

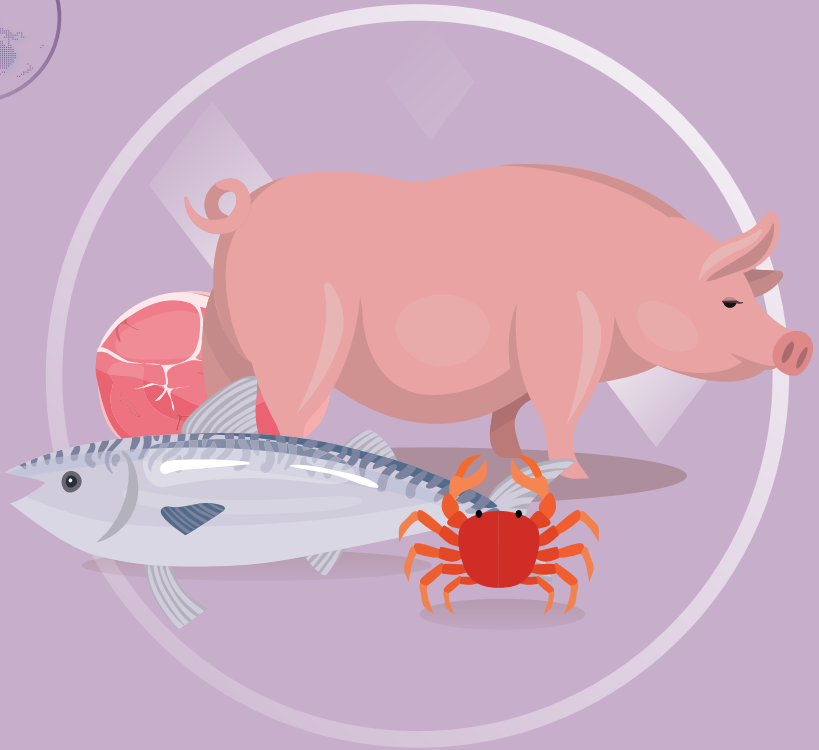


Food and Agriculture
Organization of the
United Nations

Parasites in food

An invisible threat

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FOOD SAFETY
TECHNICAL TOOLKIT FOR ASIA AND THE PACIFIC

Food and Agriculture Organization of the United Nations
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Abstract

Foodborne parasitic diseases are often neglected in various food safety control systems, even though they can create severe human health problems. Because the production and monetary losses associated with them are often not visible, and the infected animals often show no signs, they are very difficult to detect. Different types of parasitic diseases can be transmitted to humans from pork, fish, freshwater crustaceans, vegetables, water and the environment. The risks associated with all of them can, however, be avoided through the application of good hygiene, farming and fishing practices, and with the promotion of the community awareness. For example, the promotion of a participatory approach and the development of training packages for food businesses operators would be beneficial in raising awareness within the community. Basic information regarding the how the parasites are transmitted and their effects, and any and all preventive measure that each person can take should be included in communication topics. Food safety authorities can play an important part by using the guidance provided by Codex Alimentarius regarding animal production, food processing, and meat inspection. Furthermore, the development of networks of authorities committed to addressing the problem, would help prevent and control the spread of parasitic diseases.

Keywords

Parasites, parasitic diseases, raw fish, freshwater fish, pork, undercooking, food safety, food consumption pattern, food hygiene, community education, awareness raising, animal production, food processing, aquaculture, meat inspection, food legislations, food standards, Codex Alimentarius, Food and Agriculture Organization of the United Nations (FAO), Asia and the Pacific



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1

Introduction

When we eat food, we might not be certain of its nutritional value or whether or not it will taste good, but one thing we assume is that it will be safe. But is that always the case? Unfortunately, the answer is no. Foodborne diseases can occur when eating food or drinking beverages contaminated with viruses, bacteria and/or their toxins, or parasites. Less commonly, foodborne illnesses can occur from chemical contaminants and physical hazards.

While many people are familiar with diseases caused by bacteria, such as *Salmonella* and *Escherichia coli*, people may be unaware that parasites can be transmitted through food and water, and lead to disease in humans. Some of these parasites can produce mild or chronic disease, while others can be deadly.

Figure 1. Roasting a pig for a community party








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In this report, **we focus on the major foodborne parasites transmitted by pork, freshwater fish, and freshwater crustaceans**, for which food safety measures play an important role in their prevention and control (Table 1).

In many countries, the prevention of human exposure to some of these foodborne parasites is the responsibility of a veterinary authority or food safety authority, while in other countries, foodborne parasites are not controlled at all. One of the challenges is that the animals that are affected might not show signs of the disease, making it difficult for farmers and authorities to detect a problem. And, if there are no production or monetary losses associated with the parasite in animals, there is no incentive to control them. Therefore, the role of food safety authorities becomes even more important.

Table 1. Major foodborne and waterborne parasites in Asia

Source \ Parasite	Cestodes	Trematodes	Nematodes	Protozoa
Pigs 	<i>Tenia solium</i>		<i>Trichinella</i> spp (also other meats)	<i>Toxoplasma gondii</i> (also found in other meats)
Freshwater fish 		<i>Clonorchis sinensis</i> , <i>Opisthorchis viverrini</i>		
Freshwater crustaceans 		<i>Paragonimus</i> spp		
Marine fish 			<i>Anisakis</i> spp	
Vegetables, water and environment 	<i>Taenia solium</i> , <i>Echinococcus granulosus</i> , <i>Echinococcus multilocularis</i>	<i>Fasciola hepatica</i> , <i>Fasciola gigantica</i>	<i>Ascaris</i> spp	<i>Toxoplasma gondii</i> , <i>Cryptosporidium parvum</i> , <i>Entamoeba histolytica</i> , <i>Giardia intestinalis</i>

2

Foodborne parasitic diseases

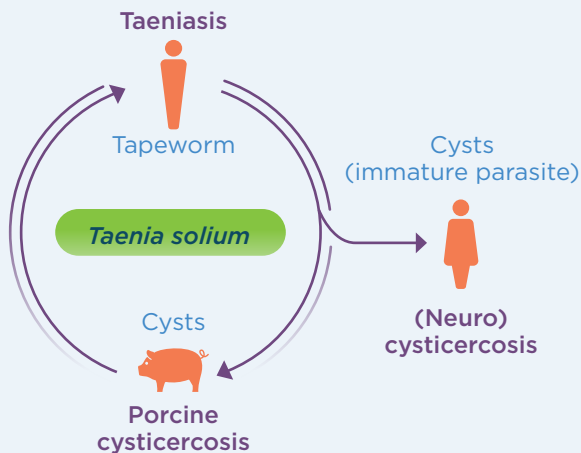
2.1. Parasites transmitted by pork

2.1.1. *Taenia solium*

Transmission cycle

The parasite *Taenia solium* in its adult form is a tapeworm that can measure up to 5 metres long. People who have the tapeworm and who defecate outdoors contaminate the environment with the parasite's eggs (Figure 2). These eggs can then be eaten by pigs, which develop the immature (larval) stages (called cysts) in their meat. The cysts in the meat are small bladders measuring 5–15 mm. with a prominent white spot (Figure 3). The disease in pigs is called porcine cysticercosis. Pigs usually do not show any signs of infection, and only heavily infected pigs show cysts on their tongue. When people eat raw or undercooked pork with viable cysts, they develop the tapeworm.

