2003  
Yoshikawa et al., 2005 |
| South Korea            | 1999–2003 | 8         | 0.016                            | Sohn et al., 2003  
Kim et al., 2003  
Lee et al., 1999 |
| Laos                   | 2004–2006 | 123       | 2.09                             | Sayasone et al., 2006  
Taybouavone et al., 2009  
Suwansrinen et al., 2007  
Barennes et al., 2008 |
| Singapore              | 1998     | 25        | 0.64                             | Kurup et al., 2000 |
| Vietnam                | 2001–2004 | 47        | 0.058                            | Taylor et al., 2009  
De et al., 2006 |

*Human trichinellosis infections acquired in countries different from those where the disease was developed and diagnosed were not included in this table. NA, insufficient data for incidence calculation.
†Incidence/10⁵ person-years. The incidence period is reported because the data may have been obtained over a period briefer than the interval on which total cases are based. For some countries, incidence was not reported and was calculated from data available in the report referenced.

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Section B. Trichinellosis infections acquired in countries different from those where the disease was developed and diagnosed, 1986–2009

| Country where the infection was developed and diagnosed | Country where infection was acquired | Period               | No. clinical cases | References                                      |
|--------------------------------------------------------|-------------------------------------|----------------------|--------------------|------------------------------------------------|
| Austria                                                | Yugoslavia                         | 2000–2006            | 10                 | Austrian Ministry of Health Report, 1986–2009   |
| Czech Republic                                         | Poland                              | 1992–2006            | 2                  | National Reference for Tissue Helminthosis      |
|                                                        | Ukraine                             |                      |                    |                                                |
|                                                        | France                              |                      |                    |                                                |
| Denmark                                                | Poland                              | 2007                 | 12                 | Stensvold et al., 2007                         |
| France                                                 | Algeria                             | 1986                 | 5                  | Michel et al., 1986                            |
|                                                        | Turkey                              | 1994–1995            | 3                  | Dupouy-Camet et al., 1998                      |
|                                                        | Kenya                               |                      | 2                  |                                                |
|                                                        | Greenland                           | 1995                 | 2                  | Nozais et al., 1996                            |
|                                                        | Laos                                | 1991                 | 1                  | Ancelle et al., 2006                           |
|                                                        | Yugoslavia                          | 1996                 | 1                  |                                                |
|                                                        | Croatia                             | 1999                 | 1                  |                                                |
|                                                        | Cameroon                            | 1999                 | 1                  |                                                |
|                                                        | Spain                               | 2001                 | 1                  |                                                |
|                                                        | Canada                              | 2004                 | 1                  |                                                |
|                                                        | Thailand                            | 2004                 | 1                  |                                                |
|                                                        | Laos                                | 2005                 | 3                  |                                                |
|                                                        | Canada                              | 2005                 | 8                  |                                                |
|                                                        | Algeria                             | 2004                 | 1                  | Nezri et al., 2006                             |
|                                                        | Laos                                | 2007                 | 1                  | Dupouy-Camet et al., 2008                      |
|                                                        | Senegal                             | 2009                 | 5                  | Dupouy-Camet et al., 2009                      |
| Belgium                                                | Canada                              | 2009                 | 1                  | Houzé et al., 2009                             |
| People’s Republic of China (Hong Kong Special Administrative Region) |                                    |                      |                    |                                                |
| France                                                 |                                     |                      |                    |                                                |
| Germany                                                |                                     |                      |                    |                                                |
| Germany                                                | Poland                              | 2007                 | 3                  | Schmiedel and Kramme, 2007                     |
| Italy                                                  | Romania                             | 2008                 | 4                  | Angheben et al., 2008                          |
| Netherlands                                            | Yugoslavia                          | 1992                 | 3                  | T. Kortbeek, pers. comm.                       |
|                                                        | Montenegro                          | 1999                 | 5                  | Pinelli et al., 2004                          |

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Section D. Summary of sex and age data on persons with trichinellosis cases, by World Health Organization region, 1986 to 2009

