Annex 8

Regional Reports

The experts were grouped into seven geographical regions and were asked to prepare and bring to the meeting regional information that considered the current overall quantity and quality of data at the regional and global levels; burden of disease and food attribution; data on parasite prevalence; incidence and concentration in the main food categories; agri-food trade; consumer perception; social sensitivity; and risk management options. These reports were used by the experts in their deliberations during the meeting. The seven geographical regions represented were Africa, Asia, Pacific (primarily Australia), Europe, Near East, North America and South America. What little that was available for Central America was added to the North America section.

Note on information sources: The references for the Asia regional report were revised after the meeting, and a few were updated (2013).

Note on taxonomy: There has been confusion concerning the causative agent of giardiasis, and it has variously been named as *Giardia duodenalis*, *Giardia lamblia* or *Giardia intestinalis*. The general consensus is that the parasite should be identified as *Giardia duodenalis,* with *Giardia lamblia* and *Giardia intestinalis* considered synonyms.

ANNEX 8.1 – AFRICA

A8.1.1 Introduction

The group members (Erastus Kang'ethe, Kenya; Allal Dakkak, Morocco; and Samson Mukaratirwa, South Africa) were responsible for collating data on food-borne parasites relevant to the African region, deriving the information from the proposed list and based on their experiences and information available in the literature. Communication and exchange of information among members of the group was through e-mail.

Samson Mukaratirwa, as the Group leader, was responsible for compiling the contributions from members, following the specific guidelines from the Secretariat of the FAO/WHO Joint Expert Meetings on Risk Assessment (JEMRA).

A8.1.2 Data availability in humans, and food attribution

To some extent data is available on the prevalence of *Taenia solium*, *T. saginata*, *Echinococcus granulosus* and *Toxoplasma gondii*, but not enough to quantify the burden of the disease in humans in the region. In many African countries there is virtually no data on prevalence in humans, and there is a general lack of surveillance systems, which leads to no availability of data to quantify the burden of the disease. With the advent of the HIV-AIDS pandemic in sub-Saharan Africa there are reports of cases of cryptosporidiosis and toxoplasmosis, but mainly in immuno-compromised individuals. Efforts have been made in the last decade to estimate the burden of *T. solium* cysticercosis in sub-Saharan Africa, with some success in Cameroon and South Africa, and in Africa as whole the burden of ascariasis and trichuriasis has been estimated.

For other foodborne parasites, more prevalence studies are needed to quantify the disease burden. in humans Although parasites like *Toxoplasma gondii*, *Giardia* spp., *Cryptosporidium* spp. and *Trichinella* spp. have a global importance, they are still very much underreported in Africa, either because of lack of prioritization by relevant authorities or by being overshadowed by the importance of other parasites, such as *Plasmodium* spp. There is need to collect data on the prevalence of these parasites in order to estimate the burden of the disease in the region, especially for neglected rural communities, where the prevalence is assumed to be very high.

TABLE A8.1.1 Data availability on the burden of disease and food attribution at the regional and global level for Africa

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Ancylostoma duodenale	Yes [28, 33] North Africa: 0–1.9%; Central Africa: 10–20%; South and West Africa: 50-70%.	Yes [28, 30, 33] High prevalence in sub-Saharan Africa	Main mode of transmission is via skin penetration. Oral transmission through ingestion of contaminated vegetables and drinking water may occur. Children are at high risk [28, 32, 33]	Yes [28, 32]	Yes [28, 32]	[28, 32]
Ascaris lumbricoides	Yes [27]	Yes [27] 91333.5 000 DALYs in Africa	Contaminated water, fruits and edible plants [27]	Yes [27]	Yes [27] 1 851 000 DALYs in the world.	Contaminated water, fruits and edible plants [27]
Cryptosporidium spp.	Yes [21] Mainly in immuno-compromised individuals.	Yes Related to urban dwellers with poor supply of potable water and HIV-infected. High pathogenic effects in children aged 6 to 36 months, particularly those who are malnourished or positive for HIV infection.	Mainly contaminated water, fruits and edible plants	Yes [22, 23]	Yes [22]	Mainly contaminated water and edible plants [22]
Echinococcus granulosus	Yes [12, 13, 14, 15] Hydatidosis is highly prevalent and 3 to 7 surgical cases per 100 000 inhabitants a year in sub-Saharan Africa. There is rather conspicuous concentration of human cases in NW Sudan, NE Uganda, SE Ethiopia and extreme SE Sudan.	Yes [14, 15] Young children are most often affected because of their constant hand-to-mouth behaviour	Edible fruits, plants and water contaminated with eggs [14, 15]	Yes [16] Cystic hydatidosis is one of the most important zoonotic diseases	Yes [17] Global DALYs lost due to disease is estimated at 285 407	Edible plants, fruits and water contaminated with eggs

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	**Disease severity/ main populations at risk**	**Main food source and attribution**	**Disease in humans**	**Disease severity/ main populations at risk**	**Main food sources and attributions**
Taenia saginata	Yes [9, 10] Not many studies conducted in humans and in many instances there is difficulty in differential Dx with T. solium eggs. Occurs in most African countries, but the epidemiological patterns in the African countries are far from being complete.	Yes [10, 11] Scanty reports for the disease in humans. Main populations at risk are rural communities with poor sanitation. Disease is not considered as severe in humans.	Meat [10, 11] (undercooked or raw beef)	Yes [11]	Yes [11] Population in areas where poor sanitation and animal husbandry facilitate parasite transmission	Meat [11] undercooked or raw beef
Taenia solium	Yes [1, 2] Except for the Muslim regions, where pork is not eaten for religious reasons, T. solium cysticercosis affects virtually all countries in Western and Central Africa West Africa: 0.6–17%; Central Africa: 0.6–20%; West Africa: 0.1–6.5%. Neurocysticercosis is considered to be the commonest parasitic disease of the human nervous system	Yes [3, 4, 5, 6] Underestimated because of lack of cheap and reliable Dx test. Monetary burden valued at US$ 34.2 million in the Eastern Cape Province of South Africa. 9.0 DALYs lost per 1000 persons in Cameroon.	Meat (undercooked or raw pork); edible raw plants and fruits contaminated with eggs; autoinfection	Yes [7, 8]	Yes [7]	Meat (undercooked or raw pork); edible raw plants and fruits contaminated with eggs; autoinfection [8]

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Toxoplasma gondii	Yes [18] Mainly in immuno-compromised individuals. Occurs in most African countries, where it seems to be frequent, but the epidemiological patterns in the African countries are far from clear. The prevalence of infection seems to be high and varies from 15 to 60%.	Yes [19] Reports related to HIV infection and congenital infections.	Yes Milk and raw or undercooked meat from livestock contaminated with tachyzoites and bradyzoites; drinking of water and ingestion of edible plants contaminated with oocysts.	Yes [8] High sero-prevalence in North America (10%) and UK (40%); 50 to 80% in continental Europe and Latin America. However, prevalence is steadily decreasing.	Yes Due to HIV-AIDS pandemic in sub-Saharan Africa.	Milk and raw or undercooked meat from livestock contaminated with tachyzoites and bradyzoites; drinking of water and ingestion of edible plants contaminated with oocysts [8]
Trichuris trichiura	Yes [27]	Yes [27] 236 000 DALYs in Africa	Contaminated water, fruits and edible plants [27]	Yes [27]	Yes [27] 1 012 000 DALYs in the world	Contaminated water, fruits and edible plants [27]
Trichinella spp	Yes [24] Sporadic cases reported in Africa. Species identification from cases not always done.	Yes Sporadic clinical cases confirmed in humans but species not determined.	Meat (undercooked or raw meat and products from wild pig, warthog, bush pig).	Yes [26]	Yes [26] About 11 million people may be infected	Meat [26] undercooked or raw meat and products from pigs, horses and wildlife of temperate regions, like bears and seals.

Notes: Dx = diagnostic; DALY = disability-adjusted life year

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TABLE A8.1.2 Data availability for parasite prevalence or concentration in the main food categories for Africa

Taenia saginata	
Beef	Yes [6–9]
Game	Yes [6–9]
Echinococcus granulosus	
Beef	Yes [10]
Game	Yes [11]
Other	Yes [10] Caprid meat
Taenia solium	
Pork	Yes [1–5]
Fruits	Yes [1–5] Contaminated with T. *solium* eggs.
Vegetables	Yes [1–5] Contaminated with T. *solium* eggs.
Other	Yes [1–5] Drinking water contaminated with T. *solium* eggs.

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A8.1.3 Agri-food trade

Most of the above parasites have minor regional or global trade implications, except for *T. solium*, *Trichinella* spp. in pork and pork products, and *T. saginata* in beef and beef products, which do have trade implications. In most countries, carcasses may not be released even for the domestic market unless they have been inspected and/or tested to ascertain absence of infection.

A8.1.4 Consumer perception

Because of lack of public awareness campaigns and education concerning the risks of eating certain foods, especially meat and meat products, in many African countries, consumers in Africa are ignorant of the prevalent of foodborne parasites. To some extent, consumers in some countries are aware of *T. solium* and saginata cysticercosis, but in some cases they are ignorant of the importance of meat inspection and hygiene. In some countries, consumers are aware of the effects of hydatid cysts of *Echinococcus granulosus* but are ignorant of not how the parasite is transmitted. The risk of human infection from infected meat and vegetables is reduced by cooking, which destroys the pathogen, because of the reduced use of raw vegetables this has limited transmission.

A8.1.5 Social sensitivity

Neurocysticercosis due to *T. solium* infection is one of the main causes of epilepsy in rural African communities. This comes with social stigma for those affected by the parasite. Another disease that might have social sensitivity in the African context is congenital toxoplasmosis, which might cause abortions and foetal deformities, creating a variety of social problems within a community. The disease has substantial global impact in terms of disability adjusted life years (DALYs) and monetary losses. Furthermore, in most reports, between 1 and 2 hydatid cysts in humans are fatal, depending on their location, and the DALYs are substantial.

T. solium, *T. saginata* and *E. granulosus* are considered to have economic impact when it comes to monetary loss due to carcass devaluation or condemnation, which is recognized by a lot of the people. This affects not only human and animal health directly, but also agriculture in general.

A8.1.6 Risk management

TABLE A8.1.3 Data availability for risk management options for main parasite-commodity combinations in Africa.

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

***Cryptosporidium* spp.**	
Beef	Yes [9]
Fruits	Yes [12, 13]
Vegetables	Yes [12, 13]
Other	Yes [12, 13]
Echinococcus granulosus	
Beef	
Other	Yes [9–11]
Taenia solium	
Pork	Yes [1–4]
Other	Yes [1–4]
Taenia saginata	
Beef	Yes [6]
Pork	Yes [5]
Other	Yes [5, 6]
Trichinella spiralis	
Pork	Yes [7, 8]
Game	Yes [7, 8]

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ANNEX 8.2 – ASIA

A8.2.1 Introduction

Foodborne Parasitic diseases are widely distributed in south-east, east and south Asia, and have been major public health problem for the population in the countries and regions. Distribution and endemicity of individual foodborne parasitic diseases vary greatly among countries and regions. While a majority of foodborne parasitic diseases are restricted to a few countries, or even local areas, there are some diseases prevalent much more widely. This section tries to summarize the current status of foodborne parasitic diseases in Asia.

The information for Asia was collected by Nguyen Van De, Viet Nam; Tomoyoshi Nozaki, Japan; Subhash Parija, India; and Paiboon Sithithaworn, Thailand.

One should note that some of statistics regarding endemicity were based on serology and/or microscopy, and thus potentially erroneous due to lack of proper objective diagnostic methods such as PCR and antigen detection of parasites, and confounded by potential cross-reactivity of sera from individuals infected with other parasites in tests using crude or undefined antigens.

A8.2.2 Description of individual foodborne parasitic diseases

The foodborne parasitic diseases are considered hierarchically as, firstly, meat-, fish-, shellfish- and plant-borne infections, secondly as protozoan and helminth infections, and thirdly in alphabetical order.

A8.2.2.1 Meat-borne parasite infections

Sarcocystosis (intestinal)

Intestinal sarcocystosis domestically is distributed in some countries, including China (29.7%), Malaysia (19.7% of 243 persons had antibodies to sarcocystis), India (11 case reports from 1990 to 2004), Thailand (1.5%) and Japan (case reported). In Viet Nam none were reported. In Japan, a case that may be relevant to international trade has recently emerged. Sarcocystis infection through consumption of raw horse meat ("Basashi") is becoming an important social health problem, with 37 clinical complaints related to consumption of fresh market horsemeat reported, mainly from the producing centres in Japan. The *Sarcocystis* species responsible for cases has been determined by rRNA sequencing to be closest to *S. fayeri*. Both horse meat imported unfrozen and live horses imported (mainly from North America) and raised in Japan were proven to be infected with the species at high possibility. Proper freezing (-20°C for >48 hours) can eliminate live parasites.

Toxoplasmosis

Toxoplasmosis, caused by the protozoan parasite *Toxoplasma gondii*, is prevalent in

Asia. However, data on most the serious form of toxoplasmosis, congenital toxoplasmosis, is largely unavailable.

In China, the first human case of toxoplasmosis was reported in 1964 in Jiangxi Province. Many human cases have been were reported in China since the first epidemic survey on toxoplasmosis was carried out in Guangxi Province in 1978. Between 2001 and 2004, a national serological survey of 47 444 people in 15 provinces and autonomous regions estimated a mean prevalence of 7.9% by using enzyme-linked immunosorbent assay (ELISA). High seroprevalence of latent *T. gondii* infection has been found among immunocompromised patients. Prevalence of *T. gondii* infection in cancer patients ranged from 24% to 79%. Surveys of *T. gondii* infection in individuals with tuberculosis and hepatitis B showed that the prevalences were 35.3% and 19.3%, respectively. In India, in the general population, seropositivities were 10.8–51.8% for IgG and 2–5% for IgM. In females with a bad obstetric history IgG was 49.5%. In HIV-infected subjects, seropositivity for IgG was 70%. In Thailand, the prevalence of toxoplasmosis was 2.6%. In Viet Nam, some cases of toxoplasmosis were reported. In Sri Lanka, the prevalence of toxoplasmosis was 27.5%. In Japan, the prevalence of toxoplasmosis was 1.8–5.6%. In Malaysia, the prevalence of toxoplasmosis was 10–50%. In Nepal, the prevalence of toxoplasmosis was 45.6%. In Viet Nam, some cases were reported. Food attribution to toxoplasmosis in Asia remains not well understood.

Taeniasis/cysticercosis

Human *Taenia*sis refers to foodborne infections with adult tapeworms: *Taenia solium*, *Taenia asiatica* (from pigs) or *Taenia saginata* (from cattle). Cysticercosis is a tissue infection with the larval cysticercus or metacestode stage of tapeworms, and occurs most commonly in pigs and cattle. The larval stage of *Taenia solium* can also infect humans and cause cysticercosis/neurocysticercosis, which is considered widespread in the developing countries of Latin America, Africa and Asia.

In Viet Nam, the infection rate of *Taenia* (serology) was 0.5–2% in the plains area, 3.8% in the highlands and 2–6% in mountain areas. Most taeniasis was due to *T. saginata* and *T. asiatica* (78–80%) or *T. solium* (20–22%). Cysticercosis is distributed in many provinces (over than 50 provinces), the prevalence was 5–7% in some villages. In China, the emergence of cysticercosis as a serious public health problem was recognized by the Chinese Government. Human cysticercosis caused by the larval stage of *T. solium* occurred in 29 provinces/autonomous regions/municipalities, and about 7 million people were estimated to be infected. Currently, *T. solium* and cysticercosis are highly endemic, primarily in Yunnan, Sichuan and Guizhou in the south-west, and in Qinghai province and Inner Mongolia in the north-west and northern regions. In Thailand, the prevalence of *Taenia*sis varies from 0.6 to 5.9%, and cysticercosis was 4% (based on serology). In Japan, 446 cysticercosis cases were reported up to 2004. In the Philippines, the reported prevalence of *Taenia*sis varied greatly, from 0.56 to 10% and cases reported. Indonesia, the prevalence of *Taenia* was 8–9% and cases reported of cysticercosis. In Bangladesh, case reports identified *Taenia* spp. In Nepal, the prevalence of *Taenia* spp. was 43% and cases reported for cysticercosis. In India, the prevalence of *T. solium* (18.6%), prevalence of neurocysticercosis (NCC) in asymptomatic individuals (15.1%), prevalence of NCC in active epileptics (26.3–56.8%) and prevalence of *T. saginata* was 5.3%. Note that these statistics regarding endemicity were often based on serology, and thus potentially erroneous due to cross-reactivity. In addition, as these infections occur mostly with domestically, but not internationally, traded meats, these diseases may not currently be a serious issue in Asia.

Trichinellosis

Trichinellosis in Asia is restricted to China and a few south-eastern countries. In China, more than 500 outbreaks in 12 of 34 provinces were reported, with 25 685 persons affected and 241 deaths. In Viet Nam, 5 trichinellosis outbreaks were reported, in the province of Yen Bai in 1970, Dien Bien in 2002 and 2004, Son La in 2008 and Thanh Hoa in 2012, with 114 cases and 8 deaths in total. In Thailand, the prevalence of trichinellosis was 0.9–9% (based on serology). In Japan, only one case was reported of trichinellosis. In India, there have been very few case reports, but recently a point source outbreak involved 42 cases. Note that these statistics regarding endemicity were mostly based on serology, and thus potentially erroneous due to cross-reactivity. In addition, as these infections occur mostly with domestically, but not internationally traded meats, these diseases may not currently be a serious issue in Asia.

A8.2.2.2 Fish- and shellfish-borne parasites

Anisakiasis (including *Pseudoterranova* sp.)

Anisakiasis is endemic in eastern Asian countries and regions, including Japan, Korea, mainland China and Taiwan. Due to the increasing popularity of Sushi and Sashimi, its worldwide distribution has potentially some relevance to the present FAO/WHO consultation. The worm species most commonly involved in human infections is *Anisakis simplex*. In Japan, 2 511 cases were reported between 2001 and 2005, and it is estimated—based on a survey using medical practitioners' receipts for health insurance claims—that a few to several thousand cases occurred annually in Japan. Anisakiasis has not been reported in South-East and South Asian countries, including India, Thailand and Viet Nam. The only cases reported of *Pseudoterranova decipiense* were from Japan and Taiwan.

Capillariasis

Capillaria philippinensis was reported in the Philippines, Japan, Thailand, Taiwan, Indonesia and India, with 3 case reports up to 2012.

Clonorchiasis

The oriental liver fluke, *Clonorchis sinensis*, is of socioeconomic importance in East and South-East Asia, including China, Taiwan, Viet Nam, Korea, and, to a lesser extent, in Japan. It is estimated that about 35 million people are infected globally, of whom approximately 15 million are in China in 27 provinces, which is a three-fold increase in the last decade. In Korea there have been 2 million infected, with a prevalence of 1.4–21.0%. In Japan, the prevalence was 1.0–54.2% (1960) and 10.9–66% (1961), but now has almost disappeared. In Viet Nam, the prevalence is 19.5% (0.2–40%) in 15 of 64 provinces in the north of the country. In Taiwan, prevalence is 10–20%. India has had very few cases reported. Note that these statistics regarding endemicity were very often based on serology, and thus potentially erroneous due to cross-reactivity. In addition, as these infections occur mostly with domestically but not internationally traded meats, these diseases may not currently be a serious issue in Asia.