Figure 2. Transmission cycle of *Taenia solium*

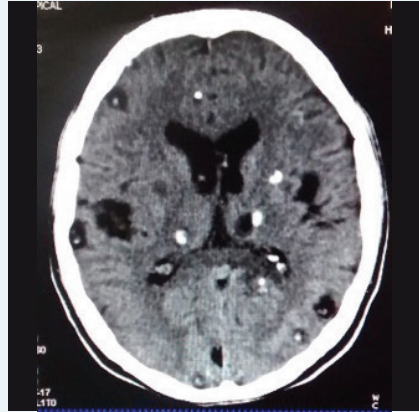


Humans can also become infected by ingesting the eggs via the faecal-oral route, or by eating vegetables and drinking water contaminated with the eggs. In this case, they develop cysts in different parts of the body, including the brain (Figure 4).

Figure 3. *Taenia solium* cysts in pork



Figure 4. *Taenia solium* cysts in a human brain



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❖ Health impacts

In humans, *Taenia solium* causes two diseases: 1) taeniasis, which is usually asymptomatic and occurs when humans have the adult tapeworm in their intestines; and 2) neurocysticercosis, which is more serious, and occurs when immature parasites form cysts, mainly in the brain, causing seizures and other neurological disorders. Neurocysticercosis is the main cause of acquired epilepsy in poor communities where *Taenia solium* is endemic, and in which epilepsy is very difficult to treat. Less frequently, cysts can also develop in muscles, eyes and other organs.

❖ Public health prevention and control

To break the transmission cycle of the disease, a One Health approach is most efficient, with interventions targeting both humans and pigs. Prevention and control measures include:

- People: Can be treated for tapeworms using praziquantel or niclosamide, and this can be done with community-wide interventions.

- Pigs: Ideally, pigs should be confined so that they do not roam and come into contact with the parasite's eggs. This might be difficult, however, in poor communities where farmers cannot feed their pigs, and where pigs roam free and feed themselves. Pigs can be vaccinated (TSOL18 vaccine) and simultaneously treated with oxfendazole to cure infected animals at the time of vaccination (under the supervision of a veterinarian, community animal health worker, or animal technician trained for the purpose).
- Safe water, sanitation and hygiene (WASH) activities should be practiced, and open defecation should not be allowed.
- Promote community education and awareness of the risk factors and prevention measures, such as practicing good hygiene, stopping open defecation, and ensuring that meat is properly cooked.

⌘ Specific food safety interventions at authorities' level

- Food safety authorities can promote the implementation of good farming practices by, for example, facilitating the training of farmers (by agricultural extension officers) in actions that help keep pigs in pens (e.g. alternative foods, using local materials to build pig pens), and avoid letting pigs roam free.
- Meat inspection. Only heavily infected pigs can be detected with standard meat inspection practices used in slaughterhouses, but many pigs have only light infections. However, if infected pigs are detected, food safety authorities should recommend that meat be treated as per the World Organisation for Animal Health (OIE) Code (see Chapter 5), and the source of the pigs identified (if possible) to implement prevention and control actions at the source.
- Food safety authorities can promote awareness in the community about thoroughly cooking pork. *Taenia solium* is killed when meat reaches 60 °C during cooking, but other pathogens in pork may require higher temperatures, so it is better to recommend 71 °C and above. The parasite can be killed by freezing pork at -10 °C (or less) for ten days, but this might not be feasible in poor communities. Some suggested activities for food safety authorities are listed in Chapter 4.
- *Taenia solium* cysts can be visible to the naked eye; therefore, food safety authorities can support the training of butchers and the community to recognise the cysts, and the steps to take if cysts are identified (e.g. discard the meat or cook or freeze it, depending on local legislation).

2.1.2. *Trichinella* spp.

❖ Transmission cycle

When an animal eats another animal that is infected with the immature stages (larva) of the parasite *Trichinella*, the parasite matures in the intestine, and when the parasite reaches the adult stage, it mates and produces larvae that cross the intestinal wall and lodge in muscles (Figures 5 and 6). The adult parasite is a small roundworm that is between 1.5 and 4.0 mm long. There is a domestic cycle involving pigs and rodents, and a sylvatic cycle involving wild animals. Infected animals usually do not exhibit signs.

Humans become infected by eating raw or undercooked meat containing the larvae of *Trichinella*. Usually, humans get infected by eating pork or wild boar, but depending on the region, people can also become infected by eating raw or undercooked horses or wild animals such as bears.

❖ Health impacts

About 15 percent of people who eat infected meat develop the intestinal phase, which usually includes non-specific signs such as gastroenteritis and diarrhoea. When larvae migrate from the intestine to other parts of the body, people may present fever, muscle pain, inflammation of the upper eyelids (a common sign), headaches and other signs. The signs depend on the number of parasites. A small number of severely affected patients may experience skin rashes and respiratory and neurologic symptoms. Occasionally, there are life-threatening manifestations such as heart failure.

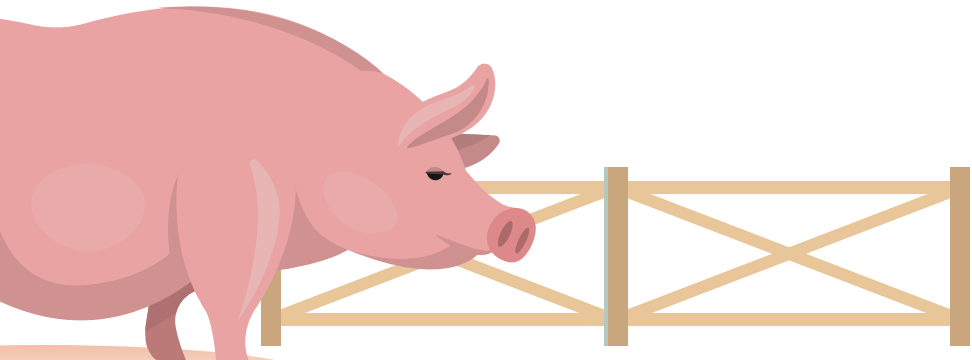
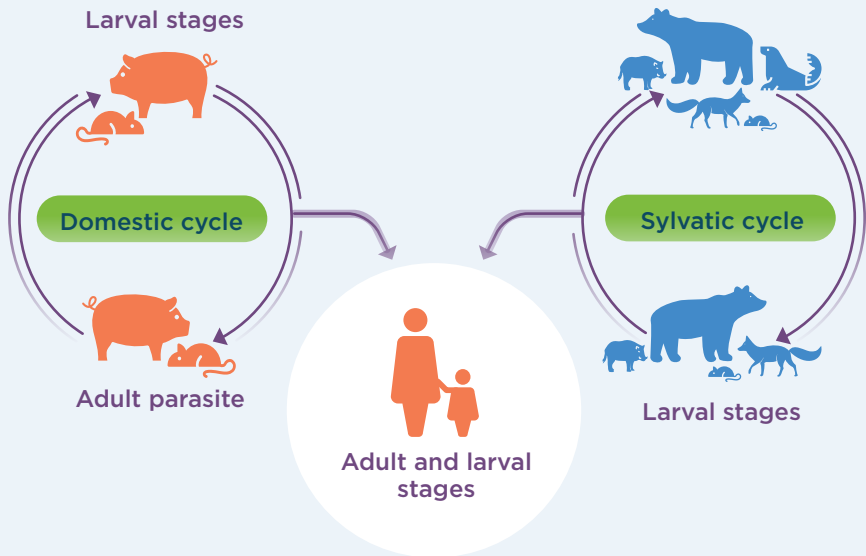