| Region/Country            | % Males (total no. cases)* | Age, y, of infected persons (no. cases) | References                                      |
|---------------------------|-----------------------------|----------------------------------------|------------------------------------------------|
| African Region            | 100 (28)                    | Range: 23–25 (3)                       | Kefenie et al., 1988                           |
| Ethiopia                  | 100 (28)                    | Mean: 24 (3)                           | Kefenie and Bero, 1992                         |
| Region of the Americas    |                             |                                        |                                                |
| Canada                    | 62.1 (150)                  | Range: 21–67 (85)                      | MacLean et al., 1992                          |
|                           |                             | Mean: 34.4 (65)                        | Greenbloom et al., 1997                       |
|                           |                             |                                        | Schellenberger et al., 2003                   |
|                           |                             |                                        | Serhir et al., 2001                           |
|                           |                             |                                        | Ancelle et al., 2006                          |
|                           |                             |                                        | McAuley et al., 1991                          |
|                           |                             |                                        | McAuley et al., 1992                          |
|                           |                             |                                        | Moorhead et al., 1999                         |
|                           |                             |                                        | Roy et al., 2003                              |
|                           |                             |                                        | Kennedy et al., 2009                          |
| USA                       | 57.5 (632)                  | Range: 1–87 (412)                      | MacLean et al., 1992                          |
|                           |                             | Mean: 42.0 (126)                       | Greenbloom et al., 1997                       |
|                           |                             | Median: 37.1 (232)                     | Schellenberger et al., 2003                   |
|                           |                             |                                        | Serhir et al., 2001                           |
|                           |                             |                                        | Ancelle et al., 2006                          |
|                           |                             |                                        | McAuley et al., 1991                          |
|                           |                             |                                        | McAuley et al., 1992                          |
|                           |                             |                                        | Moorhead et al., 1999                         |
|                           |                             |                                        | Roy et al., 2003                              |
|                           |                             |                                        | Kennedy et al., 2009                          |
| Mexico                    | 35 (59)                     | Range: 25–44 (59)                      | Zamorano et al., 1994                         |
|                           |                             |                                         | Schenone et al., 2002                         |
| Chile                     | 60 (687)                    | Range: 5–70 (687)                      |                                                 |
|                           |                             |                                         |                                                 |
| Eastern Mediterranean     |                             |                                        |                                                |
| Region                    |                             |                                        |                                                |
| Lebanon                   | 54 (44)                     | Range: 10–70 (44)                      | Haim et al., 1997                             |
|                           |                             | Mean: 33 (44)                          |                                                 |
| European Region           |                             |                                        |                                                |
| Bulgaria                  | 49 (228)                    | Range: 1–70 (228)                      | Petkova et al., 2008                           |
| Croatia                   | 57 (200)                    | Range: 3–67 (200)                      | Cvitovic et al., 2007                         |
|                           |                             | Mean: 35 (200)                         | Venus et al., 2008                            |
| Czech Republic            | 41.9 (31)                   | Range: 9–68 (31)                       | National Reference Laboratory for Tissue Helminthosis |
|                           |                             | Mean: 35.9 (31)                        | Gari-Toussaint et al., 2004                    |
|                           |                             |                                        | Ancelle et al., 2006                          |
|                           |                             |                                        | Ranque et al., 2000                           |
|                           |                             |                                        | Laurichesse et al., 1997                      |
|                           |                             |                                        | Bernard et al., 1995                          |
|                           |                             |                                        | Ancelle et al., 1998                          |
|                           |                             |                                        | Ranque et al., 2000                           |
|                           |                             |                                        | Gari-Toussaint et al., 2004                    |
|                           |                             |                                        | Bancalier et al., 2007                        |
|                           |                             |                                        | Dupouy-Carnet et al., 2005                     |
|                           |                             |                                        | Dupouy-Carnet et al., 2010                     |
|                           |                             |                                        | Schmiedel and Kramme, 2007                     |
|                           |                             |                                        | Neckler et al., 2007                          |
|                           |                             |                                        | Pozio et al., 1986                            |
|                           |                             |                                        | Pozio et al., 1986                            |
|                           |                             |                                        | Frongillo et al., 1992                        |
|                           |                             |                                        | Pozio et al., 1993                            |
|                           |                             |                                        | Tamburrini et al., 2001                       |
|                           |                             |                                        | Nezhina et al., 2009                          |
|                           |                             |                                        | Reiterová et al., 2007                        |
| Germany                   | 51.9 (104)                  | Range: 1–73 (101)                      | Jansen et al., 2008                           |
|                           |                             | Mean: 34.8 (101)                       | Nothdurft et al., 1995                        |
|                           |                             |                                        | Schmiedel and Kramme, 2007                     |
|                           |                             |                                        | Neckler et al., 2007                          |
|                           |                             |                                        | Pozio et al., 1986                            |
|                           |                             |                                        | Pozio et al., 1986                            |
|                           |                             |                                        | Frongillo et al., 1992                        |
|                           |                             |                                        | Pozio et al., 1993                            |
|                           |                             |                                        | Tamburrini et al., 2001                       |
|                           |                             |                                        | Nezhina et al., 2009                          |
|                           |                             |                                        | Reiterová et al., 2007                        |
|                           |                             |                                        | Paraličová et al., 2009                       |
| Isreal                    | 100 (26)                    | Mean 32 (26)                           | Marva et al., 2005                            |
| Italy                     | 50.3 (382)                  | Range: 1–90 (382)                      | Pozio et al., 1986                            |
|                           |                             | Mean: 36.7 (382)                       | Pozio et al., 1988                            |
| Romania                   | 53.2 (521)                  | Range: 1– >60 (521)                    | Neghina et al., 2009                          |
|                           |                             | Mean: 31.4 (521)                       |                                                 |
| Slovakia                  | 63.6 (11)                   | Range: 16–80 (21)                      | Reiterová et al., 2007                        |
|                           |                             | Mean: 40.5 (21)                        | Paraličová et al., 2009                       |
| Country                        | Prevalence (%) | Range:     | Mean:     |
|-------------------------------|----------------|------------|-----------|
| Spain                         | 57.5 (237)     | 2–86 (140) | 40.7 (177) |
| Turkey                        | 52.6 (418)     | 1.5–73 (418)| 31.1 (418) |
| Thailand                      | 71 (165)       | 7–70 (210) | 35.6 (208) |
| Laos                          | 47% (111)      | 5–69 (111) | 34.5 (90)  |
| Singapore                     | 56% (25)       | 20–60 (42) | 22.5 (25)  |
| Vietnam                       | 92% (42)       |            | 45.4 (42)  |

*Data are from those reports which presented adequate sex and age data of no fewer than 10 cases during 1986–2009.

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