Gnathostomiasis

Gnathostomiasis is restricted to South-East Asian countries. Cases reported of *Gnathostoma* spp. include 40 cases in Japan (2000–2011), 86 in China, and 34 in other Asian countries. Cases have been reported in China, Thailand, Viet Nam, India, Laos PDR, Myanmar, Cambodia, Bangladesh, Malaysia, Indonesia, Philippines and in India, with 14 cases reported up to 2012.

Echinostomiasis

Reported prevalences of *Echinostoma* spp. were 0.04–55.3% in Thailand, 1.5–20.1% in China (based on serology), a single case in Viet Nam and a few cases in India.

Kudoa infections

Kudoa infections from consumption of unfrozen raw flatfish ("Hirame") have been reported only recently in Japan. However, the number of cases is growing since the identification and notification of the causative agent. By 2011, 33 incidents involving 473 cases had been reported, with outbreaks also common. Food poisoning associated with flatfish consumption can be prevented by freezing at -20°C for 4 hours or heating at 90°C for 5 minutes, which inactivates *Kudoa septempunctata*. However, in view of the high market value of live flatfish, the Fishery Agency is currently taking measures towards Kudoa-free flatfish aquaculture. Currently, unfrozen flatfish is consumed only in East Asia, including Japan and Korea, but *Kudoa* may have an impact on food trade when flatfish consumption becomes more widely popular.

Opisthorchiasis

Opisthorchiasis is restricted to a few SE countries, where eating raw freshwater fish is common. In Thailand, prevalence of opisthorchiasis was 15.7%. In Lao PDR, the prevalence of opisthorchiasis was 37–86%. In Cambodia, opisthorchiasis was found in some cases. In Viet Nam, the prevalence of opisthorchiasis was 1.4–37.9% in 9/64 provinces in the south. In Malaysia, one case was reported of opisthorchiasis. In India, no cases have yet been reported. As opisthorchiasis occurs mostly in a domestic context, it is irrelevant to international trade in Asia.

Paragonimiasis

Paragonimus westermani has major socioeconomic importance in some restricted SE Asian countries and China. The parasite is transmitted via snails to freshwater crabs or crayfish, then to humans and other mammals, such as cats and dogs, and causes paragonimiasis. Thus, paragonimiasis is restricted to countries and regions where easting raw crab meat, which is locally distributed, is practised. In China, species of medical importance are *Paragonimus westermani*, *P. szechuanensis*, *P. heterotremus*, *P. huetiungensis* and *P. skrjabini*. *P. westermani* has been reported in humans from 24 provinces of mainland China, with a prevalence of 4.1–5.1%, with the population at risk of paragonimiasis being about 195 million. In Viet Nam, prevalence was 0.5–15% in 10/64 provinces based on serology. Adult worms found in dogs and infected cats, identified by morphology and molecular methods, were *P. heterotremus*. In Thailand, cases were reported in 23/68 provinces. In Japan, over 200 cases have been reported, but only a few recent cases. In Philippines, prevalence was 27.2–40% by serology in some areas. In India, it is endemic to the north-eastern states of Manipur, Nagaland and Arunachal Pradesh, where *P. heterotremus* is the common species, with up to 50% seroprevalence in these regions. Note that these statistics regarding endemicity were mostly based on serology and thus potentially erroneous due to cross-reactivity. In addition, as these infections occur mostly through domestically but not internationally traded meats, these diseases may not currently be a serious issue in Asia.

Small intestinal flukes

Small intestinal flukes reported included Heterophiydae (*Haplorchis taichui, H. pumilio, H. yokogawai, Metagonimus* spp, *Centrocestus* spp, Lecitodendriids) and Echinostomatidae (*Echinostoma* spp., *Echinochasmus* spp.). Many cases were reported of small intestinal flukes in Korea, with 19 species identified. In Viet Nam, small intestinal flukes were widely distributed with a high prevalence (over 50% in some endemic areas), with 6 species in humans. Flukes are common in Thailand, with cases reported from China, Japan and India.

Sparganosis

A case was reported of *Spirometra erinacei* causing sparganosis in humans in Japan (an imported case), and Viet Nam and India have had few cases reported.

A8.2.2.3 Plant (fruit and vegetable)-borne parasites

Amoebiasis

Entamoeba histolytica is widely distributed in Asia. For instance, in Viet Nam, prevalence is 2-6% in children; in India, intestinal amoebiasis with *E. histolytica* or *E. dispar* (1–58%), intestinal amoebiasis with proven *E. histolytica* (34.6% of all the samples found to be positive for *E. histolytica* or *E. dispar*), extra-intestinal amoebiasis – amoebic liver abscess (3–9% of all the cases of intestinal amoebiasis). In Japan, in contrast, *E. histoltyica* infections are restricted to faecal spread though anal intercourse or faecal smearing by persons with intellectual disabilities, and thus its impact on foodborne transmission of the disease is very limited. In addition, as its transmission is primarily local and domestic in all endemic countries and regions, amoebiasis may be irrelevant to international trade. Furthermore, as transmission occurs locally and domestically in all endemic countries and regions, amoebiasis is irrelevant to international trade.

Cryptosporidiosis

In Viet Nam, an infection rate of cryptosporidiosis was 2.8% reported on a national basis. In India, the infection rate of Cryptosporidiosis was 18.9% in children, who had diarrhoea. In Japan, no foodborne case of cryptosporidiosis has been reported. In China, the infection rate of Cryptosporidiosis was 1.36–13.3%. Note that some of these numbers may not be reliable. As its transmission occurs locally and domestically in all endemic countries and regions, cryptosporidiosis is probably irrelevant to international trade. In addition, the main route of transmission is drinking water, and food attribution is not well understood.

Giardiasis

Giardiasis is caused by *Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*), which constitutes the most common intestinal protozoan worldwide. Contaminated water is an important source of human infection, either through direct consumption or through the use of contaminated water in food processing or preparation. Human infection with *Giardia duodenalis* has been documented in every province of mainland China. The infection rate ranged from 8.67% to 9.07%, which were extracted from 13 areas out of 35 cities at the provincial level. Giardiasis is more common in children (<10 years old), and the prevalence varied from 5.0% in children aged 5–9 years to 4.2% in children aged 10–14 years. In Viet Nam, the prevalence was 1–10%. In India, countrywide distribution was 8.4–53.8%. However, as its transmission is principally local and domestic in all endemic countries and regions, giardiasis is irrelevant to international trade. In addition, the main route of transmission is drinking water, and food attribution is not well understood.

Ascariasis

Ascariasis is among the most common helminth infections worldwide, including Asia. However, as its transmission is local and domestic in all endemic countries and regions, ascariasis is irrelevant to international trade. In China, a recent nationwide survey suggested that *Ascaris lumbricoides* infection was the most common helminthiasis, with an overall prevalence of 47% and an estimated 531 million infections, and was most prevalent in children between 5 and 19 years old. In Viet Nam, the prevalence of ascariasis in communities in most provinces was 10–95%, with the greatest endemic infection rates being 80–95% in the Red River delta region, and least in the south and highland regions (10–40%). In Japan, the prevalence of Ascariasis was 8.2% in 1956, and is currently very low. In India, countrywide it is the commonest intestinal helminth ((28.4–68.3%). However, since its transmission is local and domestic in all endemic countries and regions, ascariasis is irrelevant to international trade.

Angiostrongyliasis

Angiostrongyliasis caused by *Angiostrongylus cantonensis* is a potentially fatal parasitic disease. The biggest outbreak in China thus far could be attributed to a freshwater snail and took place in the capital Beijing in 2006. Of the 160 infected individuals involved in this outbreak, 100 were hospitalized. In Thailand, case reports showed 484 cases from 1965 to 1968. In Viet Nam, over 60 cases were reported from many areas, most of them in children. In Japan, there have been 54 cases reported. In India, there is a single case report. Angiostrongyliasis is regionally restricted and irrelevant to international trade.

Coenurosis

Cerebral coenurosis or, more appropriately, central nervous system coenurosis (CNSc), is caused by infection with the larval stage (Coenurus cerebralis) of Taenia multiceps. This disease is very rare in humans and only about 100 cases have ever been recorded in China. Most human cases occur in developing countries, including India.

Echinococcosis

Echinococcosis, including cystic echinococcosis (CE) caused by the cestode *Echinococcus granulosus* and alveolar echinococcosis by *E. multilocularis* are regarded as among the most serious parasitic zoonoses. In China, the recent nationwide ELISA survey estimated that 380 000 people were infected with echinococcosis and ca. 50 million at risk of infection. In Japan, 373 cases (26 deaths) of alveolar echinococcosis were reported in 1997. Infection of wild foxes still persists, which may pose a public health risk for foodborne transmission of echinococcosis. Cases have been reported in South Korea, Mongolia, Thailand, Bangladesh, Nepal and India. Despite the fact that food attribution of echinococcosis is not well understood in Asia, it may have some relevance to international trade due to the severity of disease outcomes.

Fasciolopsiasis

Fasciolopsis buski is an intestinal trematode of humans and pigs that is acquired by consumption or handling of aquatic plants Fasciolopsiasis is restricted to some part of SE and East Asia, and irrelevant to international trade. In China, the first national survey between 1988 and 1992 revealed that fasciolopsiasis was distributed across 16 provinces and affected a total of 9531 infected people with 10.2–92.9% in some areas. The prevalence of infection in children ranged from 57% in mainland China to 25% in Taiwan. In Viet Nam, the prevalence of fasciolopsiasis was 0.5–3.8% in 16/64 provinces. In Thailand, its prevalence was 10% in children, who had intestinal parasites. Cases have been reported in Taiwan, Cambodia, Laos, Malaysia, Indonesia, Myanmar and India with a prevalence of 0–22.4%.

Fascioliasis

Fascioliasis is restricted to some part of SE Asia, and irrelevant to international trade. In Viet Nam, fascioliasis has been found in 52 of 63 provinces of the country, including 26 provinces in the south and 26 provinces in the north. Samples of *Fasciola* eggs and adult worms collected from the patients were analysed and identified by molecular methods as *Fasciola gigantica*. It is suggested that the Vietnamese *F. gigantica* has been hybridized with *F. hepatica*. In China, a national survey between 1988 and 1992 found 148 people were infected with *F. hepatica* and 9 with *F. gigantica*. Cases have been reported in Thailand, Korea, Islamic Republic of Iran, Japan, Malaysia, Singapore, Laos, Cambodia, Philippines and India.

Hookworm disease

In Viet Nam, the hookworm infection rate of was 30–85% in the north and 47–68% in the south, most of them being *Necator americanus* (95–98% of cases). Country-wide distribution in India was 28.9–43%. Cases have been reported in China, Korea and Japan. Significance of foodborne transmission of hookworms in Asia is not known.

Toxocariasis

In India, it is endemic in the northern states, up to 33% in Kashmir and with seropositivity of 6–23% in other northern states. In Viet Nam, one case report indicated hundreds of cases. In Japan, some cases have been reported. Foodborne attribution is not known.

Trichuriasis

In Viet Nam, distribution of trichuriasis is as wide as ascariasis, with a prevalence rate of 0.5–89% in surveys, with the infection rate in the north higher than in the south. In Thailand prevalence was 70%, and in Laos it was 41.5%.

A8.2.3 Risk management strategies

The strategies for control of foodborne parasites are combination of the regulation of an entire food chain from production to consumption. They also include creation of consumer perception and agri-food trade regulation. For some foodborne parasitic diseases, food habits of eating raw materials (e.g. freshwater fish) are the primary cause of endemicity and national, regional, and local activities to increase public awareness are essential. However, these diseases are mostly local and consequently not addressed as part of the meeting.

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TABLE A8.2.1 Data availability on the burden of disease and food attribution at the regional and global level for Asia

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Ancylostoma duodenale, Necator americanus	Yes [92, 126–129] Viet Nam: – all country (3–85%) China, Korea, Japan India – countrywide (28.9–43%)	Yes [127–129] Anaemia	Yes [92, 126–129] Vegetables, soil	No data	No data	Vegetables, soil
Angiostrongylus spp.	Yes [24, 121–123] Thailand –484 cases reported from 1965 to 1968 China – 160 Cases reported in many areas Viet Nam – >60 cases reported in many areas Japan – 54 cases reported India – one case report	Yes	Yes [24, 121] Snails, vegetables	Yes	Yes	Snails/ vegetables
Anisakis simplex	Yes [79] Japan a case reported China – cases reported Not reported in India	No data	Yes [79] Marine fish	No data	No data	Yes Fish
Ascaris lumbricoides	Yes [59, 92, 112, 126, 128, 144] Viet Nam – countrywide (5–95%) Japan – 8.2% in 1956 China – 47% India – countrywide (commonest intestinal helminth) – 28.4–68.3%	Yes [112, 144] Intestinal obstruction, mostly in children	Yes [112, 144] Poor sanitation and hygiene	No data	No data	Vegetables, food transmision
Capillaria philippinensis	Yes [45, 65] Cases reported in Philippines, Japan, Thailand, Taiwan, Indonesia; India – 3 case reports till 2012	Yes [65] Diarrhoea, liver dysfunction	Yes Raw fish			Fish

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Clonorchis sinensis	Yes [24, 46, 48–52] China – 15 million Korea – 2 million infected, prevalence of 1.4–21.0% Japan – prevalence of 1.0–54.2% (1960); 10.9–66% (1961); now almost disappeared Viet Nam – prevalence of 19.5% (0.2–40%) in 15/64 provinces in the north Taiwan – prevalence of 10–20% China – 15 million infected in 27 provinces India – Almost absent. Very few case reports	Yes [46, 48, 51, 52] 601 million Acute disease	Yes [48, 50] Raw & under-cooked fish.	Yes [46, 47]	Yes [46] 601 million	Raw & under-cooked fish (freshwater)
Cryptosporidium spp	Yes [92, 95] Viet Nam – 2.8% and case reported (national) India – 18.9% in children with diarrhoea Japan – case reported China – 1.36–13.3%	No data [95]	Yes [92–94] Vegetables, water raw meat (*yukke*)	No data [91]	No data [91]	Yes [91] Water, vege-tables HIV-related
Diphyllobothrium spp.	Yes [81–87] Cases reported of *D. nihonkaiense, D. latum, D. pacificum, D. cameroni, D. yonagoense* in Japan Few cases of *D. latum* reported from south India	Yes [81, 82]	Yes [81–87]	No data	No data	No data
Diplogonoporus bala-enopterae	Yes [66, 89] Case reported in Japan Not reported in India, Viet Nam or Thailand	Yes [66, 89]	Yes [89]	No data	No data	No data
Echinococcus spp.	Yes [59, 135–140] Cases reported in Japan, China (380 000 cases), Korea, Mongolia, Thailand, Bangladesh, Nepal India – prevalence not clearly known; endemic in both rural and urban areas of southern and central states.	Yes	Yes vegetables	No data	No data	Vegetables
Echinostoma spp	Yes [73–75] Japan – 22.4% Thailand – 0.04–55.3% China – 1.5–20.1% Viet Nam – a case reported India – very rare; very few case reports	Yes	Yes [73] Raw snail & fish	No data	No data	Yes Snail; fish

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Entamoeba histolytica	Yes [92, 148–152] Viet Nam – 2–6% in children India – intestinal amoebiasis with E. histolytica or E. dispar (1–58%); intestinal amoebiasis with proven E. histolytica (34.6% of all samples found +ve E. histolytica or E. dispar); extra-intestinal amoebiasis – amoebic liver abscess (3–9% of all the cases of intestinal amoebiasis)	Yes	No data	No data	No data	Vegetables, water, food transmission
Enterobius vermicularis	Yes [92, 111, 112, 157] Viet Nam – 29–43% in the north; 7.5–50% in the centre; 16–47% in the south; 51.2% in children 1–5 years old India – countrywide in children (0.5–12.6%); more common in rural than urban areas	Yes	Yes [111, 112] Over-crowding	No data	No data	
Fasciola spp	Yes [79, 92. 96, 99] Viet Nam – >20 000 cases from 52/64 provinces Cases reported in China (148 cases), Thailand, Korea, Iran, Japan, Malaysia, Singapore, Laos, Cambodia & Philippines India – A few case reports	No data	Yes [79, 92, 96] Water, raw vegetables	No data	No data	Yes [79] water, vegetables
Fasciolopsis buski	Yes [73, 92, 102, 103] Viet Nam – 0.5–3.8% in 16/64 provinces China – 10.2–92.9% in some areas Thailand – 10% in children with intestinal parasites Cases reported in Taiwan, Cambodia, Laos PDR, Malaysia, Indonesia & Myanmar India – endemic in E & NE states – prevalence of 0–22.4%	Yes [102] Abdominal pain, diarrhoea, intestinal obstruction	Yes [73, 92, 102] Water, raw vegetables	No data	No data	Water, raw vegetables

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Giardia duodenalis (syn. *G. lamblia, G. intestinalis*)	Yes [92, 110, 154] Viet Nam – 1–10% China – infection rate ranged from 8.67%–9.07%, found in 13 areas of 35 cities at the provincial level India – countrywide distribution (8.4–53.8%)	Yes [110, 154]	No data	No data	No data	Vegetables, water, food transmission
Gnathostoma spp	Yes [70–72, 90] Cases reported in Japan with 3 225 cases, including 86 from China and 34 from other Asian sources. Cases reported in China, Thailand, Viet Nam, India, Laos PDR, Myanmar, Cambodia, Bangladesh, Malaysia, Indonesia and Philippines. India – 14 cases reported until 2012	Yes [71, 72] Ocular and cerebral manifestations	Yes [70] Raw fish, amphibian reptile			Fish, amphibian reptile
Heterophyids	Yes [53–55] Thailand – 0.3–7.8% Viet Nam – 0.5–64.4% in >18 provinces China – 1–2% Japan – 11% India – Not yet reported	Yes [55]	Yes [53, 55] Raw fish dishes	Yes	Yes	Raw Fish
Kudoa septempunctata	No data Not reported in India	Yes Acute and self-limiting	Yes [88] Raw flat fish (Paralichthys olivaceus) 100% food-borne transmission	No data	No data	Yes Fish; food-borne transmission
Metagonimus spp.	Yes [57, 76, 78] Many cases reported in Korea & China India – very rare. Very few case reports of Metagonimus yokogawai	Yes [76, 78] Acute diarrhoea	Yes [76, 78] Undercooked freshwater fish	No data	No data	Yes Fish

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Opisthorchis viverrini	Yes [42, 44, 45] Thailand – 15.7% Lao PDR – 37–86% Cambodia – some cases Viet Nam – 1.4–37.9% in 9/64 provinces in the south. Malaysia – a case reported India – No cases yet reported.	Yes [42, 44] 67 million	Yes [42, 44] Raw fish dish	Yes [43] 10 million	Yes [43] 67 million	Yes [42] Koi pla; Lap pla; Pla som; Raw-fish
Paragonimus spp.	Yes [56–62] Thailand – cases reported in 23/68 provinces Viet Nam – 0.5–15% in 10/64 provinces Japan – case reports with >200 cases Philippines – 27.2–40% in some areas China – 4.1–5.1% in 24 provinces India – endemic to NE states (Manipur, Nagaland and Arunachal Pradesh); Paragonimus heterotremus is the common species; up to 50% seroprevalence in these regions.	Yes [60–62] Cough, dyspnoea, recurrent haem-optysis	Yes [56, 60–62] Raw crab; freshwater crab, wild boar meat in Japan	Yes	Yes	Freshwater crab; wild boar meat [56]
Pseudoterranova decipiense	Yes [79] Case reported in Japan Not reported in India	No data	Yes [79] Marine fish	No data	No data	Yes Fish
Sarcocystis fayeri	Yes Case reported in Japan [158]	Yes [158] Acute and self-limited	Yes [158] Raw horse meat 100% food-borne			
Sarcocystis spp.	Yes [1, 2, 4, 6] Thailand (1.5%) India – 11 case reports from 1990 to 2004. A few earlier reports. China (29.7%) 46 cases reported by 1990 in Asia, including China, Malaysia and India. In Malaysia, 19.7% of 243 persons had antibodies to Sarcocystis	No data	Yes [2,–4, 6] Meat (pork and beef) Raw pork muscle and offal	No data	No data	Yes Meat (pork and beef)