Figure 5. *Trichinella* spp. transmission cycle

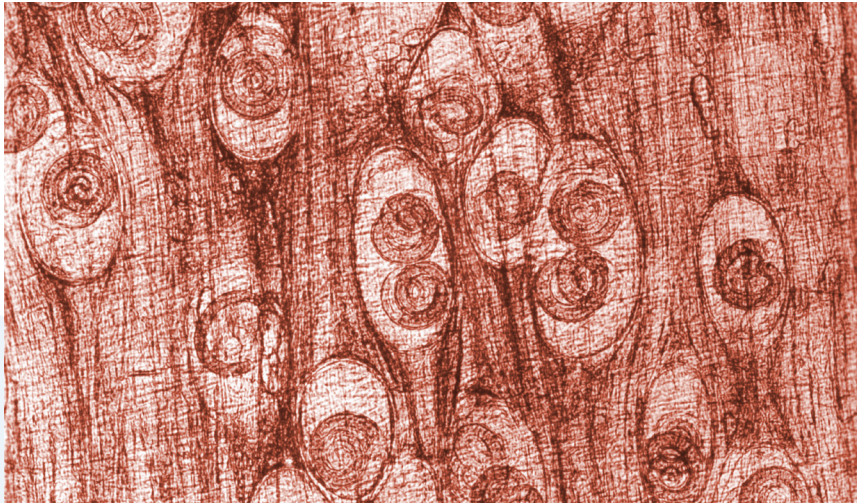


Public health prevention and control

Trichinella spp. cysts are invisible to the naked eye, and specific techniques need to be used for diagnosing when slaughtering animals. This is usually done at the slaughterhouse, and some local veterinarians might offer a diagnostic service when home slaughter is allowed.

- Prevention in pig farms: Encouraging good farming practices, such as controlling rodents, ensuring that swill (waste food given to the pigs) is boiled for 30 minutes (in places where swill is allowed), and disposing of (adequately and quickly) dead animals to avoid scavenging by pigs.
- Providing community education and raising awareness about risk factors and prevention measures, such as good hygiene (e.g. washing hands with soap after handling raw meat, cleaning meat grinders after each use), and ensuring that meat is properly cooked.

Figure 6. Photomicrograph of a muscle tissue showing numerous *Trichinella spiralis* cysts



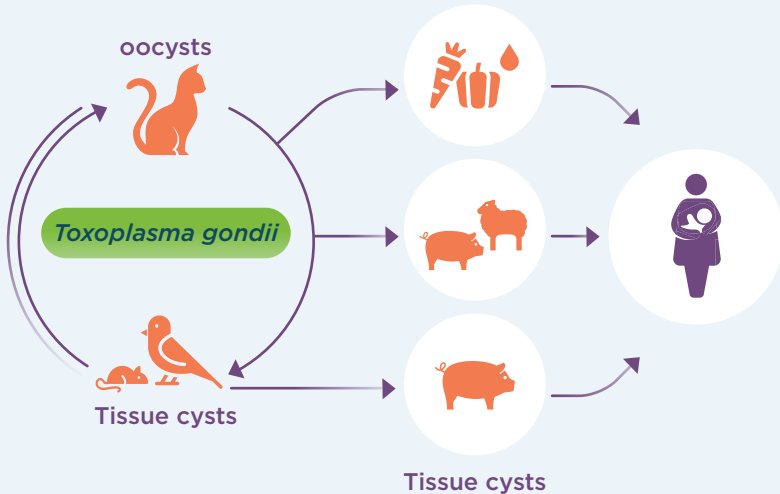
❖ **Specific food safety interventions at authorities' level**

- Food safety authorities can promote the implementation of good farming practices as explained above by, for example, facilitating the training of farmers by agricultural extension officers.
- Food safety authorities can also promote awareness in the community about the risk factors mentioned above, and to thoroughly cook pork. This parasite can be killed by reaching 71 °C for at least one minute (the meat should change colour from pink to grey throughout, and the muscle fibres can be easily separated from each other). Curing, drying or smoking the meat are inadequate methods to kill the parasite. Some species of *Trichinella* can be killed by freezing (time and temperatures depends on the thickness of the meat cuts) but not all species of *Trichinella*. Some suggested activities for food safety authorities are listed in Chapter 4.

2.1.3. *Toxoplasma gondii*

The protozoan (a single-cell microscopic organism) parasite *Toxoplasma gondii* causes toxoplasmosis, a very common infection in warm-blooded animals, including humans. The only host in which the parasites reproduce sexually are wild and domestic cats, which usually do not present any clinical signs. The cats become infected when eating infected prey (such as rodents) or raw meat (Figure 7). Infected cats release oocysts (a thick-walled stage of the parasite) in their faeces, and these oocysts mature and infect other animals (e.g. rodents or pigs) and humans (e.g. by eating contaminated vegetables or fruit). When the oocysts are ingested by other animals, they form cysts in their tissues that remain for life. These cysts are infectious to cats, people and other animals such as pigs. Infected, poorly cooked meat of many animals, especially pigs, can transmit toxoplasmosis to humans.

Figure 7. The transmission cycle of *Toxoplasma gondii*



Infection in humans is common, although clinical disease is rare, and signs are similar to influenza. The main populations at risk of clinical disease are pregnant women and individuals with depressed immunity. When mothers are infected for the first time during pregnancy, they can miscarry, have a stillborn child, or the child can show – later in life – vision loss and mental disabilities. Preventing pigs from becoming infected, is based in implementing effective rodent control programmes (based on rodenticides or traps), decreasing the number of cats in pig farms (they are used for rodent control), and minimising their contact with pigs. Also, any meat fed to pigs should be cooked because that can also be a source for infection.

It is not possible to detect toxoplasmosis cysts in meat by visual inspection, and laboratory methods are used for diagnostic testing. The parasite can be killed by cooking meat for 44 seconds at 55 °C or for 6 seconds at 63 °C. Freezing the meat for 3 days at -20 °C can also kill the parasite.

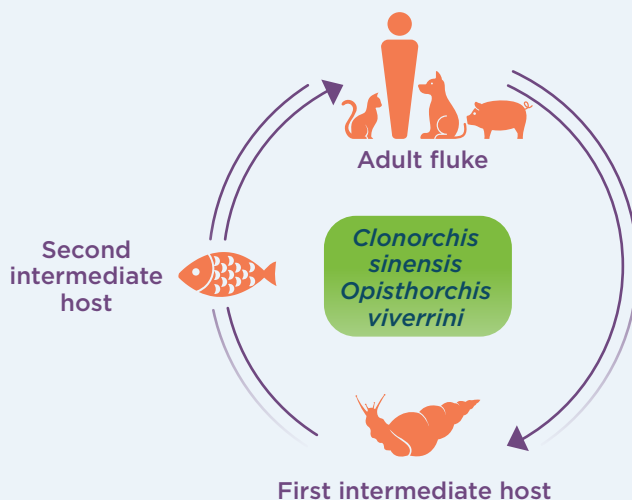
Food safety authorities should promote awareness about good hygiene (especially washing hands after touching cats), washing raw vegetables and fruits with safe water, and using safe cooking practices. Some suggested activities are listed in Chapter 4.