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Spirometra erinacei-europaei (sparganosis)	Yes [66–69] Japan – case reported Viet Nam – case reported India – a few case reports	Yes [66–69] Abdominal, cerebral & ocular manifestations	No data	No data	No data	Frog
Taenia spp.	Yes [8, 10–19] Thailand – Taeniasis (0.6–5.9%) & cysticercosis (4%). Viet Nam – Taeniasis (0.5–12%) & cysticercosis (7%) in more than 50/64 provinces. Japan – cysticercosis 446 cases up to 2004. China – 7 million people infected in 29 provinces. Philippines – Taeniasis (0.56–10.26%) & case reported of cysticercosis. Indonesia – Taeniasis (0.56–10.26%) & case reported of cysticercosis. Bangladesh – case reported. Nepal – Taeniasis (43%) & case reported of cysticercosis. India – T. solium Taeniasis prevalence 18.6%; NCC prevalence in asymptomatic individuals 15.1%; NCC prevalence in active epileptics 26.3–56.8%; T. saginata Taeniasis prevalence 5.3%.	Yes [13, 17] Taeniasis – No NCC – Yes Epilepsy	Meat (pork & beef)	Yes [9] DALY: 2–5 ×106	Yes [9]	Beef, pork, pig viscera [9]
Toxocara spp.	Yes [92, 126. 132, 133] Viet Nam – one case report Japan – one case report India – endemic in northern states; up to 33% in Kashmir; seropositivity of 6–23% in other northern states	Yes [133]	Yes [133] Vegetables, food transmission	No data	No data	Vegetables

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources and attributions
Toxoplasma gondii	Yes [30, 31, 33–41] Thailand – 2.6% China – 12-45% and 12.7–15.1% Viet Nam – some cases reported Sri Lanka – 27.5% Japan – 1.8–5.6% Malaysia – 10–50% Nepal – 45.6% India – seropositivity for IgG in general population – 10.8–51.8% and for IgM – 2–5%; in females with bad obstetric history – IgG was 49.5%; in HIV-infected cases seropositivity for IgG 70%.	Yes [33, 36–38] CNS disease in HIV infected	Raw meat, pork, chicken, fruit, vegetables [30]	Yes [32]	Yes [32]	Yes [30, 32] Beef, pork, goat, horse, sheep, chicken; contaminated fruit & vegetables; raw mussels, clams & oysters
Trichinella spiralis	Yes [20–28] Thailand – 0.9–9% Viet Nam – 5 outbreaks in north mountainous provinces, with >100 patients and 8 deaths up to 2012. China – >500 outbreaks in 12/34 provinces, with 25 685 persons affected (241 deaths). Japan – 1 case reported. India – very few case reports. Recently a point source outbreak of 42 cases.	Yes [25, 27] High mortality	Yes [21, 26, 27, 29] Meat; consumption of inadequately cooked wild boar meat	Yes [21, 26, 29]	Yes [21, 26, 29]	Yes [21, 26, 29] Domestic pigs, wild boar, raw horse meat 100% foodborne transmission
Trichuris trichiura	Yes [105, 108–112] Thailand – 70% Laos PDR – 41.5% Viet Nam – 70–80% in the north and 5–10% in the south India – adults 2–6.6%; children 8–26.4%	Yes [106–109] Rectal prolapse	Yes Vegetable, personal hygiene	Yes	Yes [107] For 2010, global population at risk: 5023.3 (millions)	Foodborne

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TABLE A8.2.2 Data availability for parasite prevalence or concentration in the main food categories for Asia

NOTE: Please read table in close association with Table A8.2.1. Game could include fish as sources are unclear.

Ancylostoma duodenale, Necator americanus	
Game	Yes. Viet Nam – country-wide (3–85%); China, Korea, Japan.
Vegetables	Yes
Other	Yes [22] Vegetables, soils contact, walking barefoot on soil.
***Angiostrongylus* spp.**	
Game	Yes. Thailand – 484 cases from 1965 to 1968; China – cases reported in many areas; Viet Nam – >50 cases in many areas; Japan – event reported with 54 cases.
Other	Yes [13] Snails, vegetables, raw frogs.
Anisakis simplex	
Beef	Yes [17]
Pork	Yes [17]
Game	Yes. Case reported.
Other	Yes. Marine fish.
Ascaris lumbricoides	
Game	Yes. Viet Nam – country-wide (5–95%); Japan – 8.2% in 1956.
Vegetables	Yes. Vegetables, improperly washed vegetables.
Other	Yes [24, 25] Vegetables, food transmision.
Capillaria philippinensis	
Game	Yes. Cases reported in Philippines, Japan, Thailand, Taiwan, Indonesia.
Other	Fish [14] Undercooked freshwater fish.
Clonorchis sinensis	
Game	Yes. China – 35 million; Korea – 2 million infected, prevalence of 1.4–21.0%; Japan – prevalence of 1.0–54.2% (1960) & 10.9–66% (1961); Viet Nam – prevalence of 19.5% (0.2–40%) in 15/64 provinces in the north; Taiwan – prevalence of 10–20%.
Other	Yes [3, 4] Fish.
***Cryptosporidium* spp.**	
Pork	Yes.
Game	Yes. Viet Nam – 2.8% prevalence and case reported (national); India – 18.9% found in children with; Japan – case reported.
Fruits	Yes [8]
Vegetables	Yes [8] Grown in contact with soil
Other	Yes [8] Water; vetgetables; HIV-related. Water contaminated with human & animal excreta.
***Echinococcus* spp.**	
Game	Yes. Cases reported in Japan, China, Korea, Mongolia, Thailand, Bangladesh, Nepal, India
Vegetables	Yes. Vegetables, but very little data.
Other	Yes [28] Vegetables, water and food contaminated with infected dog faeces, fingers as fomites on contact with dogs.

***Echinostoma* spp.**	
Game	Yes. Japan – 22.4%; Thailand – 0.04–55.3%; China – 1.5–20.1%; Japan – 22.4%.
Other	Yes [18] Undercooked snails & freshwater fish.
Entamoeba histolytica	
Game	Yes. Viet Nam – 2-6% in children.
Vegetables	Yes [26] Improperly washed vegetables.
Other	Yes [26] Food transmision, food contaminated with human faeces.
***Fasciola* spp.**	
Pork	Yes. Water, raw vegetables.
Game	Yes. Viet Nam – >20 000 cases from 52/64 provinces; Cases reported in China, Thailand, Korea, Iran, Japan, Malaysia, Singapore, Laos, Cambodia, Philippines.
Vegetables	Yes. Vegetables.
Other	Yes [20] Water, vegetables, aquatic plants, watercress.
Fasciolopsis buski	
Dairy	Yes
Game	Viet Nam – 0.5–3.8% in 16/64 provinces; China – 10.2–92.9% in some areas; Thailand: 10% in children with intestinal parasites; Cases reported in Taiwan, Cambodia, Laos, Malaysia, Indonesia, Myanmar, India.
Vegetables	Yes. vegetables; vegetables from aquatic plants.
Other	Yes [21] Water, vegetables, aquatic vegetation.
Giardia duodenalis (syn. G. lamblia, G. intestinalis)	
Game	Yes. Viet Nam – 1–10%.
Vegetables	Yes [27] Vegetables, improperly washed vegetables.
Other	Yes [27] Vegetables, food transmision, food contaminated with human faeces.
***Gnathostoma* spp.**	
Game	Yes. Case reports from Japan (3225 cases including 86 in China and 34 in other Asian areas); Cases reported in China, Thailand, Viet Nam, India, Laos PDR, Myanmar, Cambodia, Bangladesh, Malaysia, Indonesia, Philippines.
Other	Fish & amphibian reptiles. [16] Raw or undercooked freshwater fish, amphibians, birds and mammals.
Heterophyids	
Game	Yes. Thailand – 0.3–7.8%; Viet Nam – 0.5–64.4% in >18 provinces; China – 1–2%; Japan – 11%.
Other	Yes. Fish.
***Metagonimus* spp.**	
Game	Cases reported in Korea and Japan.
Other	Yes [19] Fish, undercooked freshwater fish.
Opisthorchis viverrini	
Game	Thailand – 15.7%; Lao PDR – 37–86%; Cambodia – some cases; Viet Nam – 1.4–37.9% in 9/64 provinces in south.
Other	Yes. Fish.

***Paragonimus* spp.**	
Game	Yes. Thailand – reported in 23/68 provinces; Viet Nam – 0.5–15% in 10/64 provinces; Japan – >200 cases reported; Philippines – 27.2–40% in some areas.
Other	Yes [9] Raw freshwater crab. Almost all Potamiscus manipurensis crabs found in streams in Nagaland contained metacercariae.
***Sarcocystis* spp.**	
Beef	Yes [6]
Pork	Yes [7] Raw muscle and offal.
Game	Yes. Thailand – 1.5%.
Other	Yes [6, 7] Meat (pork, beef); wild boar.
Spirometra erinaceieuropaei	
Beef	Yes. Japan – case reported; Viet Nam – case reported.
Other	Frog [15] Drinking water with infected copepods; raw frog.
***Taenia* spp.**	
Beef	Yes.
Pork	Yes [5] 7–20% of slaughtered pigs have cysticerci in their muscles.
Game	Yes. Thailand – 06–3.4%; Viet Nam – 0.5–12% in >50/64 provinces.
Vegetables	Improperly washed vegetables eaten raw in salads.
Other	Yes. Pork, beef.
Toxoplasma gondii	
Beef	Yes [11, 12]
Dairy	Yes [11, 12]
Pork	Yes [11, 12] Raw pork.
Poultry	Yes [11, 12]
Game	Yes. Thailand – 2.6%; China – 12–45%; Viet Nam – some cases reported; Sri Lanka – 27.5%; Japan – 1.8–5.6%; Malaysia – 10–50%; Nepal – 45.6%.
Other	Yes. Beef, pork, goat, horse, sheep, chicken; contaminated fruit, vegetables; raw mussels, clams, oysters.
Trichinella spiralis	
Beef	Yes [1]
Pork	Yes. Raw or undercooked.
Game	Thailand – 0.9–9%; Viet Nam – 5 outbreaks with over 100 cases (8 deaths); China – >500 outbreaks in 12/34 provinces, with 25 685 persons affected (241 deaths).
Other	Yes [2] Under-cooked wild boar meat.
Trichuris trichiura	
Game	Yes. Vegetables, personal hygiene.
Other	Yes [10] Drinking water contaminated with human faeces.
***Toxocara* spp.**	
Game	Yes. Viet Nam – case reported; Japan – case reported.
Vegetables	Yes. Vegetables, improperly washed vegetables.
Other	Yes [23] Vegetables, food transmision.

Sources used for Table A8.2.2, but read in conjunction with references cited in the main text and in Table A8.2.1

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TABLE A8.2.3 Data availability for risk management options for each parasite-commodity combination in the Asia context.

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

***Angiostrongylus* spp.**	
Other	Yes [18] Proper cooking of frogs and snails
Ancylostoma duodenale, Necator americanus	
Other	Yes [28] Hookworm larvae were in areas 2.1–5.2% on vegetables. Vegetables & food transmission, so use sanitary disposal of human excreta; avoid walking barefoot.
Anisakis simplex	
All	No substantive data found.
Ascaris lumbricoides	
Vegetables	Yes. *Ascaris* eggs were in areas reported as 2.1–2.7% in vegetables.
Other	Yes [30] Vegetables & food transmission; hand washing; washing of vegetables before consumption; proper sanitation.
Capillaria philippinensis	
Other	Yes [19] Proper cooking of freshwater fish.
Clonorchis sinensis	
Dairy	Very little data [4]
Game	Yes [4] Viet Nam – 44.4–92.9% freshwater fish infected by Clonorchis sinensis larvae.
Other	Yes. Proper cooking of freshwater fish.
***Cryptosporidium* spp.**	
Beef	Yes [11]
Other	Yes. Vegetables, food, water transmission; hand washing, boiling or filtration of drinking water
***Echinococcus* spp.** [34]	

Vegetables	Yes.
Other	Yes [34] Proper care of pet dogs; avoid close contact with stray dogs; hand washing; thorough washing of vegetables before consumption.
***Echinostoma* spp.** [23]	
Other	Proper cooking of freshwater snails.
***Fasciola* spp.**	
Other	Yes [25, 26] *Fasciola* larvae in areas reportedly 0.4% in vegetables. Avoid eating uncleaned aquatic plants and vegetables.
Fasciolopsis buski	
Other	Yes [27] Avoid eating uncleaned aquatic plants and vegetables.
Entamoeba histolytica	
Game	Yes.
Vegetables	Yes. *E. histolytica* cysts in areas reportedly 1.8–6.7% in vegetables.
Other	Yes [31] Vegetables & food; water transmission; hand washing; thorough washing of vegetables before consumption; proper sanitation.
***Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*)**	
Game	Yes.
Vegetables	Yes. *Giardia* cysts were in areas reportedly 2.7–13.9% in vegetables.
Other	Yes [32, 33] Vegetables & food; water transmission; hand washing; thorough washing of vegetables before consumption; proper sanitation.
***Gnathostoma* spp.**	
Game	Yes. *Gnathostoma* larvae were in areas reportedly 6.7–11.4% in eels.
Other	Yes [22] Fish, eel, amphibians. Proper cooking of freshwater fish & frogs.
Heterophyids	
Game	Yes [12] Heterophyid larvae 7.4–62.8% in various fish species.
Other	Yes. Fish.
***Metagonimus* spp.**	
Other	Yes [24] Proper cooking of freshwater fish.
Opisthorchis viverrini	
Game	Yes [4] Viet Nam – 10–29% freshwater fish infected by O. viverrini.
Other	Yes. Fish.
***Paragonimus* spp.** [13]	
Pork	Yes. Wild boar meat.
Game	Viet Nam – rate of *Paragonimus* larvae was 9.7% to 98.1% in *Potamicus* crab.
Other	Yes [14] Freshwater crab, wild boar meat – proper cooking of crabs.
***Sarcocystis* spp.**	
Pork	Yes [9] Proper cooking.
Other	Yes. Proper cooking of wild boar meat.
Spirometra erinaceieuropaei	
Game	Yes. 8–10% frogs reportedlt infected by *S. erinaceieuropaei* larvae.
Other	Yes [21] Frogs & amphibians; boiling or filtration of drinking water; Yes [17] Proper cooking. Proper cooking of frogs
***Taenia* spp.** [6]	
Beef	Yes [7, 8] Discard infected meat in abattoir; proper cooking.

Pork	Yes. Discard infected meat in abattoir; proper cooking.
Game	Yes. Viet Nam – 0.02–0.9% of pigs infected by T. solium larvae.
Vegetables	Yes. Proper washing before eating raw.
Other	Yes. Pork, beef.
***Toxocara* spp.** [15]	
Vegetables	Yes [29]
Other	Thorough washing of vegetables before consumption.
Toxoplasma gondii	
Beef	Yes [17] Proper cooking.
Dairy	Yes [17] Proper cooking.
Pork	Yes [17] Proper cooking.
Poultry	Yes [17] Proper cooking.
Trichinella spiralis	
Pork	Yes. Proper cooking
Game	Yes [1, 2] Viet Nam – 70–879 *Trichinella* larvae per gram pork; China – 0.06%–5.6% infected in pigs, 16.2% in dogs, 0.7% in cattle and 0.8% in sheep.
Other	Yes [3] Livestock meat – proper cooking.
Trichuris trichiura [15]	
Game	The rate of *Trichuris* eggs in vegetable was 1.8–2.4%.
Other	Yes [16] Vegetables, food transmission. Pit latrines and potable drinking water would reduce prevalence.

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ANNEX 8.3 – AUSTRALIA

A8.3.1 Preparation

The information for Australia was compiled by Dr Rebecca Traub, Senior Lecturer in Veterinary Public Health, School of Veterinary Sciences, The University of Queensland, Gatton. In developing this section of the report, Dr Traub used literature searches using PubMed (search terms used = "Parasite Name" + Australia) together with personal communications with experts in academia and the Department of Agriculture, Fisheries and Forestry (DAFF), Queensland Health, and Food Standards Australia.

A8.3.2 Data availability in humans and food attribution

Surveillance systems in place include the National Animal Health Information System (NAHIS) and National Notifiable Diseases Surveillance System (NNDSS), which collect, collate, analyse and report on data on animal and human health status. In general, information with regard to the incidence or burden of foodborne parasites in humans and animals in Australia is lacking, but is assumed to be negligible. Although limited, most data is generated from research-based surveys conducted by academic institutes, together with published hospital case reports. Surveillance (end product testing for foodborne parasites) is usually not considered necessary due to the low perceived risks to public health, based on:

- High standards of food safety and inspection practices that utilize a 'whole-of-chain' approach, which includes implementation of risk-based hazard analysis and HACCP. In addition to this, all exported food must comply with the Export Control (Prescribed Goods - General) Orders 2005, and the Export Control (Plants and Plant Products) Orders, 2005. Exporters must meet both the requirements of relevant export legislation and of any importing country requirements for the Australian Quarantine and Inspection Service (AQIS) to provide the necessary documentation to enable products to be exported.
- The dietary habits of most Australians, namely eating medium- to well-cooked meats.
- The absence of many of the foodborne parasites of public health concern in Australia (exotic pathogens).

Except for *Cryptosporidium*, no other foodborne parasites are listed in the human notifiable diseases list. For example, cystic hydatid disease in humans is no longer notifiable on a state or national level, despite its enzootic nature in rural settings. Many of the fish- and plant-borne parasites (e.g. Anisakiasis, plant- or vector-borne protozoa and helminth infections) may be missed unless an 'obvious outbreak' has been detected and reported to the State Public Health Unit. Primary means of surveillance of foodborne parasites are performed through abattoirs due to export certification requirements, such as data on the incidence of suspect *Cysticercus bovis* lesions in beef and *Trichinella* in game meat, and exports would be well documented.