2.2. Parasites transmitted by freshwater fish and crustaceans

2.2.1. *Clonorchis sinensis* and *Opisthorchis viverrini*

These two species of liver flukes (a type of flatworm shaped like a leaf), which are approximately 7–25 mm long, are very similar parasites so they will be dealt with together here. A key difference is their geographical location: *Clonorchis sinensis* is found in China, the far east of the Russian Federation, the Republic of Korea, the northern Viet Nam and Taiwan Province of China; *Opisthorchis viverrini* is found in Cambodia, the Lao People's Democratic Republic, Viet Nam and Thailand.

Figure 8. Transmission cycle of *Opisthorchis viverrini* and *Clonorchis sinensis*



Transmission cycle

Adult flukes live in the liver of humans, cats, dogs, pigs and other fish-eating mammals (Figure 8). The adult flukes produce eggs that are released in the faeces of humans and other animals. The eggs need to reach freshwater and be found by specific types of snail. When the snails eat the eggs, the eggs hatch in the snail, and immature parasites called miracidia are released into the snail. These immature parasites continue to develop until they reach a juvenile stage (called cercariae) that eventually leave the snail and enter into freshwater. When these juvenile parasites find a fish, they penetrate the skin of the fish and form a cyst (called metacercariae). Humans and many other animals can become infected by eating raw or undercooked freshwater fish that contain the parasitic cysts (Figure 9). Once the cysts are eaten, the young flukes are released in the small intestine and, through the bile duct, they reach the liver where they become adult flukes.

Figure 9. Villagers eating raw fish in Thailand



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❖ Health impacts

Most infected persons do not show any signs or symptoms, and the signs depend on the number of parasites. In heavily infected people, there is a loss of appetite, indigestion and diarrhoea, and the parasites can block the liver ducts. There can also be fever and pain in the abdomen. Untreated infections may last 25 years or more, and can lead to liver enlargement and liver damage, including a severe and fatal type of cancer called cholangiocarcinoma.

❖ Public health prevention and control

The young parasites in fish (called metacercariae) are very small, approximately 0.1 mm in diameter and are best seen using laboratory methods. They are not detectable by a fish seller at the market or by a person at home. To break the transmission cycle of the disease, using a One Health approach is the most efficient, with interventions targeting people, animals and snails. Interventions include:

- People can be treated for adult flukes using praziquantel. This can be done with community-wide interventions.
- Dogs and cats, especially ones roaming free near fish ponds, can also be treated with praziquantel. Feeding domestic animals raw fish should be avoided, and they should not be allowed to scavenge food remains.
- Measures should be taken to prevent faecal contamination of water used for fish culture (by humans or animals), and manure should not be used to fertilize the ponds. Snail control should also be implemented, and there are several options for control, including physical, chemical and biological methods. Many chemical treatments (molluscicides) are not recommended or allowed, as they can damage the environment.
- Safe water, sanitation and hygiene (WASH) activities should be practiced in order to promote efficient sanitation and the use of latrines, and to reduce faecal contamination of aquaculture systems.
- Community education and awareness of risk factors and prevention measures – such as good hygiene and ensuring fish are properly cooked or frozen prior to cooking – should be promoted.

❖ **Specific food safety interventions at authorities' level**

- Food safety authorities should promote the implementation of good fish farming practices and encourage the proper design and construction of fish farms, such as locating fish ponds away from latrines, livestock and poultry, and encourage good practices such as ensuring that manure is not used to fertilize ponds and that an effective and appropriate snail control is in place. This can be done by supporting training by specialised extension officer or providing appropriate educational materials. The World Health Organization has produced specific materials for trainers, such as “Five keys to safer aquaculture products to protect public health” (see “Resources” section at the end of this document).

- Food safety authorities can promote awareness in the community regarding the risk factors of specific parasites or diseases, and the importance of thoroughly cooking or freezing fish. The parasites can be killed by reaching 70 °C. Inactivation by salting and pickling depends on the different parameters used, but lime juice or vinegar in low concentrations do not kill the parasite. Hot smoking is generally sufficient to kill parasites. Freezing fish at -20 °C for seven days or at -35 °C for 24 hours will kill the infective stages of these parasites. Freezing above -20 °C does not kill the parasite. Some suggested activities for food safety authorities are described in Chapter 4.

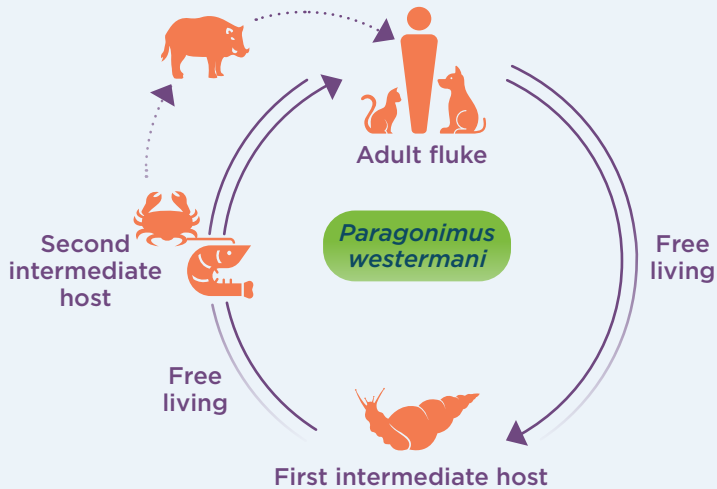
2.2.2. *Paragonimus* spp.

❖ Transmission cycle

Paragonimus is also known as lung fluke. The adult flukes are reddish-brown, about 7-15 mm long (similar to small coffee beans) and usually live in the lungs of humans, dogs, cats and other mammals that eat freshwater crustaceans. The type of animals transmitting the parasite vary, depending on the species of *Paragonimus*. The adult flukes lay eggs that can be expectorated in the sputum, or swallowed and excreted with the faeces (Figure 10).

The eggs must reach freshwater to hatch, and the miracidiae (the immature parasite) must enter specific types of snails in which they continue to develop. After several stages of development in the snail, the juvenile parasites (called cercariae) leave the snail and, on contact with freshwater crabs or crayfish, penetrate them and form a cyst. Crabs and crayfish can also become infected by eating infected snails. When humans, dogs, cats and other mammals eat raw, undercooked or pickled crustaceans with parasitic cysts, the young flukes are released from the cysts in the small intestine and migrate until reaching the lungs and other organs. In the lungs, the young flukes mature and start laying eggs. In some places, such as Japan, it has been observed that wild boars and deer might become infected, but the young fluke does not mature until a human, for example, eats the meat of those animals.

Figure 10. Transmission cycle of *Paragonimus westermani*.
Other species of *Paragonimus* have a similar transmission cycle



⌘ Health impacts

Health impacts vary, depending on the species of *Paragonimus* and the number of parasites; but in general, when the young parasites migrate from the intestine to the lungs, they can cause abdominal pain, fever and diarrhoea. Once they reach the lungs, symptoms can include a chronic productive cough, chest pain, blood-stained sputum, and sometimes fever. Signs can be similar to those of tuberculosis or lung cancer. Sometimes the parasites become “lost” on their way to the lungs, and end up in the brain, chest muscles, under the skin and other places, producing a variety of signs and symptoms.

⌘ Public health prevention and control

Because of the habitat of the crabs (such as small mountain streams) and the life cycle involving wild animals, the transmission cycle of *Paragonimus* spp. is difficult to break, and prevention and control rely mainly on treating infection and on community education.

- The young parasites in crustaceans (called metacercariae) are very small, approximately 0.2–0.4 mm, and are best seen using laboratory methods. Community education and awareness regarding prevention measures – such as ensuring crabs and crayfish are properly cooked, and avoiding cross-contamination of kitchen utensils – are very important. Education to promote WASH activities and the use of latrines to reduce faecal contamination of freshwater habitats is also important.
- Humans can be treated for adult flukes using triclabendazole or praziquantel. This can be done with community-wide interventions, if necessary.
- Snail control is a possibility, but due to the characteristics of some snail species, their natural habitat, and the tools available, this might not be feasible.
- Treatment of domestic animals such as dogs and cats with praziquantel is an option, but the prevalence is generally very low, so is usually unnecessary.

❖ **Specific food safety interventions at authorities' level**

- Food safety authorities can promote awareness in the community regarding the risk of contaminating freshwater streams with faeces, and the need to properly cook crabs. It is difficult to specify cooking times and temperatures due to differences in size and shape of different crabs but a temperature of 55 °C for 10 minutes will kill the parasites. Most heat-cooking techniques, including boiling water, should destroy the parasite. In practical terms the crabs need to be cooked until the muscles turn white and the meat can be easily removed from the shell. Freezing the crabs at -20 °C for 48 hours will kill these parasites. Pickling in brine, vinegar or wine does not kill metacercaria. Some suggested activities for food safety authorities are described in Section 4.

2.3. Parasites transmitted by vegetables, water and the environment

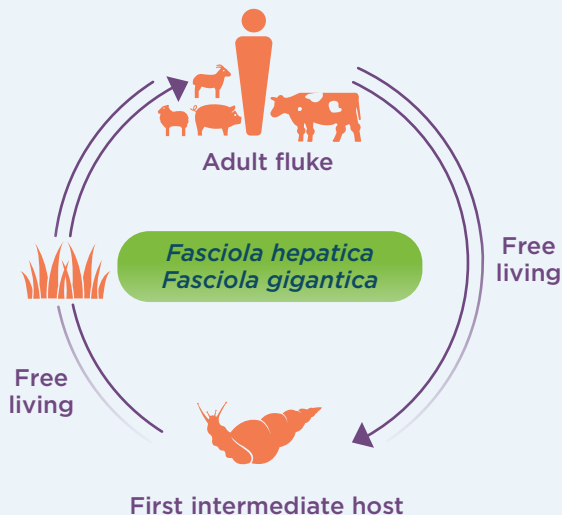
2.3.1. Fascioliasis

This infection is caused by two species of leaf-shaped flatworms that particularly affect the liver: *Fasciola hepatica* and *Fasciola gigantica*. It is acquired mainly by eating raw plants such as watercress and other freshwater cultivated or wild plants, but can also be transmitted by drinking contaminated water.

✦ Transmission cycle

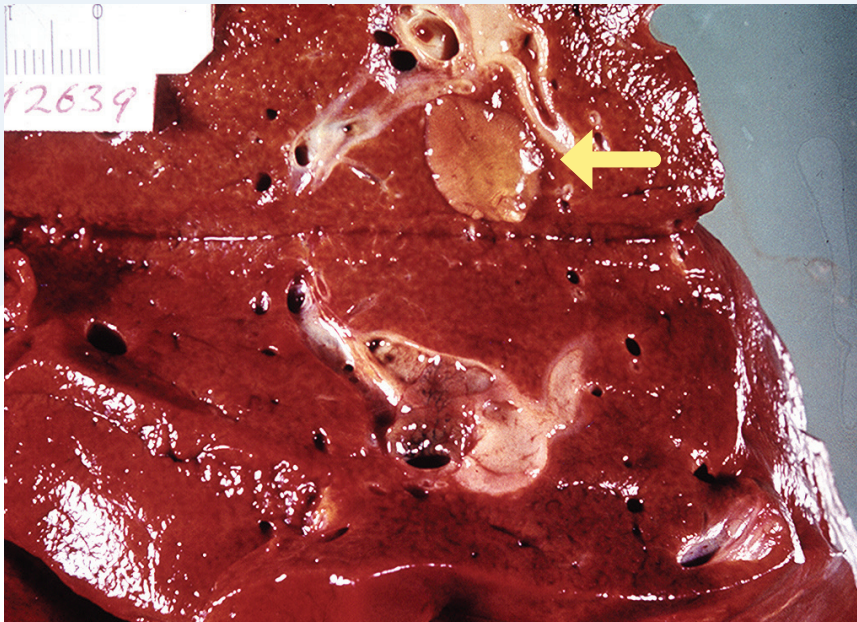
With *Fasciola hepatica*, the adult parasites are relatively large flukes, with *Fasciola hepatica* measuring 20-40 mm x 10-15 mm, and *Fasciola gigantica* 25-75 mm x 12 mm. Both species live in the large bile ducts of the liver and gallbladder of ruminants, especially sheep, goats and cattle. Other animals such as buffalo, deer and pigs can also become infected. While this is mainly a non-human animal disease, it does occasionally affect people. However, the epidemiology is complex, and the frequency of the parasite in animals does not appear to be closely correlated to the occurrence in people.

Figure 11. Transmission cycle of *Fasciola hepatica* and *Fasciola gigantica*



The adult flukes lay eggs that, through the bile, reach the intestines and are eliminated with the faeces (Figure 11). Under the right conditions, the eggs hatch and release a very small immature parasite, called miracidium. The miracidium invades specific types of amphibious snails (depending on the species of *Fasciola*), where the parasite continues to develop. Once it reaches a certain stage of development (called cercaria), the still immature parasite leaves the snail. The cercaria swim in the water for as long as a couple of hours until they attach themselves to aquatic plants and encyst, becoming metacercaria. The encysted parasites measure about 0.2 mm in diameter. They can survive on the plants for up to one year. Once a ruminant or other suitable animal (including a human) eats the plants with the encysted parasite (or even drinks water with the parasite that has washed off plants) and reaches the intestine, the parasite is released from the cyst, crosses the intestinal wall and migrates to the liver, where it finally becomes an adult fluke (Figure 12).

Figure 12. *Fasciola hepatica* in the liver of a sheep



⌘ Health impacts

Symptoms depend on the number of parasites and the duration of the infection. In the early stages (acute phase), symptoms are due to the parasite's migration from the intestine to the liver, and may include fever, abdominal pain, loss of appetite, abdominal flatulence, nausea and diarrhoea. Once the parasite is in the liver (chronic phase), there may be inflammation of the liver and obstruction of the bile ducts. This is presented as abdominal pain, weight loss, diarrhoea, fatty food intolerance, nausea and, in some cases, jaundice. Many people with slight infections do not have severe symptoms.