TABLE A8.3.1 Data availability on the burden of disease and food attribution at the regional and global level for Australia

Parasite species	Data availability on human-disease-related parameters					
	Regional level			Global level		
	Disease in humans?	Disease severity and main population(s) at risk	Main food source and attribution	Disease in humans?	Disease severity and main populations at risk	Main food sources and attributions
Angiostrongylus cantonensis	Yes – qualitative – case reports [21]	Yes – qualitative – case reports [21]	Yes – anecdotal from case history [21]			
Anisakis spp.; *Contracaecum* spp.	Yes [12]	No data	Yes [13] Yellow eye mullet, tiger flathead, sea mullet, King George whiting, bream, sand flathead, pilchard			
Cryptosporidium spp. (including *C. hominis* and *C. parvum*)	Yes [22]	Yes [22]	Yes. Most outbreaks water-borne recreational swimming. Other sporadic outbreaks 'Unknown' source [22]			
Echinococcus granulosus	Yes – retrospective hospital cases. Not notifiable since 2000 [19]	Yes	Yes – quantitative data on prevalence in wild and farm dogs [20] No attribution to food.			
Enteric protozoa *Giardia*, *Cyclospora*, *Blastocystis*, *Dientamoeba fragilis, Isospora belli*	No data	Yes Indigenous Australians [23] Immuno-suppressed HIV/AIDs patients [24]	No data			
Enteric helminths; *Ascaris*; *Trichuris;* hookworms	No data	Yes Indigenous Australians [23]	No data			
Spirometra or sparganosis	No data	No data	Wild boar, snake			
Taenia saginata	No data	No data	Beef – 100% meat-borne [11]			Cattle – 100% foodborne

Parasite species	Data availability on human-disease-related parameters: Regional level – Disease in humans?	Disease severity and main population(s) at risk	Main food source and attribution	Global level – Disease in humans?	Disease severity and main populations at risk	Main food sources and attributions
Toxoplasma gondii	0.6% posterior uveitis – Aboriginal Australians [14] 3.5% of encephalitis hospitalizations; down since 1990s (HIV peak) [15] 2 reported outbreaks (raw lamb and kangaroo) [16]	No data	Yes – quantitative serological data [17] Kangaroo meat; lamb (sheep); pigs [16, 18]			
Trichinella papuae in Torres Strait Islands	Yes – qualitative anecdotal reports[1, 2]	No data	Wild boar (*Sus scrofa*) [3] Imported crocodile meat from PNG 4]	Yes [5, 6]	Yes [5, 7]	Domestic and wild boar [5] Crocodile meat, turtle meat [8] 100% foodborne
Trichinella pseudospiralis – Tasmania	No data	No data	Dasyurids (quolls; Tasmanian devil,) and carrion-feeding birds (marsh harrier, masked owl) [9] Purely sylvatic cycle	Yes [6, 10]	Yes [7, 10]	Domestic and wild boar [9] 100% foodborne

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TABLE A8.3.2 Data availability for Australia for parasite prevalence or concentration in the main food categories

Angiostrongylus cantonensis	
Other	No direct data. Some snail surveys. Anecdotal evidence of increase in incidence in domestic pets and wildlife in urban areas of Brisbane and Sydney. Human case reported from ingesting slugs while intoxicated [1]
***Anisakis* spp., *Contracaecum* spp.**	
Seafood	Little data. Prevalence in Yellow eye mullet, flathead, sea mullet, King George Whiting, Bream, sand flathead, pilchard described and endemic off coastal Australia. Most larvae in viscera post-harvest and not muscle [2, 3].
Other	Yes. Wild caught and commercial fish at post-harvest level.
***Cryptosporidium* spp. (including *C. hominis* and *C. parvum*)**	
Beef	Yes
Dairy	Yes
Pork	No data
Game	No data
Seafood	Yes [4]. Reported *Cryptosporidium* oocyst contamination of some high-risk foods.

Fruits	Yes [4]. Reported *Cryptosporidium* oocyst contamination of some high-risk foods.
Vegetables	Yes [4]. Reported *Cryptosporidium* oocyst contamination of some high-risk foods.
Other	Goat meat (India)
Echinococcus granulosus	
Vegetables	No data
Other	No direct data. Abattoir reports suggest hydatid disease is still highly endemic among livestock. Prevalence studies in dogs, esp. in rural areas, also demonstrate high prevalence among farm dogs [5, 6]
Enteric helminths: *Ascaris, Trichuris,* Hookworms	
Fruits	No data
Vegetables	No data
Enteric protozoa: *Giardia, Cyclospora, Blastocystis, Dientamoeba fragilis, Isospora belli*	
Fruits	No data
Vegetables	No data
***Spirometra erinacei* or sparganosis**	
Quantitative data may be obtained from Biosecurity Queensland records. Endemic in tropics, esp. wild boar, native frogs, feral cats, dogs.	
Pork	No data
Game	No data
Other	Wild boar Northern Australian Quarantine Strategy (NAQS) surveys
***Taenia saginata* or bovine cysticercosis**	
Beef	Incidence estimated to be less than 1 in 500 000 head according to a recent national survey [7]. However sporadic cases or outbreaks, although rare, are known to occur and have subsequently been confirmed as *C. bovis* [8, 9].
Toxoplasma gondii	
Beef	Yes [10]. Most cited references in report from 1975 and 1980s.
Dairy	Yes [10]. Most cited references in report from 1975 and 1980s.
Pork	Yes [10]. Most cited references in report from 1975 and 1980s.
Poultry	Yes [10]. Most cited references in report from 1975 and 1980s.
Game	Yes [10]. Most cited references in report from 1975 and 1980s.
Fruits	No data
Vegetables	No data
Other	Pademelons, wallabies, lamb. 15.5% kangaroos from WA positive by ELISA [11].
Trichinella papuae, T. pseudospiralis	
Pork	No data

Poultry	No data
Game	Yes. All horse, crocodile and wild pig exported to EU from mainland Australia undergoes pooled Artificial Digestion technique (AD). To date no larvae detected on mainland. Recent research-based survey using AD and polymerase chain reaction (PCR) detected 2 pigs positive for larvae/DNA of *T. papuae* on a remote island of the Torres Strait [15]. Moreover, recent serological evidence for *Trichinella* on mainland [12, 14].
Other [14]	Foxes and wild dogs on mainland. Tasmanian quolls, possums, raptoral birds [19, 20]. Limited indicator species testing on mainland (200 rats; 60 foxes, 31 wild dogs, 9 cats, 27 quolls) tested by AD, all negative [16–18].

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A8.3.3 Agri-food trade

Foodborne parasites that currently have implications for the meat industry in terms of extra costs associated with inspection and testing are primarily restricted to *C. bovis* in the domestic and exported beef industry, and *Trichinella* testing of game meat (farmed crocodile, wild boar and horses) destined for the EU. However, for example, were anisakidosis to become an emerging public health problem in Australia, the fish industry would have to bear the costs of additional end-product inspection (e.g. candling, pooled PCR) to certify high-risk marine species safe for consumption.

Bovine cysticercosis

Although rare, sporadic cases of *C. bovis* continue to be reported in the beef industry. Carcasses heavily positive for suspect *C. bovis* lesions are condemned, whereas those with low levels of infection are excluded from the export chain. Any visible lesions are trimmed at boning under veterinary supervision, freeze certified and sold on the domestic market. At present the abattoirs (industry) bear the cost of positively inspected carcasses. There is a move to reform this and place more cost and responsibility on the farmer by bringing in on-plant monitoring schemes that feed back to the farm level, providing incentive for modification or improvements in farm management. Given the low incidence of bovine cysticercosis and poor positive predictive value of organoleptic inspection, a risk-based system for inspecting *C. bovis* is being proposed and reviewed (Webber *et al.*, 2012).

Trichinella spp.

At present, game meat (wild boar, horse, crocodile) destined for the EU (primary consumers) is required to undergo pooled artificial digestion and examination for *Trichinella* larvae, and results in a direct cost to the game meat industry. To date, testing of ~3.2 million wild boars and 300 000 horses over 22 years has yielded no *Trichinella*-positive carcasses. However, wildlife surveys in indicator species (foxes, feral cats, crocodiles, turtles and wild boar in high-risk areas, e.g. northern Queensland, are limited. Detection of *Trichinella* on mainland Australia will most likely have most impact on the domestic pork industry in relation to more intensive pre-harvest control measures required to meet domestic and overseas certification of pig farms as *Trichinella*-free. At present, domestic pork exported is freeze-certified for *Trichinella*.

A8.3.4 Consumer perception

Consumer perception is difficult to assess and is largely dependent on approaches taken by the media and government in the form of risk communication to the public in the case of an 'outbreak' or discovery of a previously 'exotic' or 'undetected' foodborne parasite. At present, Australians are generally aware of governmental responsible for regulating the quality and safety of food, and consumers display considerable trust in government (and farmers) to protect food safety. There is little evidence of the politicization of food, reflecting a level of trust in the Australian food governance system that may arise from a lack of exposure to major food scares. Consumers tend to be more critical of the role of the food industry in food safety, believing that profit motives will undermine effective food regulation. Most Australians would associate foodborne illness with 'take-away' foods from retail outlets or a problem associated with overseas travel. Consumers usually perceive the risk of 'parasites' in game meats like kangaroos and feral pigs higher than traditional meats. Australians are generally aware of personal responsibility for food safety practices (Henderson, Coveney and Ward, 2010). Consumers (public) in overseas markets are likely to have a similar level of 'trust' in foods exported from Australia.

A8.3.5 Social sensitivity

If an 'outbreak' of a foodborne parasitic disease due to non-compliance with current food safety regulations or due to consumers harvesting their own food sources (in the case of home-grown vegetables, home-made fish sashimi or undercooked foods, hunted feral pig or crocodile meat, etc.) should occur, this has the potential to lead to a substantial decline in the level of consumer trust placed in the food safety management system of Australia. This will have significant repercussions on the industry in some cases (e.g. outbreak of anisakiasis may lead to loss of business for Japanese restaurants or sea-food retailers). An outbreak of trichinellosis may have similar consequences, but to a lesser extent as the public is more likely to associate the pathogen with consumption of self-butchered game meat rather than commercially supplied meats.

A8.3.6 Risk management

Data are summarized in Table A8.3.3.

A8.3.7 Sources cited in the discussion

Henderson, J.A.B., Coveney, J.A. & Ward, P.A. 2010. Who regulates food? Australians' perceptions of responsibility for food safety. *Australian Journal of Primary Health,* 16(4): 344–351.

Webber, J.J., Dobrenov, B., Lloyd, J. & Jordan, D. 2012. Meat inspection in the Australian red-meat industries: past, present and future. *Australian Veterinary Journal*, 90(9): 363–369.

TABLE A8.3.3 Data availability for risk management options for each of parasite-commodity combinations for Australia.

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

Angiostrongylus cantonensis	
Fruits	No data
Vegetables	No data
Other	No – snails
Anisakids	
Seafood	Little data. Extensive surveys performed for the Australian marine fish/ anisakid species. No experimental studies to determine post-harvest migration or larvae for Australian species. Preliminary research surveys (see Table A8.3.1) indicate larvae primarily in viscera, current FSANZ food safety Standard 4.2.1[5] stipulates chilling (-1°C to 5°C or lower) post-harvest. All exported fish frozen to inactivate larvae.
***Cryptosporidium* spp. (including *C. hominis* and *C. parvum*)**	
Other	The prevalence or intensity of protozoa, helminth and cestode stages contaminating fresh produce along the production chain is not readily available. However, in general, risk is mitigated by producer obligations to follow standards outlined by the Codex Code of Hygienic Practice for Fresh Fruits and Vegetables.
Echinococcus granulosus	
Fruits	No data
Vegetables	No data
Enteric helminths	
No data.	

Enteric protozoa, including *Giardia, Cyclospora, Blastocystis, Dientamoeba fragilis* and *Isospora belli*	
No data.	
***Taenia saginata* or bovine cysticercosis**	
Beef	Yes [1, 2]. See also Table A8.3.1
Other	Low incidence and poor PPV of inspection of predilection sites – more emphasis on farm-level management to reduce risks.
Toxoplasma gondii	
Regionally, a risk profile [3] was conducted by New Zealand Food Safety Authority, based on outdated prevalence data for retail raw meats. Globally, the requirements for inactivation of tissue cysts in meat have been well studied and documented.	
Beef	Yes qualitative. Quantitative lacking on % positive retail meats with viable tissue cysts lacking.
Dairy	Food Standards Australia New Zealand (FSANZ) Standard 4.2.4 – Primary Production and Processing Standard for Dairy Products
Pork	Yes qualitative. Quantitative lacking on % positive retail meats with viable tissue cysts lacking
Poultry	Yes qualitative. Quantitative lacking on % positive retail meats with viable tissue cysts lacking
Game	Yes qualitative. Quantitative lacking on % positive retail meats with viable tissue cysts lacking
Fruits	No data
Vegetables	No data
Trichinella papuae, T. pseudospiralis	
Pork	No data
Game	No extensive surveys in 'hot-spots' Experimental studies in pigs for *T. papuae* lacking to assess survivability, freeze tolerance
Other	No surveys on the mainland. A small-scale survey in feral pigs by Cuttell [4] (see Table A8.3.1) allowed a qualitative risk assessment to be attempted.

Sources cited in Table A8.3.3

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02. **Webber, J.J., Dobrenov, B., Lloyd, J. & Jordan, D.** 2012. Meat inspection in the Australian red-meat industries: past, present and future. *Australian Veterinary Journal*, 90(9): 363–369.

03. **Lake, R., Hudson, A. & Cressey, P.** 2002. Risk profile: Toxoplasma gondii in red meat and meat products. Prepared as part of a New Zealand Food Safety Authority contract for scientific services. 36 p. See: http://www.foodsafety.govt.nz/elibrary/industry/Risk_Profile_Toxoplasma-Science_Research.pdf

04. **Cuttell, L., Cookson, B., Jackson, L.A., Gray, C. & Traub, R.J.** 2012. First report of a *Trichinella papuae* infection in a wild pig (*Sus scrofa*) from an Australian island in the Torres Strait region. *Veterinary Parasitology,* 185(2-4): 343–345.

05. **FSANZ (Food Safety Australia New Zealand).** 2012. Australia New Zealand Food Standards Code - Standard 4.2.1 - Primary Production and Processing Standard for Seafood (Australia Only). Current. See: http://www.comlaw.gov.au/Series/F2012L00291

ANNEX 8.4 – EUROPE

A8.4.1 Preparation

The information was compiled by a group comprising Lucy Robertson, Norway (Group leader-*cum*-coordinator); Pascal Boireau, France; Joke van der Giessen, The Netherlands; Malcolm Kennedy, Scotland, UK; and Patrizia Rossi, Italy, although Patrizia was away during report writing, and thus contributed only information.

Communication among the group members was largely by e-mail, and the final version (following inclusion of comments on and modifications to the draft) was submitted on 20 August.

The different group members used their own approaches to data gathering, accessing:

- published scientific papers (identified using their knowledge and experience of the topic, coupled with appropriate database searches;
- national reports or risk assessments, or both;
- the European Union Reference Laboratory for Parasites (EURLP) in Rome (http://www.iss.it/crlp/),
- scientific reports submitted to European Food Safety Authority (EFSA);
- reports from World Organisation for Animal Health (OIE), World Health Organization (WHO), and European Centre for Disease Prevention and Control (ECDC);
- reports from EU research groups (e.g. MedVetNet, Echinorisk);
- Codex Alimentarius Commission reports; and
- books and book chapters.

A8.4.2 Data availability in humans and food attribution

Data from Europe is patchy. EFSA has had initiatives in which data concerned with meat-borne parasites (*Sarcocystis* spp., *Toxoplasma* spp., *Trichinella* spp., *Taenia solium* and *Taenia saginata*), *Echinococcus* spp. and fish-borne parasites (particularly *Anisakis simplex*) have been reported, including proposals for harmonized monitoring tools.

These reports give a relatively good overview of the data available in EU member states.

Although *Sarcocystis* spp. is probably widespread, the low public and zoonotic health impact means that *Sarcocystis* spp. should not be considered a parasite of major concern in Europe.

Data on distribution regarding *Taenia* spp. is patchy, but taeniosis and/or cysticercosis caused by *T. solium* in humans in Europe is considered rare.

Data on *Toxoplasma gondii* and *Trichinella* spp. is relatively good, particularly for the latter parasite and for *Toxoplasma* spp. if mandatory screening is in place; both, particularly *T. gondii* in high risk groups, are considered of importance.

Data on *Echinococcus* (*E. granulosus sensu lato* and *E. multilocularis*) are patchy; this is largely due to lack of notifications, diagnostic difficulties and uneven distribution of infection around Europe, although evidence suggests that *E. multilocularis* infection is spreading in foxes in Europe, resulting in greater infection risk in humans.

Data on infection with intestinal protozoa such as *Cryptosporidium, Giardia* and *Cyclospora* are patchy, being, relatively good in some places (e.g. United Kingdom), but poor in others, but whether sporadic infections are foodborne or not is usually impossible to ascertain; some outbreaks have been shown to be foodborne.

Data on infection with trematodes and nematodes is patchy unless associated with specific outbreaks.

It can be assumed that many foodborne parasitic infections in Europe are not diagnosed, due to non-specific symptoms, or, if they are diagnosed, foodborne transmission is not recognized, particularly for sporadic cases not associated with outbreaks.

A8.4. 3 Data on the burden of disease and food attribution

See Table A8.4.1.

A8.4.4 Data on parasite prevalence, incidence and concentration in the main food categories

The data are summarized in Table A8.4.2.

A8.4.5 Agri-food trade

Agri-food trade is affected when parasite contamination is found in imported products, particularly if: a) the imported parasite does not exist in the region previously and/or b) an outbreak of infection results.

Meat

Meat on the market must be free of *Trichinella* larvae, and metacestodes of *Taenia* and *Echinococcus*. Some countries also regulate against *Sarcocystis,* such as the

Italian requirement from 1992 for restaurants to freeze fishes to be served raw or undercooked. Meat inspection is used for metacestodes (and sarcocysts). For *Trichinella*, a specific lab analysis (digestion) is used. For the EU there are definitive regulations (EU legislation on the hygiene of foodstuffs). There is a meat inspection on target hosts. Only *Trichinella* needs a specific laboratory analysis. The cost and reliability of this analysis is important to take into account in the balance of cost vs benefit. Some one-third of European countries impose individual carcass control for *Trichinella* as a requirement for exportation. *Trichinella* "negligible risk" areas were defined in Europe to reduce the cost of individual carcass control. However, for trade in pig meat, countries ask for individual carcass control even from negligible risk areas. Currently, harmonized risk-based control strategies are evaluated by OIE, Codex and EU bodies. Exotic meats are also subject to these controls (e.g. crocodile meat and *T. zimbabwensis*).

Although *Toxoplasma* is a high risk in meat, it is so widespread that it does not affect the agri-food business at present. Currently, no specific regulations are in place to identify *Toxoplasma* in meat.

Seafood

There has been a significant increase in fish or seafoodborne parasitic diseases in Europe, caused either by infection following ingestion of viable parasites or as an allergenic reaction against parasite antigens (hypersensitivity). Due to modern cooking habits, there is a need to harmonize control measures for fish to decrease the risk of fish-borne parasites. In the EU, raw fish meant for human consumption (herring, salmon) should be frozen before consumption, but more and more raw or undercooked fish (which is unregulated for parasites) is being consumed nowadays.

In Europe, the most important fish parasites causing illness in humans are from the Anisakidae family, with 24 genera, although the species most commonly associated with human infection is *Anisakis simplex*, followed by *Pseudoterranova decipiens*. Nevertheless *A. simplex* is the primary instigator of the different forms of allergy, triggered by infection by live larvae. However, it is not known if this increase in parasitic disease has affected agri-food trade. Human outbreaks of *Opisthorchis* infection have been identified (e.g. Italy, the Netherlands), but it is not clear whether this has affected agri-food trade.

Fresh produce

Outbreaks associated with contaminated fresh produce may affect agri-food trade (as exemplified by the raspberries/*Cyclospora* impact on import to North America from Guatemala). Although there have been outbreaks of parasitic infection associated with imported fresh produce in Europe (e.g. in Sweden, *Cyclospora* on sugarsnap peas from Guatemala; *Cryptosporidium* on parsley from Italy), there do not appear to have been long-term effects on agri-food trade. Similarly, it is unclear whether outbreaks associated with local fresh-produce (e.g. *Fasciola* on watercress in France) have affected agri-food trade exports.

Conclusion

Important parasite-commodity combinations that could affect agri-food trade in Europe include: meat+*Trichinella*; meat+*Taenia*; meat+*Echincoccus*; fish+all parasites, including flukes; fresh produce+*Cryptosporidium*; fresh produce+*Cyclospora*; fresh produce+*Giardia*; and fresh produce+*Fasciola*. Current concern seems to be more for public health and food import than for trade and export. However, this situation is likely to change should an extensive outbreak be associated with an exported European food product.

A8.4.6 Consumer perception

There have been no specific surveys at EU level to analyse consumer perceptions regarding the risks generated by parasites in food, although there have been various general surveys performed in Europe or specific countries. One of the most relevant is from 2005 (Anon. 2006), in which the then 25 countries of the EU (without Romania and Bulgaria, which joined the EU in 2007) were interviewed to assess consumer risk perceptions, particularly regarding food safety. Although foodborne parasitic infections were not specifically addressed, the survey demonstrated that the major concerns regarding food safety in the EU were directed towards pesticide residues in fruit, vegetables and cereals; residues such as antibiotics and hormones in meats; unhygienic conditions in food processing plants, shops or restaurants' contamination with bacteria (food poisoning); pollutants such as mercury or dioxins; genetically modified products; and additives such as colours, preservatives or flavourings. According to the survey results, on a country basis, the Greeks, Italians and Cypriots were the biggest worriers about food contamination issues, but respondents in Sweden and Finland worried the least. Nordic countries also appeared to have greater confidence in public authorities concerning provision of information on specific food safety issues, with Finland demonstrating the greatest confidence in the authorities.

Globally, consumers tend to have more trust in vegetables and fruits than meat products when it comes to safety (Anon., 2004). Fewer respondents thought that food was become worse with regard to safety. A locally or regionally adapted food-risk communication is preferred by EU consumers, and may be more efficient that a pan-European communication, due to different culinary habits across Europe and differing parasite densities transmitted in different regions.

However, harmonized communication on the risks for foodborne parasites, e.g. *Echinococcus multilocularis,* is needed, as risk communication is currently scattered and inconsistent.

Outbreaks obviously affect consumer perceptions considerably (perhaps out of proportion to the risk), and this again means that communication is important.

A8.4.7 Social sensitivity

The presence of Anisakis in fish meat is not acceptable. Even if the meat is frozen there is a risk of allergenicity. This secondary danger is not well known by consumers. In addition, the finding of parasites in fish food during consumption (visual) engenders emotional reactions, and even if the public health risk is low, it is unacceptable to European consumers.

Consumers expect meat to be parasite-free. For parasites in meat that are not visible to the naked eye (*Sarcocystis, Toxoplasma*), restrictions are important if local culinary habits (raw or undercooked meat consumption) increase infection risk. The detection and reporting of a parasite risk in meat (or probably any other food commodity) induces an immediate drop in consumption. This was particularly well studied during trichinellosis in France (1986–1998) after infection of consumers eating horse meat.

The increased risk of parasitic infections when organic meat is consumed is not well understood by the public. In general, people believe that organic products are more healthy, which is usually not the case regarding parasitic risks. Some ‘organic products’ may, however, be perfectly acceptable produce, but it should also be recognized that specialist producers are most likely to be affected should an outbreak reported in the media be specifically associated with their specialization, regardless of their own standards, epitomized by the recent furore over alfalfa sprouts and bacterial infection.

Food sovereignty is an important concept regarding developing countries exporting produce (meat, fish, fresh produce) to wealthier countries that may ultimately reject on microbiological grounds or for other reasons. This concept is being explored in some research projects (e.g. Veg-i-Trade, *see*: www.vegitrade.com).

The parasite-commodity combinations that are probably most relevant from a European perspective are: meat+*Trichinella*; meat+*Taenia*; meat+*Echincoccus*; fish+all parasites, including flukes; fresh produce+*Cryptosporidium*; fresh produce+*Cyclospora*; and fresh produce+*Giardia*. Concern is more for public health and food imports than for trade and exports.

A8.4.8 Risk management

The data are summarized in Table A8.4.3.

A8.4.9 Sources cited in the text of the Europe section discussion

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Anon. 2006. Risk Issues. Special Eurobarometer 238 / Wave 64.1. prepared by TNS Opinion & Social for Directorate-General Health and Consumer Protection as well as the European Food Safety Authority and coordinated by Directorate-General. *See:* http://ec.europa.eu/food/food/resources/special-eurobarometer_riskissues20060206_en.pdf

TABLE A8.4.1 Data availability on the burden of disease and food attribution at the regional (European) and global levels

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Man food sources and attributions
Alaria alata	Yes -very rare. Humans can be paratenic hosts.	no	Yes [26, 27] Consumption of wild boar meat contaminated with larvae. Consumption of frog is questionable.	no	no	
Anisakis spp. (and other anisakids)	Yes [32, 33]	Yes [32, 33] Hypersensitivity risk and infection risk	Yes [32, 33] Infection risk: uncooked, lightly salted/smoked/pickled fish Hypersensitivity risk: as above, but also cooked or frozen fish	Yes [32, 33] Hypersensitivity risk and infection risk	No data	Yes [32, 33] Infection risk: uncooked, lightly salted/smoked/ pickled fish Hypersensitivity risk: as above, but also cooked or frozen fish
Ascaris lumbricoides, Toxocara spp. and other STH	Yes	Yes *Toxocara* infection may result in ocular problems; association with allergy	Yes Fresh produce – fruit, vegetables	Yes	Yes May result in ocular problems. May exacerbate other problems such as malnutrition	Yes Fresh produce – fruit, vegetables
Cryptosporidium parvum, Crypto-sporidium hominis & other *Crypto-sporidium* spp. Note A.	Yes [32, 38–42]	Yes [32, 38–42] Immuno-compromised, young	Yes [32, 38–42] Water and food (fresh produce, milk) contaminated by oocysts	Yes [42]	Yes [42] Immuno-compromised, young	Yes [42] Water and food (fresh produce, milk, apple juice, raw meat) contaminated by oocysts

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Man food sources and attributions
Cyclospora cayetanensis	Yes [47]	Yes [47]	Yes [47] Fresh produce (salad, mange tout)	Yes [47]	Yes [47]	Yes [47] Fresh produce (salad, raspberries)
Diphyllobothrium latum and other *Diphyllobothrium* spp.	Yes [34–37]	Yes [34–37] No data (vitamin B12 deficiency anaemia possible)	Yes [34–37] Undercooked freshwater fish	Yes [36, 37]	Yes [36, 37] No data (vitamin B12 deficiency anaemia possible)	Yes [36, 37] Undercooked freshwater fish
Echinococcus granulosus	Yes [17, 25]	Yes [17, 25]	Yes [17, 25] Food contaminated by eggs excreted by infected dogs (note that control can aim at meat in the transmission cycle – not feeding viscera to dogs – reducing prevalence in intermediate hosts)	Yes	Yes	Food contaminated by eggs excreted by infected dogs (note that control can aim at meat in the transmission cycle – not feeding viscera to dogs – reducing prevalence in intermediate hosts)
E*chinococcus multi-locularis*	Yes [17–23]	Yes [17, 19–22]	Yes [17, 19–22] Food (particularly berries) contaminated by eggs excreted by infected canids (dogs, foxes and raccoon dogs)	Yes [19]	Yes [19]	Yes [19] Food (particularly berries growing at ground level) contaminated by eggs excreted by infected canids (dogs, foxes and raccoon dogs)
Echinoccocus (non-European species)	No data			Yes	Yes	Yes [17] Food contaminated by eggs excreted by carnivorous

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Man food sources and attributions
Fasciola hepatica and other *Fasciola* spp.	Yes	Yes People eating watercress	Yes Watercress	Yes [53, 54]	Yes [53, 54]	Yes [53, 54] Lettuce, watercress
Giardia duodenalis	Yes [45, 46]	Yes [44–46] Rate of 5.6 per 100 000 in 2009. Age group 0–4 years	Yes [43, 45, 46] Water, fresh produce	Yes [46]	Yes [46]	Yes [46] Water, fresh produce
Linguatula serrata	No data	No data	No data	Yes [30, 31]	Yes [30, 31]	
Sarcocystis spp.	Yes [28]	Yes [28]	Yes [28] Pork or beef, depending on species	Yes [29]	Yes [29]	Yes [29] Depends on species
Taenia saginata (syn. *Taeniarhynchus saginata*)	Yes [7]	Yes [7] Taeniosis not severe but considered unacceptable.	Yes [7] Bovine meat	Yes [8]	Yes [8] Taeniosis not severe but considered unacceptable.	Yes [8] Bovine meat
Taenia solium	Yes [7, 10] (E. Europe only?)	Yes [7] Taeniosis not severe but considered unacceptable. Cysticercosis is severe.	Yes [7] Pork (adult *T. solium* infection) Contaminated vegetables, etc. (cysticercosis)	Yes [8, 9]	Yes [8] neurocysticercosis	Yes [8] Pork (adult *T. solium* infection) Contaminated vegetables, etc. (cysticercosis)
Toxoplasma gondii	Yes [11, 13–15]	Yes [11, 13–15] Pregnant women, immuno-compromised)	Yes [11–13–15] Meat (esp. lamb), vegetables contaminated with oocysts (food hygiene)	Yes [16]	Yes [16] Pregnant women, immuno-compromised)	Yes [16] Meat from domestic animal and wild mammals (pork, mutton, venison); milk; food contaminated by oocysts

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Man food sources and attributions
Trichinella spiralis	Yes	Yes	Yes [1, 3] 100% foodborne transmission. Meat (infected muscles from mammals (rarely birds))	Yes [1, 2, 4, 5]	Yes [1, 2, 4, 5]	Yes [1–6] 100% foodborne transmission Backyard domestic pork, horse meat, wild carnivores/ omnivores (boar, bear, walrus, etc.).
Other *Trichinella* spp.	Yes	Yes	Yes	Yes	Yes	Yes [6] Wild carnivorous meat. Horse meat possible (infrequent <1/300 000). Sea-mammals (walrus) in Arctic areas (freeze-resistant *T. nativa*)
Trypanosoma cruzi	Yes [49–52] Little data	Yes [49–52] Imported cases in Europe (under-diagnosed) – particularly countries with large Latin American communities	Yes [49–52]	Yes [48, 49]	Yes [48. 49]	Yes [48] Fresh juices

NOTES: A. Reportable infection in some European countries (incl. UK & Norway)

Sources used in Table A8.4.1

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Note: for *Echinoccocus* (non-European species), see Table C, pp. 35–36.

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TABLE A8.4.2 Data availability for Europe for parasite prevalence or concentration in the main food categories

***Anisakis* spp.**	
Seafood	Yes if unfrozen
Ascaris [12]	
Fruits	Yes
Vegetables	Yes
***Cryptosporidium parvum* (zoonotic); *Cryptosporidium hominis* (mainly anthroponotic), other *Cryptosporidium* spp.**	
Dairy	Milk has been associated with outbreaks – no survey data
Seafood	Yes [5, 10, 11] Shellfish.
Fruits	Yes [5, 12–15]
Vegetables	Yes [5, 12–15]
Other	Water – considerable data available from a range of sources
Cyclospora cayetanensis [12, 18]	
Fruits	Yes
Vegetables	Yes

***Diphyllobothrium latum* and *Diphyllobothrium* spp.** [8, 9]	
Seafood	Yes
Echinococcus granulosus	
(*E. granulosus* is transmitted to humans via eggs in dog faeces. However the occurrence of *E. granulosus* in slaughter animals is an important part of the transmission cycle, and thus the prevalence of *E. granulosus* infection in these food animals is of relevance.)	
Beef	No data as a food vehicle
Pork	No data as a food vehicle
Game	No data as a food vehicle
Fruits	Yes – little data available
Vegetables	Yes – little data available
Other	Water – little data available
Echinococcus multilocularis	
Fruits	Yes – little data available
Vegetables	Yes – little data available
Other	Water – little data available
***Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*)**	
Seafood	Yes [5, 11, 16] Shellfish.
Fruits	Yes [12–14, 17]
Vegetables	Yes [12–14, 17]
Other	Water – considerable data available from a range of sources.
Sarcocystis bovihominis [6,7]	
Beef	Yes
Sarcocystis suihominis [6,7]	
Pork	Yes
Taenia saginata	
Beef	Yes
Taenia solium	
Pork	Yes. Eastern European countries or illegally imported meat.
Toxoplasma gondii	
Beef	Yes [1]
Dairy	Yes [1] In meat of dairy cattle, but not in milk.
Pork	Yes. Mainly outdoor pigs.
Poultry	Yes, but not relevant.
Game	Yes [1] Regional in wild boar.
Seafood	Possible. Sea mammals can be infected too. Data limited. [5]
Fruits	Yes [2]
Vegetables	Yes [2]
Other	Lamb and mutton; water [1–3]
Trichinella spiralis	
Pork	Yes. Outdoor pigs, pig breeding in area of high endemicity.
Game	Yes (wild boar and other game).
Other	Horse meat <1/300 000 carcasses.

Other *Trichinella* species	
T. nativa – freeze resistant, important for game and sea mammals. *T. britovi* and *T. murelli* also important.	
Pork	Yes Outdoor pigs, pig breeding in area of high endemcity.
Game	Yes (wild boar, bears).
Seafood	Sea mammals (seals, walrus).
Other	Horse meat <1/300 000 carcasses.

Main Sources used in Table A8.4.2

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03.	**Halos, L., Thebault, A., Aubert, D. and 10 others.** 2010. An innovative survey underlining the significant level of contamination by *Toxoplasma gondii* of ovine meat consumed in France. *International Journal for Parasitology,* 40(2): 193–200.	Regional
05.	**Robertson, L.J.** 2007. The potential for marine bivalve shellfish to act as transmission vehicles for outbreaks of protozoan infections in humans: A review. *International Journal of Food Microbiology*, 120(3): 201–216.	Global problem
06.	**Taylor, M.A., Boes, J., Boireau, P. and 17 others.** 2012. Development of harmonised schemes for the monitoring and reporting of *Sarcocystis* in animals and foodstuffs in the European Union. Scientific Report submitted to EFSA. 28 p. Available at http://www.efsa.europa.eu/en/supporting/doc/33e.pdf	Regional problem
07.	**Rosenthal, B., Yang, Z. & Yuan, L.K.** 2012. *Sarcocystis* spp. pp. 151–166, *in:* L.J. Robertson and H.V. Smith (editors). *Foodborne Protozoan Parasites*. Nova Science Publishers.	Global problem
08.	**Scholz, T., Garcia, H.H., Kuchta, R. & Wicht, B.** 2009. Update on the human broad tapeworm (genus *Diphyllobothrium*), including clinical relevance. *Clinical Microbiology Reviews,* 22(1): 146–160.	Global with regional foci
09.	**EFSA** [European Food Safety Authority]. 2011. Scientific Opinion on assessment of epidemiological data in relation to the health risks resulting from the presence of parasites in wild caught fish from fishing grounds in the Baltic Sea. Prepared by EFSA Panel on Biological Hazards (BIOHAZ). *EFSA Journal*, 9(7): Art. No. 2320 [40 p.].	Regional
10.	**Robertson, L.J. & Fayer, R.** 2012. *Cryptosporidium* spp. pp. 33–64, *in:* L.J. Robertson and H.V. Smith (editors). *Foodborne Protozoan Parasites*. Nova Science Publishers.	Global with regional foci
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12.	**Robertson, L.J. & Gjerde, B.** 2001. Occurrence of parasites on fruits and vegetables in Norway. *Journal of Food Protection*, 64(11): 1793–1798.	Regional
13.	**Amorós, I., Alonso, J.L. & Cuesta, G.** 2010. *Cryptosporidium* oocysts and *Giardia* cysts on salad products irrigated with contaminated water. *Journal of Food Protection*, 73(6): 1138–1140.	Regional

14.	**Di Benedetto, M.A., Cannova, L., Di Piazza, F., Amodio, E., Bono, F., Cerame, G. & Romano, N.** 2007. Hygienic-sanitary quality of ready-to-eat salad vegetables on sale in the city of Palermo (Sicily). *Igiene e Sanita Pubblica,* 63(6): 659–670.	Regional
15.	**Rzezutka, A., Nichols, R.A., Connelly, L., Kaupke, A., Kozyra, I., Cook, N., Birrell, S. & Smith, H.V.** 2010. *Cryptosporidium* oocysts on fresh produce from areas of high livestock production in Poland. *International Journal of Food Microbiology,* 139(1-2): 96–101.	Regional
16.	**Gomez-Couso, H. & Ares-Mazas, E.** 2012. *Giardia duodenalis*. Contamination of bivalve molluscs. pp. 133–150, *in:* L.J. Robertson and H.V. Smith (editors). *Foodborne Protozoan Parasites.* Nova Science Publishers.	Global with regional foci
17.	**Cook, N. & Lim, Y.A.L.** 2012. *Giardia duodenalis*. pp. 107–132, *in:* L.J. Robertson and H.V. Smith (editors). *Foodborne Protozoan Parasites*. Nova Science Publishers.	Global with regional foci

TABLE A8.4.3 Data availability for risk management options for each of parasite-commodity combinations

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

Ascaris suum	
Pork	Yes – qualitative assessment [5]
Cryptosporidium	
Vegetables	Yes – quantitative & semi-quantitative [15–17]
Other	Water [11–14]
***Cyclospora cayetanensis* –** No data	
Fish parasites (*Anisakis*)	
Seafood	Yes [18]
	Qualitative risk analysis
Giardia duodenalis	
Vegetables	Yes [16, 17]
	Quantitative & semi-quantitative
Other	Water [14]
Taenia solium*, *Taenia saginata	
Game	Qualitative risk analysis for the pork freezing [4]
Toxoplasma spp. [5, 8–10]	
Beef	yes
Dairy	yes
Pork	yes
Game	yes
Trichinella spiralis [1–6]	
Pork	No data, GIS mapping in the USA. [1] Qualitative risk analysis for pork freezing [4]