⌘ Public health prevention and control

There are several prevention and control measures, and all need to be considered in the local context, as epidemiological situations can be different.

- Livestock (e.g. sheep, goats, cattle): Treating livestock with anthelmintics such as triclabendazole and closantel at strategic times is very important. Management practices such as rotational grazing should also be encouraged.
- Humans: Can be treated for adult flukes using triclabendazole. This can be done with community-wide interventions when there is high prevalence, or targeting the highest prevalence groups such as school-aged children if that is the case.
- Community education and awareness of the risk factors – such as eating uncooked freshwater plants – and the importance of drinking safe water and the safe disposal of human faeces is important.
- Water sources: Measures should be taken to prevent faecal contamination of vegetable-growing areas and water by humans and, if feasible, by animals. Snail control can also be implemented, and there are several options, including the use of physical, chemical or biological methods. Many chemical treatments (molluscicides) are not recommended or allowed as they might harm the environment.
- Safe water, sanitation and hygiene (WASH) activities should be practiced to promote drinking safe water, efficient sanitation and the use of latrines. Reducing faecal contamination of water sources is also important.

❖ Specific food safety interventions at authorities' level

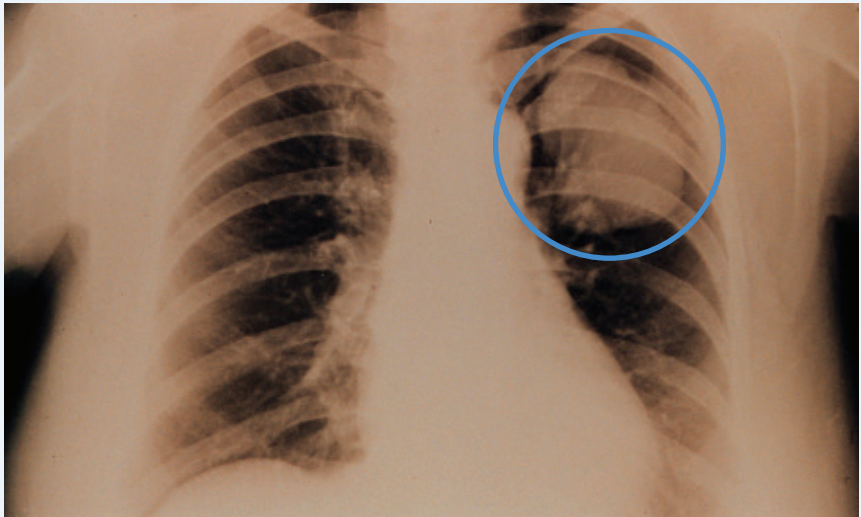
- Food safety authorities can promote awareness in the community regarding the risk factors associated with eating raw plants and drinking contaminated water, and how to prevent infection. Eating raw aquatic vegetable harvested from or near grazing lands should be avoided. Rinsing vegetables is not enough. The parasite can be killed by cooking the vegetables at 60 °C for several minutes. Many chemical products – such as potassium permanganate, citric acid and acetic acid – have been suggested, but their effectiveness varies, depending on the concentration of the agent and time. The parasites might be detached from the vegetables when using these chemical products, but are not necessarily killed, and in general, the parasites seem to be highly resistant. Freezing is not recommended. Water can be boiled or filtered. Some suggested activities for food safety authorities are described in Chapter 4.

2.3.2. Cestodes infection by tapeworm eggs

People can become infected from the eggs of tapeworms such as *Taenia solium* (discussed in Section 2.1.1), *Echinococcus granulosus* or *Echinococcus multilocularis* by eating food or drinking contaminated water that contains the eggs. Health consequences can be quite important as the eggs hatch in the intestine and the immature stages of the parasite migrate to different parts of the body where they form cysts. The cysts of *T. solium* can develop in the brain and produce neurocysticercosis, while the cysts of *Echinococcus granulosus* can be found in the liver causing cystic echinococcosis (also known as hydatid disease – Figure 13), and the cysts of *E. multilocularis* can be found in the liver, causing alveolar echinococcosis. The cysts of *E. multilocularis* can also spread to many other organs. The treatment for all these diseases is complex and requires specialized medical assistance.

The tapeworm's eggs are invisible to the naked eye. Food safety authorities should emphasize to communities the importance of personal hygiene, especially hand washing after touching animals and before eating, the use of safe water, and treating high-risk food and water. A temperature of 60 °C for 5 minutes can inactivate *T. solium* eggs, and 70 °C for 30 minutes can inactivate *Echinococcus* eggs. Freezing at -20 °C is not a good method to inactivate the tapeworm eggs. The eggs are resistant to chemical disinfectant and killing requires long exposure times and high concentrations of a chemical agent.

Figure 13. X-ray showing a hydatid cyst (cystic echinococcosis) in the lung



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2.3.3. Protozoa

There are several protozoa (single-cell microscopic organisms) such as *Cryptosporidium parvum*, *Entamoeba histolytica*, and *Giardia intestinalis* that can cause disease in people. In general terms, people become infected by ingesting vegetables and water contaminated with faeces from an infected person. Symptoms range from mild abdominal pain, diarrhoea and constipation, to acute fatal dysentery with fever and bloody diarrhoea (*Entamoeba*); profuse watery diarrhoea for one or two weeks with abdominal pain, nausea, vomiting and low fever (*Cryptosporidium*); and diarrhoea, bloating, flatulence, abdominal pain and intolerance to certain foods (*Giardia*).

Food safety authorities should promote prevention and awareness activities, especially with people handling food (in a commercial setting or at home). High-risk foods should be cooked, and water should be boiled or filtered (absolute size $<1\mu\text{m}$ pore size). Water treatment with solar disinfection has also been proved to be effective. Depending on the protozoa, some chemical agents such as tincture of iodine (9 drops of 2 percent per litre of water for 30 minutes) for *Entamoeba* can be effective in killing the parasite. But some, *Giardia* for example, are quite resistant to chemical agents such as chlorine.






Conclusion

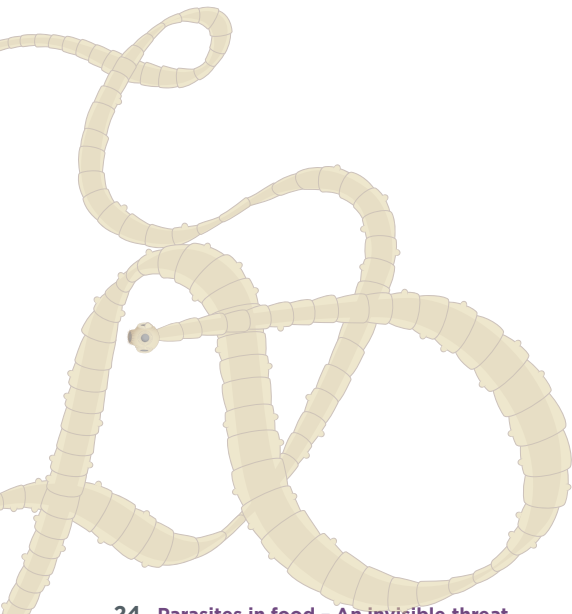
In this booklet, the major foodborne parasites transmitted by pork, freshwater fish, and freshwater crustaceans, were discussed, for which food safety measures play an important role. The prevention of human exposure to these foodborne disease are the responsibility of different authorities in different countries, or may not be the responsibility of any authority in some countries. The fact that the animals affected by parasitic diseases may not show any signs of disease and that there are no production or monetary losses due to such a disease makes it difficult to detect parasites in animals.