Sources cited in Table A8.4.3

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02.	**Takumi, K., Teunis, P., Fonville, M., Vallee, I., Boireau, P., Nöckler, K. & van der Giessen, J.** 2009. Transmission risk of human trichinellosis. *Veterinary Parasitology,* 159(3-4): 324–327.	Regional
03.	**Teunis, P.F., Koningstein, M., Takumi, K. & van der Giessen, J.W.** 2011. Human beings are highly susceptible to low doses of *Trichinella* spp. *Epidemiology and Infection,* 14: 1–9.	Regional
04.	**EFSA** [European Food Safety Authority]. 2004. Opinion of the Scientific Panel on Biological Hazards on "the suitability and details of freezing methods to allow human consumption of meat infected with *Trichinella* or *Cysticercus*". *EFSA Journal,* 142: 1–50. Online; doi:10.2903/j.efsa.2005.142.	Regional
05.	**EFSA** [European Food Safety Authority]. 2011. Scientific Opinion on assessment of epidemiological data in relation to the health risks resulting from the presence of parasites in wild caught fish from fishing grounds in the Baltic Sea. Prepared by EFSA Panel on Biological Hazards (BIOHAZ). *EFSA Journal*, 9(7): Art. No. 2320 [40 p.].	Regional
06.	**Pozio, E., Alban, L., Boes, J. and 19 others.** 2010 Development of harmonised schemes for the monitoring and reporting of *Trichinella* in animals and foodstuffs in the European Union. Scientific Report submitted to EFSA. 47 p. Available at http://www.efsa.europa.eu/en/supporting/doc/35e.pdf	Regional
07.	**Opsteegh, M., Langelaar, M., Sprong, H., den Hartog, L., De Craeye, S., Bokken, G., Ajzenberg, D., Kijlstra, A. & van der Giessen, J.** 2010. Direct detection and genotyping of *Toxoplasma gondii* in meat samples using magnetic capture and PCR. *International Journal of Food Microbiology,* 139(3): 193–201.	Regional
08.	**Opsteegh, M., Prickaerts, S., Frankena, K. & Evers, E.G.** 2011. A quantitative microbial risk assessment for meat-borne *Toxoplasma gondii* infection in The Netherlands. *International Journal of Food Microbiology,* 150(2-3): 103–114.	Regional
10.	**Bayarri, S. Gracia, M.J., Lázaro, R., Pérez-Arquillué, C. & Herrera, A.** 2012. *Toxoplasma gondii* in Meat and Food Safety Implications - A Review. Chapter 13, *in:* J. Lorenzo-Morales (editor). *Zoonosis*. Online publ. by InTech. *See:* http://www.intechopen.com/books/zoonosis	Global
11.	**Pouillot, R., Beaudeau, P., Denis, J.B. & Derouin, F.** 2004. A quantitative risk assessment of waterborne cryptosporidiosis in France using second-order Monte Carlo simulation. *Risk Analysis,* 24: 1–17.	Regional
12.	**WHO.** 2009. Risk assessment of *Cryptosporidium* in drinking-water. WHO doc. no. WHO/HSE/WSH/09.04 *See:* http://www.who.int/water_sanitation_health/publications/cryptoRA/en/	Regional
13.	**Cummins, E., Kennedy, R., Cormican, M.** 2010. Quantitative risk assessment of *Cryptosporidium* in tap water in Ireland. *Science of The Total Environment,* 408(4): 740–753.	Regional
14.	**Hunter, P.R., de Sylor, M.A., Risebro, H.L., Nichols, G.L., Kay, D. & Hartemann, P.** 2011. Quantitative microbial risk assessment of cryptosporidiosis and giardiasis from very small private water supplies.*Risk Analysis,* 31(2): 228–236.	Regional
15.	**Grace, D., Monda, J., Karanja, N., Randolph, TF. & Kang'ethe, E.K.** 2012. Participatory probabilistic assessment of the risk to human health associated with cryptosporidiosis from urban dairying in Dagoretti, Nairobi, Kenya. *Tropical Animal Health and Production,* 44(Suppl.1): S33–S40. doi: 10.1007/s11250-012-0204-3.	Global

16.	**Mota, A., Mena, K.D., Soto-Beltran, M., Tarwater, P.M. & Cháidez, C.** 2009. Risk assessment of *Cryptosporidium* and *Giardia* in water irrigating fresh produce in Mexico. Journal of Food Protection, 72(10): 2184–2188.	Global
17.	**Robertson, L.J., Greig, J.D., Gjerde, B. & Fazil, A.** 2005. The potential for acquiring cryptosporidiosis or giardiosis from consumption of mung bean sprouts in Norway: a preliminary step-wise risk assessment. *International Journal of Food Microbiology,* 98(3): 291–300.	Regional
18.	**EFSA** [European Food Safety Authority]. 2010. Panel on Biological Hazards (BIOHAZ), 2010. Scientific Opinion on risk assessment of parasites in fishery products. *EFSA Journal*, 8: 91 [33 p]	Regional

ANNEX 8.5 – NEAR EAST

A8.5.1 Compilation of data availability on food borne parasites relevant to the Near East

The group comprised Mohammad B. Rokni, Islamic Republic of Iran; Said Shalaby, Egypt; and Darwin Murrell, Denmark (who acted as group leader).

The region was subdivided into three groups of countries and each assigned to the group member with the greatest experience with the particular area. After review of the literature covering all those parasites that had been reported from the area, the group selected those parasites for which a reasonable amount of data was available, and these are listed below and in the three tables. After compiling the tables, the group then wrote this report that summarizes the information displayed in the tables, and offers opinion on research gaps and relative importance of the parasites listed.

The group selected the following parasites to be given priority:

- *Ascaris* spp
- *Cryptosporidium parvum*
- *Echinococcus granulosus* & *E. multilocularis*
- *Entamoeba histolytica*
- *Fasciola* spp.
- *Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*)
- *Haplorchis pumilio*
- *Heterophyes heterophyes*
- *Taenia saginata*
- *Toxoplasma gondii*
- *Trichuris trichiura*

The prevalence of water- and foodborne parasites in the area (*Enatamoeba, Cryptosporidium, Giardia* and *Toxoplasma*) is generally high, as evident from the numerous prevalence surveys that have been conducted (Tables A8.5.1 and A8.5.2). These parasites are also of global importance. Overall, the availability and quality of these reports is good. However, studies on disease burden (e.g. morbidity/mortality or sequelae) are generally lacking, which makes estimating very difficult. Similarly, quantitative epidemiology studies are also limited, although a few recent studies on risk factors have appeared for all of these species.

For helminths, the availability of reports on prevalence is good for certain of the parasites (e.g.,, *E. granulosus*—see Torgerson *et al.*, 2010). Although data are available from hospital records, it may not be sufficient to permit reliable estimates of disease burden.

Fasciola spp. are second only to *Schistosoma* spp. as the most common trematode infection, especially in Egypt, Yemen and Iran, and account for more than one-third of the world's cases of fascioliasis. As a proportion of the global burden of disease, fascioliasis, ascariasis and trichuriasis in Near East countries account for 36%, 3% and 1%, respectively, of the total global prevalence (Hotez, Savioli and Fenwick, 2012).

In contrast, the prevalence of human *Taenia saginata* (taeniosis) is infrequently reported, as is bovine cysticercosis from meat inspection. This is in contrast to some countries in Africa. Meat inspection data, which would be valuable in estimating risk from this parasite, are not readily available, although such data might be obtained from the grey literature.

Reports on the fish-borne intestinal flukes (e.g. *Haplorchis pumilio* and *Heterophyes heterophyes*) indicate that these parasites are common in the Nile Delta region of Egypt, where the food habit of eating improperly cooked fish is well established.

There are numerous prevalence and epidemiology reports on the soil-borne parasites, *Ascaris* spp. and *Trichuris* spp. These parasites are very common throughout the region.

Overall, the specific food sources for many of the zoonotic parasites are poorly documented.

A8.5.2 Agri-food trade

Normally, due to low income and geographical situation, many countries of the region are not exporters of meat and meat products; the greatest income in most of the countries is from oil. The same may also be true for exports of high-risk fruits and vegetables, but this needs further inquiry. A potential future obstacle for some countries in attempting to export beef and lamb could be bovine cysticercosis and echinococcosis. In some countries of Africa, income from export of beef is negatively affected by bovine cysticercosis. One study on the economic impact of echinococcosis relevant to area was found (see Table A8.5.2).

A8.5.3 Consumer perception and social sensitivity

There is limited information on knowledge, attitude and behaviour of consumers related to foodborne parasites in region. In Iran there are several studies on echinococcosis, and the results show that general perception is not good.

This topic has not been widely discussed in the region compared with other regions, judging by the global literature. Local awareness of parasitic disease is poor, although there are limited studies in Iran. Continued turmoil in many countries of the region prevents governments from raising social sensitivity on this topic, and accordingly people are not interested or aware.

A8.5.4 Risk management

The strategies for the reducing the risk from foodborne parasites vary considerably, reflecting the diversity of these parasite's life histories and their epidemiology, and so are not easily generalized. Although regional reports are few, there are numerous recommendations in the global literature, as noted in Table A8.5.3.

A8.5.5 Sources cited in the discussion

Hotez, P.J., Savioli, L. & Fenwick, A. 2012. Neglected tropical diseases of the Middle East and North Africa: Review of their prevalence, distribution, and opportunities for control. *PLoS Neglected Tropical Diseases*, 6(2): Art. no. e1475 [Online; DOI: 10.1371/journal.pntd.0001475].

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TABLE A8.5.1 Data availability on food borne parasites relevant to the Near East

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/main population at risk	Main food source and attribution	Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Ascaris lumbricoides	Yes [10, 44–55] Saudi Arabia – 0.4–22.2%; Iran – 0.57–1.5%; Qatar – 0.6%; UAE – 6.6%; Egypt – 23%; Libya – 0.1%; Sudan – 47.7%	Yes [10, 44–52] Nearly all studies have data on this topic in the region	No Contaminated salad	Yes	Yes [53, 54] Poor children in tropical countries, with overcrowded slums and inadequate sanitation	Yes
Cryptosporidium parvum	Yes [8, 14,19, 35–43] Reported human prevalence: Gaza - 16.3%; Jordan - 8.3%; Yemen - 24–44%; Saudi Arabia – 2.3–16%; Iraq – 5–9.7%; Kuwait – 3.4%; Egypt – 9% Libya – 2.5% Sudan – 16%.	Yes [8, 14,19, 35–43]	Yes Water, some transmission by contaminated plant material.	Yes Considerable data from hospital and clinic records	Yes	Vegetables washed with contaminated water
Echinococcus granulosus.	Yes [58] Iraq – 2/100 000; Iran – 0.6-1.2/100 000 and prevalence 1.2–24%; Yemen – 26–140 cases/year during 2001–2008; Egypt – 10%; Libya – 1.4%; Sudan – 0.5%.	Yes [58] shepherds followed by farmers	No data Multiple sources.	Yes [25, 59–70]	Yes [25, 59–70] Hydatid cysts are very serious and difficult to treat.	Yes Man is an intermediate host, and likely is infected by ingestion of eggs in contaminated soil and water.

Parasite species	Data availability on human disease related parameters Regional level Disease in humans	Disease severity/main population at risk	Main food source and attribution	Global level Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Entamoeba. histolytica	Yes [1-9] Reported human prevalence ranges: Lebanon– 14.0–19.5%; Gaza – 70%; Jordan – 22–80%; Syria – 22%; Yemen – 17%; Saudi Arabia – 0.14–30.3%; Iran – 1–9%; Oman – 0.5–2.4%; Qatar – 0.12%; Egypt >21%; Libya – 4.2%; Sudan – 54%	Yes [1-9] Nearly all studies have data on this topic in the region	No data Epidemiological studies on major source inadequate to determine.	Yes	Yes	Vegetables, water and soil. Relative importance of water- or foodborne uncertain; may vary in different circumstances.
Fasciola spp.	Yes [44, 72-76] Iran: – >7000 (1989) & 10 000 (1999) cases in massive outbreaks in north, and 17 cases in Iran in Kermanshah outbreak. Now less than 0.1%. Egypt has most prevalence (2.8%), followed by Yemen and Iran	Yes [44, 72-76] Iran and Egypt. In Iran there are considerable data.	Yes [72-74, 85] Two waterplants – *Nasturtium microphyllum* and *Mentha longifolia* Watercress (local name *boolagh oti*) contaminated with *Fasciola metacercariae* *Mentha pulegium* (local name *khlivash*) and *Mentha piperita* (local name *bineh*)	Yes [44, 72-76]	Yes [44, 72-76]	Yes [71, 76]

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/main population at risk	Main food source and attribution	Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Giardia duodenalis (syn. *G. lamblia*, *G. intestinalis)*	Yes [1, 3, 6, 8, 10–24] Reported human prevalence ranges: Jordan – 3.9–42.6%; Gaza – 10.3–62.2%; Lebanon – 20.7%; West Bank – 9,7%; Syria – 14.0–31.0%; Yemen – 19.7%; Saudi Arabia – 0.1–37.7%; Iran – 3.7–14.5%; Oman – 3.4–10.5%; Qatar – 1.6%; Bahrain – 4%; Iraq – 38.5%; Egypt – 42%; Libya – 1.7%; Sudan – 12.3%.	Yes [1, 3, 6, 8, 10–24] Bakery workers [82] Nearly all studies have data on this topic in the region	Yes [24] Probably mostly waterborne. Fish	Yes	Yes Children have especially high prevalence	Yes
Intestinal fishborne trematodes *Heterophyes heterophyes* *H. nocens* *Haplorchis pumilio*	Yes [45, 57, 58] Hyperendemic, especially in delta region of the Nile Egypt – 33.8%; Iran – 0.24%; Sudan – 11%.	Yes [45, 57, 58] Common in fishers, and others consuming improperly cooked fish.	Yes Fish meat (esp. uncooked)	Yes	Yes	Improperly cooked fish

Parasite species	Data availability on human disease related parameters					
	Regional level			Global level		
	Disease in humans	Disease severity/main population at risk	Main food source and attribution	Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Taenia saginata [12, 16, 77–81]	Yes Human prevalence in the region 0.4 and 6.0% in the few studies reported. Saudi Arabia – 0.01–0.2%; Iran – 0.1%; Qatar – 0.4%; Egypt – 0.6%; Libya – 2%; Sudan – 0.9%.	No data	Yes, beef.	No data	Yes	beef
Toxoplasma gondii	Yes [26–34] Human prevalence: Lebanon – 62%; Saudi Arabia – 3.78–4.9% and 42.3%; Qatar – 29.8%; Bahrain – 4%; Egypt – 11.7%; Libya – 43.4%; Sudan – 44.4%.	Yes [26–34] Nearly all studies have data on this topic in the region	Yes [26–34] However, direct ingestion of oocysts disseminated by infected cats are also important risk [83, 84] *Toxoplasma gondii* DNA was detected in 25% of salami, 20.3% of sausage, 21.8% of hamburger and 32.8% of kebab [29]	Yes [25]	Yes [25]	Yes Pork, lamb.
Trichuris trichiura	Yes [1, 10, 46, 55–57] Saudi Arabia – 0.36–28.8%; Qatar – 26.3%; UAE – 6.2%; Egypt – 49.7% Sudan – 46%.	Yes [1, 10, 46, 56, 57] Nearly all studies have data on this topic in the region	No data	Yes	Yes	Yes

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TABLE A8.5.2 Data availability for parasite prevalence or concentration in the main food categories in the Near East

Ascaris lumbricoides	
Fruits	Via municipal recycling of waste-water in farming.
Vegetables	Yes [3, 34] Via municipal re-cycling of waste-water in crops.
Other	Accidental ingestion of mature *Ascaris* eggs through contaminated food or water.
Cryptosporidium parvum [6,22]	
Fruits	Yes. If contaminated with water containg oocysts
Vegetables	Yes. As for fruit.
Other	Mostly waterborne.
Echinococcus granulosus [30]	
Fruits	Yes [32]
Vegetables	Yes [31, 33]
Other	The eggs may be eaten in foods (e.g. vegetables, fruits or herbs, or drunk in contaminated water
Entamoeba hystolytica	
Fruits	Yes 2, 4]
Vegetables	Yes [1–3]
Other	Water [1-2]
***Fasciola* spp.** [23–25]	
Vegetables	Yes [3, 26}
Other	Primarily leafy greens raised in water (ponds, streams). Some infective stages (metacercariae) may be transmitted by water.
Fish-borne trematodes	
Seafood	Ingestion of improperly cooked fresh and brackish-water fish
Giardia duodenalis* (syn. *G. lamblia, G. intestinalis)	
Fruits	Yes [10]
Vegetables	Yes [1, 5–7]
Other	Yes [1, 5–9] Water, fish.

Taenia saginata [27–28]	
Beef	Yes
Toxoplasma gondii	
Beef	Yes [17]
Dairy	Yes [15–16]
Pork	Yes [11–14]
Poultry	Yes [19]
Game	Yes
Fruits	Yes [20]
Vegetables	Yes [11–14] When cat faeces deposited in vegetable farm.
Other	Yes [11–14, 18] Soil and water; pork and oocyst contaminated water, fruits and vegetables have been implicated; *T. gondii* DNA was detected in 25% of salami, 20.3% of sausage, 21.8% of hamburger and 32.8% of kebab samples. [18]

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17.	**Kijlstra, A. & Jongert, E.** 2008. Control of the risk of human toxoplasmosis transmitted by meat. *International Journal for Parasitology,* 38(12): 1359–1370.	Regional
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Table A8-5-3 Data availability for risk management options for each of parasite-commodity combinations in the Near East

Read in close conjunction with Tables A8.5.1 and A8.5.2

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

Ascaris lumbricoides, Trichuris trichiura

The main source of infection is vegetables, so the best management would be to prevent use of night soil on vegetable farms, and improving composting techniques for manure.

Fruits	Yes
Vegetables	Yes [27]

Echinococcus granulosus

Control of dog populations in endemic areas is necessary. There are possible implication for fruits and vegetables. See references 15–22.

Beef	Yes
Pork	Yes
Game	Yes
Fruits	Yes
Vegetables	Yes

Entamoeba hystolytica, Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*) and *Cryptosporidium parvum

The parasites *Entamoeba*, *Giardia* and *Cryptosporidium* can be grouped as primarily waterborne. Risk reduction involves the supply of potable, safe water for not only drinking, but also for food preparation and washing mouth and hands. Relevant publications linked to these parasites are in Table A8.5.2.

Fruits	Yes [1–10]
Vegetables	Yes [1–10]
Other	Yes. All are water-borne.

Fishborne trematodes: *Heterophyes heterophyes, Haplorchis pumilio, Procerovum* spp.

Only fish and humans are important in the control of this zoonosis. Dogs may play a role as alternative definitive host in endemic areas. Major risk factors include the use of fish from infested regions and improper cooking, or even eating fish raw with spices. Strict fish muscle examination is needed, especially for imported fish. Deep freezing on board is mandatory for imported fish. Examination by veterinary and health authorities and application of national standards is obligatory.

Seafood	Yes

***Fasciola* spp.**

Risk management programmes are described in numerous publications, specific for humans or for livestock. See references 23–24.

Beef	Yes
Dairy	Yes
Pork	Yes
Game	Yes
Vegetables	Yes

Taenia saginata

Because of strict host specificity, only cattle and humans are important in the epidemiology and control of this zoonosis. Major risk factors include exposure of animals to faecal waste. For humans, exposure to inadequate meat inspection, inadequate cooking temperatures. Considerable information on this available in the WHO/FAO/OIE Guidelines[28].
For mitigation of risk in cattle and consumer meats, see reference 25.
For control in humans and egg contamination of the environment (by cattle), see reference 26.

Beef	Yes
Dairy	Yes?

Toxoplasma gondii

Recent evidence that *Toxoplasma* could be transmitted by contaminated fruits and vegetables is covered in references 11–14, *q.v.* See Table A8.5.2 for references on meat and water transmission. Risk management will require improvement in water safety as well as prevention of exposure of livestock to infected cats.

Beef	Yes [11–14]
Dairy	Yes [11–14]
Pork	Yes [11–14]
Poultry	Yes [11–14]

Fruits	Yes [11–14]
Vegetables	Yes [11–14]
Other	Yes [11–14]

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ANNEX 8.6 – NORTH AMERICA WITH NOTES ON CENTRAL AMERICA

A8.6.1 Report preparation

This summary of data availability on foodborne parasites relevant to the North American region was compiled by Ronald Fayer, USA; Brent Dixon, Canada; and Ynes Ortega, USA, who acted as leader. Communication via e-mail and telephone served to compile information and complete the tables used to draft this report.

A8.6.2 Data availability on human occurrences and food attribution

Four parasite genera are of most importance in North America: *Toxoplasma*, *Cryptosporidium*, *Cyclospora* and *Giardia*. Data relevant to these parasites are available in published reports on cases, outbreaks, surveys and public records. There is insufficient or lack of data from exporting countries (fresh produce, meats, fish and shellfish) and where parasites are endemic. There was limited information on good agricultural practices, water quality, and worker hygiene (sanitation). Information that could be used for trace-back investigations is not readily available, which delays outbreak investigations.

In addition, an attempt was made to identify appropriate sources from Central America. The meagre information available is summarized in Table A8.6.4.