Among parasitic diseases transmitted by pork, there are *Taenia solium*, *Trichinella* spp. and *Toxoplasma gondii*. These diseases might be quite serious depending on the number and location of the parasites. For these diseases, there are specific actions that food safety authorities can take, such as promoting the implementation of good farming practices, conducting meat inspections, promoting awareness of hygiene and the main risk factors.

Parasitic diseases transmitted by freshwater fish and crustaceans include *Clonorchis sinensis*, *Opisthorchis viverrini* and *Paragonimus* spp. In the first two, most infected persons do not show any signs or symptoms, but if the infection is serious, the liver duct can become blocked, causing liver damage and can also induce cancer of the bile ducts. In *Paragonimus* spp., the parasite could reach the lungs, generating signs similar to those of tuberculosis or lung cancer. To prevent and control these infections, the most effective action is community education and awareness of the risk factors, as well as the implementation of good fish farming practices.

Parasitic diseases transmitted by vegetables can be caused by two species of leaf-shaped flatworms – *Fasciola hepatica* and *Fasciola gigantica* – that particularly affect the liver. Diseases caused by these are acquired mainly by eating raw plants such as watercress and other freshwater cultivated or wild plants, but can also be transmitted by drinking contaminated water. Signs of infection depend on the number of parasites and the duration of the infection. Awareness raising within the community is, as always, required to prevent and control the parasite's transmission to humans and animals.

People can become infected with the eggs of tapeworms such as *Taenia solium*, *Echinococcus granulosus* or *Echinococcus multilocularis* by eating food or drinking contaminated water with the eggs. Health consequences can be quite important as the eggs hatch in the intestines, and the immature stages of the parasite migrate to different parts of the body where they form cysts. Several protozoa (single-cell microscopic organisms) such as *Cryptosporidium parvum*, *Entamoeba histolytica* and *Giardia intestinalis* can cause disease in people. In general terms, people become infected by ingesting products such as vegetables and water contaminated with faeces from an infected person.










Practical generic recommendations for food safety authorities

4.1. Practical recommendations

1. Develop communications materials for the general public and food business operators in order to encourage adequately cooking or freezing food from animal sources before consuming them (see Table 2, Summary of treatments to decrease the risk of foodborne parasites).
2. Develop a training package or programme for the general public and the food business operators to consider using effective filtration and treatment of water for drinking and cooking, or encourage it to be boiled (See Table 2, Summary of treatments to decrease the risk of foodborne parasites).
3. Review the relevant legislation and regulations to ensure that the roles and responsibilities of stakeholders are clearly defined. For example, in some countries, home butchering might be allowed, while in others it might not be permitted. International guidance regarding animal production, food processing, meat inspection and related topics is provided by the Codex Alimentarius (see the “Resources” section).
4. Implement a community-based, awareness-raising campaign on common prevention measures for all foodborne parasites and diseases among the community, and on the prevention measures that should be taken among the different members of the food value chain. Prevention measures applicable to most foodborne parasites include good hygiene and better sanitation to avoid faeces contaminating the environment and potential food sources. Community awareness of the diseases and prevention measures is a critical component to decrease diseases caused by foodborne parasites. Food safety authorities can play a very important role in creating that awareness.

- Develop a network with relevant partner agencies, such as the Ministry of Public Health, the Ministry of Education, to create awareness in schools, with the Ministry of infrastructure, Ministry of Environment, local government agencies and others to improve access to safe water and basic sanitation; and with the Ministry of Agriculture (livestock, fisheries or similar) to create awareness and train farmers on good farming practices. Food safety authorities can work in synergy with other authorities responsible for improving access to safe water and basic sanitation to decrease diseases caused by foodborne pathogens.

Table 2. Summary of treatments to decrease the risk of foodborne parasites

Parasite Source	Heat	Cold	Others
Pigs 	≥71 °C	<i>Taenia</i> : ≤-10 °C for 10 days <i>Toxoplasma</i> : ≤-20 °C for 3 days <i>Trichinella</i> : ≤-15 °C for 3 weeks (up to 15 cm thick).	Curing, drying or smoking the meat are not adequate methods to kill <i>Trichinella</i>
Freshwater fish 	≥70 °C	-20 °C for 7 days	Inactivation by salting and pickling depends on the different parameters used
Freshwater crustaceans 	≥55 °C for 10 minutes	-20 °C for 2 days	
Vegetables 	≥60 °C	Not recommended	Chemical agents depend on product, time and concentration
Water 	Boil for one minute	Not recommended	<ul style="list-style-type: none"> Filtration absolute size <1µm Solar disinfection

4.2. Specific training and awareness creation activities

Some suggested actions for food safety authorities include:

- **Promote awareness of the dangers of foodborne diseases, promote food from animal sources to be adequately cooked before they are eaten, and promote filtration or boiling of drinking water.** Different members of the community and the food chain need to be made aware of the key messages. Food safety authorities can design specific activities aimed at the different target groups. Suggested training activities are included in Table 3.

- **Awareness of what to do when a parasite is found.**

Different members of the food chain need to be made aware of what should be done if a parasite is found. This might (or might not) include notifying the relevant authorities. It is important to acknowledge the implications that the event of parasites in the food chain might have, especially if the parasites are present in animals or if food need to be disposed of, and there is not economical compensation. Food safety authorities should work with different members of the food chain to create this awareness when conducting training or during awareness campaigns.

- **Awareness of food processing by street vendors.**

Processing food, handling and cooking it appropriately is important at the household level but is also important at the food retail level. Street vendors might be considered a special category, as they are more likely to have limited resources for fuel for cooking, or the lighting might not be adequate to check if the food has been thoroughly cooked. Food safety authorities should create awareness campaigns aimed at street vendors, acknowledging the limitations they face and providing practical recommendations that might be developed in conjunction with them in local workshops. The World Health Organisation (WHO) has published “Basic steps to improve safety of street-vended food” (see “Resources” section).

- **Dissemination of messages.** When planning the dissemination of a message, it is important to keep the target audience in mind and engage communities if possible. Things to consider include:
 - Is the language appropriate for the audience?
 - What is the most appropriate way to reach the audience?
Are they literate? Will a leaflet be useful if it contains mainly pictures? Should radio messages be used instead? At what time is the audience more likely to listen to the radio? Should small plays or street theatres be organised?
 - Should school children be included as a target audience within the community so they can carry the messages to their households?
 - Can farmers be given “awareness lessons” during market days? Are there any extension officers working with farmers who can assist with transmitting the message?
 - Can mothers be given “awareness lessons” in combination with other targeted actions to other women in the community?
 - Is there already awareness materials that have been created and are available? For example, WHO has many resources available under the Five Keys to Safer Food Programme (Figure 14), see “Resources” section.