A8.6.3 Data on the burden of disease and food attribution

The data accessible has been summarized in Table A8.6.1.

The estimated costs (in US dollars) of illness caused by the four pathogens of concern in North America are: *Cryptosporidium* ($47 million), *Cyclospora* ($2 million) and *Toxoplasma* ($2.973 billion). *Toxoplasma* is considered the fourth leading cause of hospitalizations (n=4428) and the second cause of deaths (n=327) associated with foodborne illnesses in the USA. Annually the estimated number of illnesses attributed to *Cyclospora* in the USA is 11 407, 57 616 for *Cryptosporidium*, 86 686 for *Toxoplasma* and 76 840 for *Giardia*.

Data on parasite prevalence, incidence and concentration in the main food categories are summarized in Table A8.6.2

A8.6.4 Agri-food trade

From the high-profile *Cyclospora* outbreaks in North America, consumers are aware of the risks of eating fresh produce from developing countries, especially raspberries, mesclun lettuce and basil. The economic impact on producers if their food item is implicated in a foodborne outbreak is significant. That was the case of *Cyclospora* in 1995, where the outbreak was incorrectly attributed to California strawberries. This resulted in a $20 million loss to that industry. Outbreaks associated with *Cyclospora* in 1996 and 1997 caused illness in more than 2000 individuals in North America. Contaminated raspberries from Guatemala were identified. As result of these outbreaks, imports of Guatemalan raspberries to the USA and Canada were restricted, resulting in significant losses to the berry industry.

A8.6.5 Consumer perception

As result of widely publicized foodborne outbreaks in North America, consumers are aware of risks associated with eating fresh produce, especially from developing countries. Washing fresh produce is common practice and thoroughly cooking or freezing of meats is common practice. Consumers expect government inspection to keep food safe, but pre- and post-harvest points of contamination for fruits and vegetables consumed raw has largely been the responsibility of the food industry. Wildlife and other uncontrollable sources of parasites make treatment of wash water and drinking water essential. Parasites are highly resistant to chlorination and many disinfectants. *Cryptosporidium* is susceptible to UV, ozone, drying and extreme temperatures. Limited information is available with other parasites, particularly *Cyclospora*.

It should be a priority for the food industry to address pre- and post-harvest points of contamination for fruits and vegetables that are intended to be consumed raw.

A8.7.6 Social sensitivity

As a result of high-profile outbreaks involving fresh produce from developing countries, consumers are concerned about working conditions for food handlers and their access to sanitation facilities.

Seafoodborne trematode infections, not yet a major problem, are associated with immigrants from SE Asia; likewise for fascioliasis and hydatidosis there is concern concerning food contamination from immigrant food handlers from Central and South America. Toxoplasmosis and trichinellosis from poorly cooked game meats (bear, wild boar, marine mammals, etc.) are primarily associated with social groups like hunters and native peoples (such as Inuit), who often consume raw or dried meats. Toxoplasmosis is a recognized concern of physicians for women during pregnancy, but emphasis for prevention is placed on potential contamination from cats rather than from foodborne infection.

A8.6.7 Risk management

Risk management is summarized in Table A8.6.3.

TABLE A8.6.1 Data availability on the burden of disease and food attribution at the regional and global level

Parasite species	Regional			Global		
	Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources
Alaria spp.	Yes [1, 5] Rare 3 cases	Yes [1, 5] Hives and bronchiospasms in a hunter	Yes [1, 5] Raw or undercooked frog meat, undercooked wild goose meat			
Anisakis spp.	Yes [26–28] 3 cases reported in Canada since 1989	Consumers of raw marine fishes	Raw marine fishes			
Blastocystis spp.	Yes [10, 11] 23% of 2896 patients in 48 USA states; 2.6% of 216 275 stool specimens	Yes Associated with irritable bowel syndrome		Yes Argentina 25% and 43%; Switzerland 16.7-19%; Chile 61.8%	Yes [12] Associated with irritable bowel syndrome	Yes [13] Well water, tap water, leafy vegetables, food vendors
Cryptosporidium spp. (*C. parvum*, *C. hominis* and several other spp.)	Yes [7, 9] Annual domestically acquired foodborne mean cases in USA: 57,616. 90% credible interval: 12,060-166,771	Yes Immunocompromised persons, children, elderly, travellers	Yes [8] 1999-2008 USA: Beverages 50%; Complex foods 50% 3 outbreaks associated with apple cider in US; also green onions, other raw produce, and prepared foods			

Parasite species	Regional			Global		
	Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources
Cyclospora cayetanensis	Yes [7, 9] Annual domestically acquired foodborne mean cases in USA: 11 407 (90% credible interval: 137 – 37 673) Foodborne outbreaks in North America yearly since 1995 (spring/summer)	Yes [8] Immunocompromised persons, travellers	Yes [8, 9] 1999–2008 USA: Complex foods 21.4%; Produce 78.6% Imported fresh raspberries, mesclun lettuce, basil			
Diphyllobothrium spp. [14–16] (*D. dendriticum*, *D. latum*, *D. ursi*, *D. nihonkaiense*)	Yes Up to 80% prevalence of *D. dendriticum* in some Inuit communities in Canada. Case of infection with *D. ursi* reported in British Columbia, Canada in 1973 One case of infection with *D. nihonkaiense* in Canada	Yes, Consumers of raw freshwater and anadromous fishes	Yes, Raw freshwater and anadromous fishes			
Echinococcus granulosus [17]	No data Number of cases specifically associated with consumption of contaminated foods is unknown	Residents of Arctic Canada; close association with dogs	No data, Contamination of foods with eggs from faeces of dogs, wolves, coyotes			

Parasite species	Regional Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Global Disease in humans	Disease severity/ main populations at risk	Main food sources
Echinococcus multilocularis [17]	No data, Number of cases specifically associated with consumption of contaminated foods is unknown	Residents of Arctic Canada and Alaska, as well as Canadian prairie provinces and 13 American states; close association with dogs	No data, Contamination of foods with eggs from faeces of dogs, cats, foxes, coyotes			
Echinostomidae	Yes [1, 2] 23 cases Several cases reported in Canada (Ontario and Alberta)	Yes [1, 2] Mostly tourists from Kenya and Tanzania.	Yes [1, 2] Raw frogs, fish, snakes, clams snails			
Fasciola hepatica	Yes [1] 1934-2008: 23 cases reported in the USA	Yes [1] Liver and bile ducts. Endemic in the USA in lymnaeid snails and herbivores. Most cases imported from a wide geographic range; only 4 locally acquired.	Yes [1, 4] Tainted aquatic vegetation (especially watercress) and water	Yes	Yes [4]	Yes [4] watercress
Giardia duodenalis (syn. *G. intestinalis*, *G. lamblia*)	Yes [7] Annual domestically acquired foodborne mean cases in USA: 76 840 (90% credible interval: 51 148 – 109 739)		Yes [8, 9] Outbreaks in USA attributed to prepared foods and fresh produce			

Parasite species	Regional			Global		
	Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Disease in humans	Disease severity/ main populations at risk	Main food sources
Heterophyes heterophyes	Yes [1, 2] 43 cases (41 in Hawaii) A few cases reported in recent immigrants to Manitoba and Alberta (Canada)		Yes [1, 2] One USA case from sushi prepared from fishes imported from SE Asia			
Metagonimus spp.	Yes [1, 2] 10 cases 2 cases reported in recent immigrants to Alberta (Canada)	Yes [1, 2] Recurrent diarrhoea reported in 1 case in the US	Yes [1, 2] Fish (sushi) 1 case report suggested salad contaminated with metacercariae from a cutting surface			
Metorchis conjunctus	Yes [2, 6] Outbreak among a group of Korean nationals who consumed raw white sucker freshly caught in river near Montreal, Canada; 17 of 19 individuals became symptomatic	Yes [1] Abdominal pain, fever, headache, anorexia, diarrhea, nausea, backache.	Yes [1] Raw white sucker	No data	No data	
Nanophyetes spp.	Yes [1, 2] 21 cases, mostly Northwestern US	Yes [1, 2]	Yes [1, 2] Raw salmon, steelhead trout, trout eggs			

Parasite species	Regional Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Global Disease in humans	Disease severity/ main populations at risk	Main food sources
Opisthorchis viverrini and *Clonorchis sinensis*	Yes [1, 2] ca. 1270 cases 1890–2009, mostly individual case reports Commonly reported among immigrants from SE Asia to Canada	Yes [1, 2] Group 1 carcinogens; liver and bile duct cancer. Infections mainly imported into the USA. Through the 1970s most were imported in Chinese, Japanese and Korean immigrants or Caucasians who had resided in China. Beginning in 1979, SE Asians were a major source of imported cases, especially those from Thai refugee camps.	Yes [1, 2] Raw or under-cooked freshwater fish	Yes	Yes	Yes [1, 2] Freshwater fish, especially cyprinids
Paragonimus spp. *P. westermani* *P. kellicotti* *P. mexicanus*	Yes [1–3] 71 cases reported 1910–2009. *P. kellicotti*: 7 cases 1968–2008, 14 cases 2009–2010. A few cases reported in immigrants to Canada from Italy, Malaysia, Philippines. One domestic case in Quebec, who sold live snails and crustaceans from exotic food section of department store.	Yes [1, 3] Most cases in 1970s and 1980s imported by SE Asian refugees from Thai camps, immigrants from Korea and Philippines; some co-infections with other helminths.	Yes [1, 3] Raw or undercooked crayfish and crabs	Yes	Yes	Yes

Parasite species	Regional Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Global Disease in humans	Disease severity/ main populations at risk	Main food sources
Pseudoterranova spp.	Yes [29] 1 case reported in Canada in 1973	Consumers of raw marine fishes	Raw marine fishes			
Toxoplasma gondii	Yes [7] Annual domestically acquired foodborne mean cases in USA: 86 686 (90% credible interval: 64–861 – 111 912)	Yes [9] Immunocompromised persons, pregnant women, consumers of raw meat (Inuit people)	Yes [8, 9] 1999–2008 USA: domestic meats 69.6%; game 20.4% produce 7.0% dairy 2.4% seafood 0.5% Outbreaks in USA attributed to rare hamburger, rare lamb, raw goat milk. Outbreak in Canada (northern Quebec) involved 4 pregnant Inuit women who had consumed raw or dried seal or caribou meat			
Trichinella spiralis	No data [23] Some of the 43 *Trichinella* spp. cases may be *T. spiralis*		Yes [23] Commercial swine in Canada are currently *Trichinella*-free			

Parasite species	Regional Disease in humans	Disease severity/main populations at risk	Main food source and attribution	Global Disease in humans	Disease severity/ main populations at risk	Main food sources
Trichinella nativa	Yes [24, 25] 95 cases reported between 1982-2009 in Northern Canada	Yes [24, 25] Inuit and aboriginal people, hunters	Yes [24, 25] Black bear meat, grizzly bear meat, walruses			
Trichinella murrelli	Yes [18] In 2008, 30 of 38 attendees of an event US. No reported cases in Canada	Yes	Yes [18] Black bear raw meat	Yes [18] 431		Yes [18] Horse meat
Trichinella pseudo-spiralis	No reported cases in Canada					
Trichinella spp. [23]	Yes [18–23] 1997–2001: 72 cases reported. 2002–2007: 66 cases reported. 2008: 5 more cases 43 cases reported in Canada in 1999	Yes [18–23] Inuit and aboriginal people, hunters	Yes [18–23] Of the 72 cases, 31 eat wild game (31), bear (29), cougar (1),wild boar (1) and pork(12) meat. Of the 66 cases, bear, deer, walrus, seal pork, and beef meat			
Trichinella genotype T6	No reported cases in Canada					

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TABLE A8.6.2 Data availability for parasite prevalence or concentration in the main food categories

***Alaria* spp.**	
Seafood	Yes [1] Frogs.
***Anisakis* spp.**	
Seafood	Yes [13–15] Marine fish, squid.
***Blastocystis* spp.**	
Vegetables	Yes [9] Leafy vegetables.
Other	Water.
***Cryptosporidium* spp.** [7]	
Dairy	Yes [8] Un-pasteurized milk.
Seafood	Molluscan shellfish.
Fruits	Yes. Apple cider.
Vegetables	Yes. Green onions; produce.
Other	Water; prepared foods.
***Cyclospora* spp.** [7]	
Fruits	Yes. Raspberry.
Vegetables	Yes. Lettuce, basil, snow peas, watercress.
Other	Water.

***Diphyllobothrium* spp.**	
Seafood	Yes [10–12] Raw freshwater and anadromous fish.
Echinostomidae	
Seafood	Yes [1. 2] Frogs, snakes, fish, clams, snails.
Fasciola hepatica	
Vegetables	Yes [1] Aquatic vegetation: watercress.
***Giardia* spp.** [7]	
Seafood	Molluscan shellfish.
Vegetables	Yes; fresh produce.
Other	Water; prepared foods.
Heterophyes heterophyes	
Seafood	Yes [2] Sushi prepared from fish imported from SE Asia.
***Metagonimus* spp.**	
Seafood	Yes [2] Sushi; possibly salad contaminated with metacercariae.
***Nanophyetes* spp.**	
Seafood	Yes [1, 2] Raw salmon, steelhead trout, trout eggs.
Opisthorchis viverrini* and *Clonorchis sinensis	
Seafood	Yes [1. 2] Numerous species of freshwater fish.
Paragonimus kellicotti	
Seafood	Yes [3] Freshwater crustaceans (100%).
Paragonimus mexicanus	
Seafood	Freshwater crustaceans (100%).
Paragonimus westermani	
Seafood	Yes [1. 2] Freshwater crustaceans (100%): crayfish, crabs.
***Pseudoterranova* spp.**	
Seafood	Yes [16] Marine fish.
***Trichinella* spp.** [4–6]	
Pork	Yes. Pork meat
Game	Yes. Bear, walrus, wild boar, cougar.
***Toxoplasma* spp.** [7]	
Beef	Yes
Dairy	Yes
Pork	Yes
Poultry	Yes
Game	Yes; caribou, seal
Seafood	Molluscan shellfish

Fruits	No data, but oocyst contamination is feasible
Vegetables	No data, but oocyst contamination is feasible
Other	Water
Trypanosoma cruzi	
Very little substantive data available.	

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TABLE A8.6.3 Data availability for risk management options in North America for each parasite-commodity combination

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

***Alaria* spp.** [1]	
Seafood	Rare
***Anisakis* spp., *Pseudoterranova* spp.**	
Seafood	Yes [3] Fish surveillance studies; candling of fillets at processing plants; use of pre-frozen fish for sushi; consumer education
***Blastocystis* spp.**	
Fruit	Good agricultural practices, e.g., water quality, worker hygiene, compost requirements; consumer and food handler education regarding fresh produce
Vegetables	Good agricultural practices; consumer and food handler education regarding fresh produce
***Cryptosporidium* spp.**	
Beef	Yes [1] Heat and freezing
Dairy	Yes [1] Pasteurization
Seafood	Yes [5] Shellfish sanitation programs
Fruit	Yes [5] Good agricultural practices, e.g., water quality, worker hygiene, compost requirements; consumer and food handler education regarding fresh produce; surveillance studies; disinfectants
Vegetables	Yes [5] Good agricultural practices; consumer and food handler education regarding fresh produce; surveillance studies; disinfectants
Other	Yes [1] Fruit juice pasteurization
Cyclospora cayetanensis	
Fruit	Yes [5] Good agricultural practices; import restrictions; surveillance studies; former "Model Plan of Excellence" program in Guatemala; disinfectants
Vegetables	Yes [5] Good agricultural practices; import restrictions; surveillance studies; disinfectants
***Diphyllobothrium* spp.**	
Seafood	Yes [5] Fish surveillance studies; wild-caught vs aquaculture (pelleted feed); consumer education
***Trichinella* spp.**	
Pork	Routine surveillance of commercial swine
Game	Surveillance of wildlife harvested for food; trichinellosis program in Arctic Canada (walrus testing); hunter education
Echinostomidae, *Heterophyes heterophyes*	
Seafood	Yes [1–3] Consumer education (cooking/freezing); good sanitation; import restrictions

Fasciola hepatica [1]	
Vegetables	Rare
Other	Rare
***Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*)**	
Seafood	Yes [5] Shellfish sanitation programmes
Fruit	Yes [5] Good agricultural practices; surveillance studies
Vegetables	Yes [5] Good agricultural practices; surveillance studies
***Metagonimus* spp.**	
Seafood	Yes [2, 3] Consumer education (cooking/freezing); good sanitation; import restrictions
***Nanophyetes* spp.**	
Seafood	Yes [1–3] Consumer education (cooking/freezing); good sanitation; import restrictions
Opisthorchis viverrini, Clonorchis sinensis* and *Paragonimus westermani	
Seafood	Yes [1–3] Consumer education (cooking/freezing); good sanitation; import restrictions
Paragonimus kellicotti	
Seafood	Yes [6] Consumer education: avoid eating raw crayfish
Paragonimus mexicanus	
Seafood	Rare
Toxoplasma gondii	
Beef	Yes [5, 6] Meat surveillance studies; consumer and food handler education (cooking and freezing)
Dairy	Yes [5, 6] Milk pasteurization requirements
Pork	Yes [5, 6] Meat surveillance studies; consumer and food handler education (cooking and freezing)
Poultry	Yes [5, 6] Meat surveillance studies; consumer and food handler education (cooking and freezing)
Game	Yes [5, 6] Meat surveillance studies; seroprevalence studies on wildlife; consumer and food handler education (cooking and freezing)
Seafood	Yes [5, 6] Shellfish sanitation programs

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TABLE A8.6.4 Data availability for Central America

Parasite species	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution
Alaria spp.			
Anisakis spp.			
Blastocystis spp.	Yes [8, 9] 30% of 456 children in day care centres in Cuba; 39% of local populations in Cuba		
Cyclospora cayetanensis	Yes [1–5] Endemic in Guatemala (2.3% prevalence). Among 182 raspberry farm workers and family members examined in Guatemala, 3.3% had *Cyclospora* infection; Another study failed to detect oocysts among raspberry farm workers in Guatemala		Yes [6, 16] Outbreak in Quebec, Canada, in 2005 associated with fresh basil from Mexico. Reported in lettuce from local markets in Costa Rica
Cryptosporidium spp.			
Diphyllobothrium spp. (*D. dendriticum, D. latum, D. ursi, D. nihonkaiense*)			

Parasite species	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution
Echinococcus granulosus, E. multilocularis			
Echinostomidae			
Entamoeba histolytica	Yes [11] In Mexico, *Entamoeba histolytica* antibodies found in 4.49%		
Fasciola hepatica			
Giardia duodenalis (syn. *G. intestinalis, G. lamblia*)	Yes [7–9] Nail biting and eating unwashed vegetables raw were significantly associated with infection in hospitalized children in Cuba; 54.6% of 456 children in day cares in Cuba; 25% of local populations in Cuba.		
Heterophyes heterophyes			
Metagonimus spp.			
Nanophyetes spp.			
Opisthorchis viverrini and *Clonorchis sinensis*			
Paragonimus spp.			
Pseudoterranova spp.			
Taenia solium	Yes [12–15] 4.9–10.8% tested positive for cysticercosis in villages in Mexico; *T. solium* taeniasis and cysticercosis are endemic in Guatemala; Clinical incidence of neuro-cysticercosis can reach 7% in Mexico. Honduras: cysticercosis annual incidence ca. 30.		

Parasite species	Disease in humans	Disease severity/ main populations at risk	Main food source and attribution
Toxoplasma gondii	Yes [10] Estimated incidence in Honduras 36 000/yr		
Trichinella spp.			

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ANNEX 8.7 – SOUTH AMERICA

A8.7.1 Report preparation

The Group members were: Jorge Enrique Bolpe, Argentina, and Jorge Enrique Gómez-Marín, Colombia. Their sources included systematic literature reviews, involving bibliographic database searches (Pubmed, Scopus, Scielo) and own data from unpublished reports (Dr Gómez-Marin). Additionally, literature reviews of bulletins, national reports, book articles and technical guidelines were used (Dr Bolpe).

A8.7.2 Data availability in humans and food attribution

Good evidence exists about *Toxoplasma* presence in meat for human consumption, although some countries have only limited data. Good quality reports exist of foodborne *Trypanosoma* infection. There is good information on the quantity and quality of regional data concerning trichinellosis and cystic echinococcosis in humans in Argentina and other countries in southern of South America, probably because these diseases are included in the national epidemiological surveillance systems in the affected countries. There is also valuable information regarding the identification of food infected with *Trichinella*, with the identification of the specific species (*T. spiralis*).

Data on the burden of disease and food attribution are summarized in Table A8.7.1, and data on parasite prevalence, incidence and concentration in the main food categories are covered in Table A8.7.2.

A8.7.3 Agri-food trade

All the countries in South America export fruits to many continents. Notably, during the last decade, Colombian fruit exports doubled to a total US$ 800 million and more than 1800 ton (Proexport data). Brazil and Argentina export significant volumes of horse and beef meat, while pork meat exportation is less important. At present there are no data indicating the presence of parasites in horses. However, in Argentina, because of trichinellosis endemicity, all horse and pork meat for exportation must be certified with a negative test of peptic digestion performed by the National Animal Health Service.

A8.7.4 Consumer perception

The recent free-trade agreement with the United States of America has raised important questions concerning sanitary security. In Colombia, for example, wide public consumer debates have developed regarding the origin and security of chicken imports from United States of America. A recent urban outbreak of foodborne trypanosomiasis in a school in Caracas, Venezuela, portends a new epidemiological situation for this disease in Brazil, Colombia and Venezuela. For trichinellosis consumer perception in Argentina, some parts of the population show a consumer willingness to accept risk in food consumption without sanitary control. In Argentina, many people are regular consumers of pork in the form of stuffed products, such as sausages produced by local butchers, and avoid foods processed under industrial conditions with sanitary control. This is enhanced by current cultural trends. In many family outbreaks, the consumers who have bred pigs using poor husbandry produced food without the detection of *Trichinella* infection in pig carcasses. Cystic echinococcosis from the ingestion of green vegetables contaminated with oncospheres is possible in rural areas the parasite is endemic, where cultural practice encourage the parasitic cycle through the slaughter of domestic sheep and the feeding of dogs with raw viscera.

A8.7.5 Social sensitivity

There have been increased foodborne outbreaks in most of countries in the region, reflecting cultural changes and increases in the frequency of eating outside the home. Theses outbreaks have been widely publicized, and public pressure developed to reinforce health authority controls.

Trichinellosis

The economic impact of trichinellosis is apparent in the control system for detecting this infection in potential *Trichinella* carriers, mainly in slaughterhouses, and the occurrence of the disease in human and animals. The economic loss due to the destruction of infected carcases is a significant economic loss in Argentina. The cost for human treatment has been estimated at US$ 6000 in the United Staes of America, and at US$ 3000 in Europe.

Cystic echinococcosis

In a Regional Socio-economic Impact of Cystic Echinococcosis (CE) in Argentina, Brazil, Chile and Uruguay, DALYs calculated for the region as a measure of damage caused by CE were 1551.83 due to premature death and 1766.93 due to different degrees of disability, both values adjusted for reported cases. The overall monetary cost of CE in the countries—collating human cases, the lost income due to relapse and morbidity, and livestock losses associated with the condemnation of the liver, reduced carcass weight, loss of milk production, decreased fertility and wool yield—was estimated in the range of at least US$ 75 million to a maximum of US$ 97 million (See ref. [83] in Table A8.7.1).

For Global Socio-economic Impact, when no underreporting is assumed, the estimated human burden of disease is 285 407 DALYs or an annual loss of US$ 193 530 000.

A8.7.6 Risk management

Data are summarized in Table A8.7.3.

TABLE A8.7.1 Data availability on the burden of disease and food attribution for South America at the regional and global levels

Species	Regional level			Global level		
	Disease in humans	Disease severity/ main population at risk	Main food source and attribution	Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Balantidium coli	Yes [53, 76] Low prevalence: Bolivia 1–5.5%; Colombia 1.8%	Yes [53] Low prevalence; infrequent cases of diarrhoea	Yes, but no data reported	Yes [77]	Yes [78] Low prevalence	Yes [77] Pigs
Blastocystis spp.	Yes [29–32, 43] 36–49% in Colombia in pre-school children; 16%–38% Venezuela; 22% Argentina; 26% Parana, Brazil; 57% Mapuera community, Brazil; 41.3–62.3% Chile. *B. hominis* Argentina: B. Aires Province – prevalence in 119 children age 1 to 14 years old (urban: 26.9%; peri-urban: 46.2%; rural: 31.7%)	Yes [33, 34] Unconfirmed, some genotypes. Pre-school children, some adults with irritable bowel syndrome	Yes [36] Eggs, plants	Yes [37] *Blastocystis* has a worldwide distribution and is often the most commonly isolated organism in parasitological surveys (up to 50% in some cohorts). Extrapolating from available prevalence data, the parasite colonizes the intestine of more than 1×10^9 people worldwide	Yes [38–40] Unconfirmed, some genotypes associated to diarrhoea, some studies indicates association with irritable bowel syndrome	Yes [39, 41, 42] Plants, food handlers, pigs, chicken
Cyclospora cayetanensis	Yes [44–47] 18–6% Perú; 2% Guatemala 11.9% Venezuela	Yes [48] Outbreaks diarrhoeal disease	Yes [49] Raspberry, plants (lettuce)	Yes [50]	Yes [51]	Yes [49]

Species	Regional level Disease in humans	Disease severity/ main population at risk	Main food source and attribution	Global level Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Echinococcus granulosus	Yes [12, 79–85] Over 2000 new human cases are reported every year in the region of South America. Incidence from 41 per 100 000 in the Patagonian region in southern Argentina, 80 per 100 000 in the XI Region of Chile; up to 100 per 100 000 in the Flores Department of Uruguay. Infection rates of 5.5% in 1986 in Black River, Argentina; 14.2% in 1988 in Loncopué, Neuquén, Tacuarembo, Uruguay; 1.6% in 1997 in Florida, Uruguay; 3.6% in 1998 in Peach, Uruguay; 5.1% in 1999 in Vichaycocha, Peru. 1418 cases have also been reported by ultrasound screening on asymptomatic human population. Argentina: Morbidity in 1987–1996: 5248 human cases, 1997–2005: 4079 human cases Argentina: between 2006 and 2010 1883 suspected Hydatidosis cases were reported. Argentina, Brazil, Chile and Uruguay: DALYs 1551.83 to 1766.93 adjusted for reported cases. Chile: 2004 estimates an incidence of 10 per 100 000, with mortality 0.3–0.4 per 100 000. Brazil: see [85] for data on Rio Grande do Sul	Yes [12, 79–85] 3.8 $\times 10^6$ rural inhabitants live in risk area.	Yes [12, 79–85] Ingestion of vegetables or polluted water with infected canine faeces.	Yes [12, 79–85] The most conservative estimate of global DALYs lost is 285,407, with no consideration for disease under-reporting.		

Species	Regional level Disease in humans	Disease severity/ main population at risk	Main food source and attribution	Global level Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Entamoeba histolytica	Yes [69, 70] Colombia: 0.6–1.4%	Yes [71] Low prevalence when studies differentiated pathogenic from non-pathogenic.	Yes, but no data reported.	Yes [72]	Yes [73]	Yes [74, 75] but little data Only one report differentiated pathogenic from non-pathogenic. Only *E. dispar* was found in food handlers
Fasciola hepatica	Yes [1–3, 86] Argentina – 619 autochthonous cases from 13 Provinces, in 58 reports of different kinds analysed up to 2010.	Yes [1–3, 86] Case spread, by gender, province, diagnostic method, treatment, etc.	Yes [1–3, 86] Ingestion of freshwater plants carrying infective metacercaria, watercress			
Giardia spp.	Yes [34, 43, 52, 53] Mexico 50%; Colombia 15,0% Argentina: prevalence of *Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*) in 119 children age 1 to 14 years old – urban 9.6%; peri-urban 34.6%; rural 7.3% Argentina: in multicentre studies using data from different provinces – prevalence of *Giardia duodenalis* (syn. *G. lamblia, G. intestinalis*) (13.17%) in 1 to 3 year-old children in the country 2004–05.	Yes [54] Retard in cognition development	Yes [55,56]	Yes [57] In developing countries around 20% (4–43%) and in developed countries 5% (3–7%)	Yes [54]	Yes [56] Canned salmon, sandwiches, noodle salad, fruit salad, raw vegetables, ice

Species	Regional level Disease in humans	Disease severity/ main population at risk	Main food source and attribution	Global level Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Hymenolepis nana	Yes [59–61] Children: 1%-6.6% Peru; 1% -14% Venezuela: 31% in aborigines in Salta in Argentina; 1% Ecuador; 7% Minas gerais, Brazil;	Yes [34, 61] No, rare cases of diarrhoea Low prevalence.	Not reported	Yes [62] Low prevalences	Yes [63–65] Infrequent Only one significant report in India. One report in immuno-suppressed patient	Yes [66–68] Food handlers
Taenia solium, cysticercosis	Yes [14] Human prevalence in Latin America: Colombia (1.8-2.2%), Brazil (3.0-5.6%), Honduras (15.6-17%), Ecuador (2.6-14.3%), Guatemala (10-17%), Bolivia (22%), Venezuela (4-36.5%).	Yes	No data	Yes [13] DALY: $2–5 \times 10^6$	No data	No data
Toxoplasma gondii	Yes [16–18] Human prevalence: Colombia 47% general population; 60% pregnant women; Perú 58% in pregnant women; Brazil 50% to 76%, Chile 36,9%; Argentina: Human prevalence Ciudad de Buenos Aires, Pregnant women 47.3%. Provincia de Buenos Aires 51.7%, Provincia de Jujuy 39.7%, Provincia de Santa Fe 42.2%, Ciudad de Resistencia 28.5%, Provincia de Chaco 23.8%.	Yes [19, 20] Newborn: 0.2% to 2% Immunosuppressed people; main cause of cerebral disease in HIV infected patients	Yes [23] Meat (see Table in Ref. 23)	Yes [21, 24] One third of human population infected	Yes [22]	Yes [23] Meat (between 20% to 50% of cases)

Species	Regional level Disease in humans	Disease severity/ main population at risk	Main food source and attribution	Global level Disease in humans	Disease severity/main population at risk	Main food sources and attributions
Trichinella spiralis	Yes [4–11] Argentina, Buenos Aires Province: Total human cases and 65 outbreaks reported from 01/2000 to 09/2004 were analysed. No. of human cases increased from 908 between 1971 and 1981, to 6919 between 1990 and 2002 Chile: Total cases 2012 and previous incidence description Argentina: Serological survey in blood donors prevalence 8.0%	Yes [4] Description of clinical symptoms and/or signs, epidemiological data and laboratory aspects of human trichinellosis	Yes [1–5, 7, 9] Meat Eating pork and pork products not sanitary inspected and not properly cooked.	Yes [1–4, 12] DALYs: The most conservative estimate of number of global DALYs lost is 285 407, with no consideration for disease under-reporting.	Yes [1–3]	Yes [1–3] Domestic pigs, wild boars, raw horse meat 100% foodborne transmission
Trichuris trichiura	No data	Yes [15]	No data	No data	Yes [15] For 2010, global population at risk: 5.023 billion.	No data
Trypanosoma cruzi	Yes [25] More than 7 ×10^6 people infected in the Americas	Yes [25, 26] 10% mortality in acute cases; 41 200 new cases per year – rate of 7.7 per 100 000 inhabitants –14 385 cases of congenital Chagas	Yes [27, 28] Açai palm juice Guava juice	No data	No data	No data

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TABLE A8.7.2 Data availability for parasite prevalence or concentration in the main food categories for South America

Balantidium coli No substantive data.	
***Blastocystis* spp.**	
Vegetables	Yes [22] Colombia: 44% tomatoes; 37% carrot; 28% cabbage; 25% onion.
Other	Yes [22] Colombia: 34% of eggs.
Cyclospora cayetanensis	
Fruits	Yes [23–25]
Vegetables	Yes [23–25]

Entamoeba histolytica No substantive data.	
***Giardia* spp.** No substantive data.	
Hymenolepis nana No substantive data.	
Toxoplasma gondii [9–21]	
Beef	Colombia: 48% by PCR Colombia: seroprevalence 35% Brazil: 49.4% seropositive (38/77) in cattle in Rio Janeiro; For comparison: 0% by bioassay in USA
Pork	Colombia: 29–70% by PCR Erechim, Brazil: 17/50 (34%) samples from the diaphragm and 33/50 (66%) samples from the tongue demonstrated a positive PCR reaction. Colombia: seroprevalence 9–15%. Rio Janeiro, Brazil: seroprevalence 7.64% (31/406) in pigs; 11.5% (7/61) in pigs. Londrina, Brazil: bioassay in mice, 13 (8.7%) sausage samples were positive, in one of them *T. gondii* was isolated and in the other 12 the mice seroconverted) 1% USA; USA 24–92% by bioassay
Poultry	40% by PCR (Colombia); Seroprevalence 16% (Colombia); 40% seroprevalence in free range chicken in Espirito Santo, Brazil.
Game	Deer: 21%-27% by bioassay (USA)
Other	Sheep: 4-77% (bioassay, USA); Brasil seroprevalence 1980–2011: 18.6% São Paulo to 61% Minas Gerais
Trichinella spiralis [1–8]	
Pork	Argentina: in 11.7% of 1128 human cases the suspected food was pork meat and derivatives 1–150 larvae per gram. Argentina: pigs in Buenos Aires Province studied by DAR had 2.07% prevalence, with worm burdens 8.4–105.6 larvae per gram of muscle. ELISA serology prevalence 20–21% Argentina: Muscle larvae of Trichinella from infected animals were identified at the species level by PCR in 38 of 56 pork products. Argentina: 300 pigs slaughtered in Rio Negro province 2000–2002 had prevalence (DAR) of 4.8–7.3%. ELISA serology prevalence in 181 animals 19.9%.
Game	Argentina: *Trichinella* spp. from a sylvatic cycle caused human outbreaks due to eating meat from puma, armadillo and wild boar. Chile: human trichinosis from eating roast wild boar (*Sus scrofa*)
Trypanosoma cruzi	
Fruits	Yes [7, 8] Experimental infection. In outbreak oral transmission by juice fruits considered the most important origin.

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TABLE A8.7.3 Data availability for risk management options for each parasite-commodity combination for South America

NOTE: The authors were asked to consider all combinations of the particular parasite and the main food categories, namely Beef, Dairy, Pork, Poultry, Game, Seafood, Fruit, Vegetables and Other.

Echinococcus granulosus (See refs 13–14)	
Beef	In endemic areas of Argentina, Chile, Uruguay, Brazil and Peru: Control programmes with systematic de-worming of rural dogs, improvement of family slaughter of sheep and pigs for human consumption, avoiding feeding dogs with raw viscera, and health education of rural inhabitants.
Pork	In endemic areas of Argentina, Chile, Uruguay, Brazil and Peru: Control programmes with systematic de-worming of rural dogs, improvement of family slaughter of sheep and pigs for human consumption, avoiding feeding dogs with raw viscera, and health education of rural inhabitants.
Vegetables	In endemic areas of Argentina, Chile, Uruguay, Brazil and Peru: Control programmes with systematic de-worming of rural dogs, improvement of family slaughter of sheep and pigs for human consumption, avoiding feeding dogs with raw viscera, and health education of rural inhabitants.

Toxoplasma gondii (See refs 10–12)

Beef	Pre harvest: remove cat from farm; reduce or prevent oocyst shedding contamination; sterilize feed and bedding; no outdoor access; reduce exposure to oocysts. *Toxoplasma*-infected rodents: rodent control programme; reduce transmission of *Toxoplasma* to omnivorous meat animals. Tissue cysts in meat: post-harverst. Irradiation at 0.4–0.7 kGy or high-pressure processing at 300–400 MPa can inactivate *T. gondii* tissue cysts in meat. However, the effects of irradiation on colour and of high pressure treatment on colour and texture have limited consumer acceptance. Freezing meat to an internal temperature of -12°C kills *T. gondii* tissue cysts. Salting, curing, smoking, and the addition of solutions to meat to enhance colour and taste can reduce the viability of *T. gondii* in meat. However, there is too much variability in these procedures to make a safety recommendation.
Pork	Pre harvest: remove cat from farm; reduce or prevent oocyst shedding contamination; sterilize feed and bedding; no outdoor access; reduce exposure to oocysts. *Toxoplasma*-infected rodents: rodent control programme; reduce transmission of *Toxoplasma* to omnivorous meat animals. Tissue cysts in meat: post-harverst. Irradiation at 0.4–0.7 kGy or high-pressure processing at 300–400 MPa can inactivate *T. gondii* tissue cysts in meat. However, the effects of irradiation on colour and of high pressure treatment on colour and texture have limited consumer acceptance. Freezing meat to an internal temperature of -12°C kills *T. gondii* tissue cysts. Salting, curing, smoking, and the addition of solutions to meat to enhance colour and taste can reduce the viability of *T. gondii* in meat. However, there is too much variability in these procedures to make a safety recommendation.
Poultry	Pre harvest: remove cat from farm; reduce or prevent oocyst shedding contamination; sterilize feed and bedding; no outdoor access; reduce exposure to oocysts. *Toxoplasma*-infected rodents: rodent control programme; reduce transmission of *Toxoplasma* to omnivorous meat animals. Tissue cysts in meat: post-harverst. Irradiation at 0.4–0.7 kGy or high-pressure processing at 300–400 MPa can inactivate *T. gondii* tissue cysts in meat. However, the effects of irradiation on colour and of high pressure treatment on colour and texture have limited consumer acceptance. Freezing meat to an internal temperature of -12°C kills *T. gondii* tissue cysts. Salting, curing, smoking, and the addition of solutions to meat to enhance colour and taste can reduce the viability of *T. gondii* in meat. However, there is too much variability in these procedures to make a safety recommendation.

Trichinella spiralis (See refs 1–9)	
Pork	Recommended methods for monitoring *Trichinella* in domestic and wild animals for human consumption *Trichinella* control at all levels (farm, slaughterhouse and processed meats) Breeding improvement
Game	Recommended methods for monitoring *Trichinella* in domestic and wild animals for human consumption *Trichinella* control at all levels (farm, slaughterhouse and processed meats) Breeding improvement

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Microbiological Risk Assessment Series

Infectious diseases caused by food-borne parasites have not received the same level of attention as other food-borne biological and chemical hazards. Nevertheless, they cause a high burden of disease in humans, may have prolonged, severe, and sometimes fatal outcomes, and result in considerable hardship in terms of food safety, security, quality of life, and negative impacts on livelihoods. The transmission routes for food-borne parasites are diverse. They can be transmitted by ingesting fresh or processed foods that have been contaminated via the environment, by animals or people. Additionally, notification to public health authorities is not compulsory for most parasitic diseases, so official reports do not capture the true prevalence or incidence of the diseases, as much underreporting occurs.

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