Figure 14. Poster with the five keys to safer food to create community awareness

Five keys to safer food

Keep clean

- ✓ Wash your hands before handling food and often during food preparation
- ✓ Wash your hands after going to the toilet
- ✓ Wash and sanitize all surfaces and equipment used for food preparation
- ✓ Protect kitchen areas and food from insects, pests and other animals

Why?

While most microorganisms do not cause disease, dangerous microorganisms are widely found in soil, water, animals and people. These microorganisms are carried on hands, wiping cloths and utensils, especially cutting boards and the slightest contact can transfer them to food and cause foodborne diseases.

Separate raw and cooked

- ✓ Separate raw meat, poultry and seafood from other foods
- ✓ Use separate equipment and utensils such as knives and cutting boards for handling raw foods
- ✓ Store food in containers to avoid contact between raw and prepared foods

Why?

Raw food, especially meat, poultry and seafood, and their juices, can contain dangerous microorganisms which may be transferred onto other foods during food preparation and storage.

Cook thoroughly

- ✓ Cook food thoroughly, especially meat, poultry, eggs and seafood
- ✓ Bring foods like soups and stews to boiling to make sure that they have reached 70°C. For meat and poultry, make sure that juices are clear, not pink. Ideally, use a thermometer
- ✓ Reheat cooked food thoroughly

Why?

Proper cooking kills almost all dangerous microorganisms. Studies have shown that cooking food to a temperature of 70°C can help ensure it is safe for consumption. Foods that require special attention include minced meats, rolled roasts, large joints of meat and whole poultry.

Keep food at safe temperatures

- ✓ Do not leave cooked food at room temperature for more than 2 hours
- ✓ Refrigerate promptly all cooked and perishable food (preferably below 5°C)
- ✓ Keep cooked food piping hot (more than 60°C) prior to serving
- ✓ Do not store food too long even in the refrigerator
- ✓ Do not thaw frozen food at room temperature

Why?

Microorganisms can multiply very quickly if food is stored at room temperature. By holding at temperatures below 5°C or above 60°C, the growth of microorganisms is slowed down or stopped. Some dangerous microorganisms still grow below 5°C.

Use safe water and raw materials

- ✓ Use safe water or treat it to make it safe
- ✓ Select fresh and wholesome foods
- ✓ Choose foods processed for safety, such as pasteurized milk
- ✓ Wash fruits and vegetables, especially if eaten raw
- ✓ Do not use food beyond its expiry date

Why?

Raw materials, including water and ice, may be contaminated with dangerous microorganisms and chemicals. Toxic chemicals may be formed in damaged and mouldy foods. Care in selection of raw materials and simple measures such as washing and peeling may reduce the risk.

Knowledge = Prevention

WHO/FAO/UNEP/WHO
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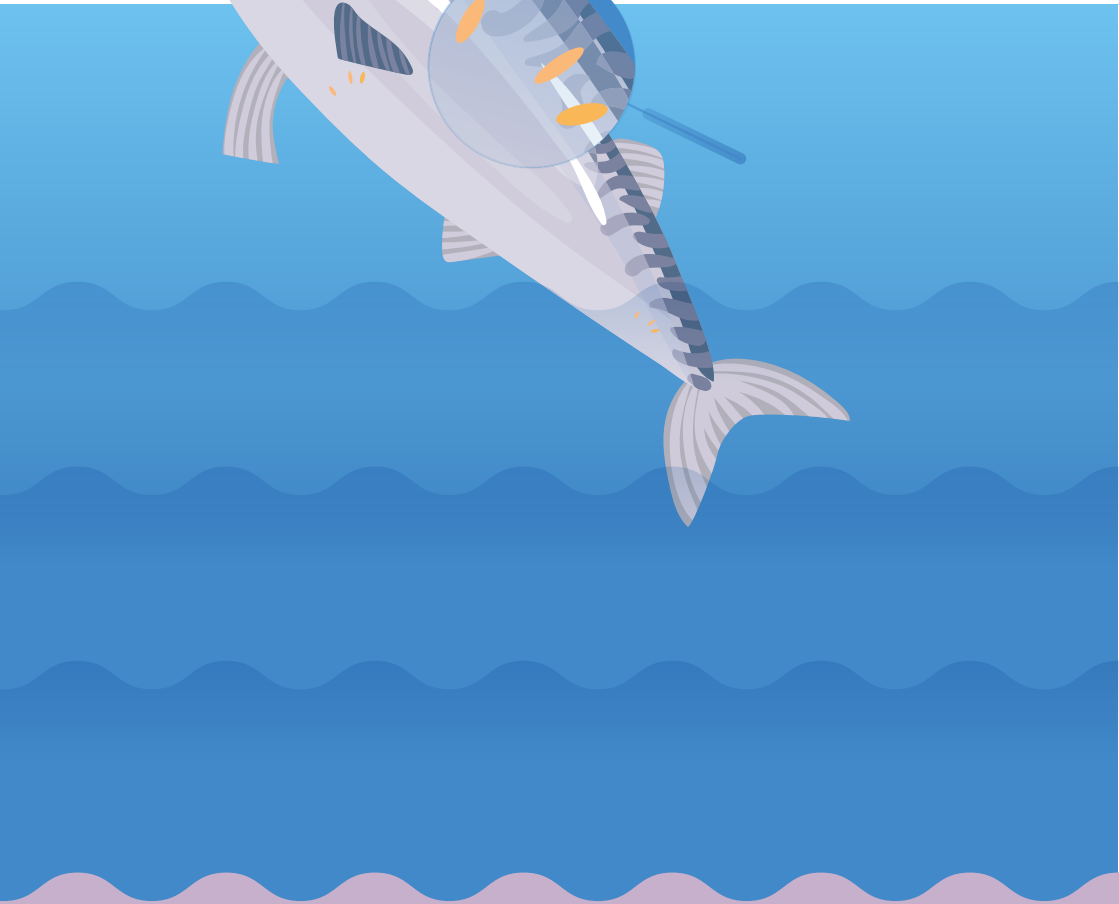
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- **Using innovative ideas.** Food safety authorities should not be shy about trying new ideas out in communities. For example, can a food demonstration and tasting session be organised for the community using cooked pork, fish and vegetables? Can community members be engaged to identify or create a recipe that is safe and acceptable by themselves? Could cooking competitions be organised in the community to obtain the best recipes with cooked pork, fish or vegetables? This might work better than simply providing recipes, as the community will participate and take ownership. Could the best recipes for the district be distributed to the whole district by the most adequate means?
- **Promoting good farming practices.** To achieve this objective, food safety authorities can work in conjunction with the Ministry of Agriculture (or its equivalent), or with local agricultural colleagues or agricultural research organizations. It is important to acknowledge that some good farming practices are difficult to implement for poor farmers. For example, pigs are not kept in pens in poor communities (where *Taenia solium* is endemic) because farmers cannot afford to feed them, or do not have enough resources to build pens. In such cases, it is important to acknowledge the limitations, and include in the training alternative food sources, and demonstrate how pig pens can be built with local easy-to-find (and inexpensive) materials. Some fish farmers, for example, might use their ponds as latrines because no other options are available. It is imperative when training farmers, to work together to identify the limitations, and try to jointly find acceptable and practical solutions, even if they are not ideal.
- **Promoting prevention in animals.** Working in partnership with other authorities or organizations, food safety authorities can promote preventive actions in animals, and should include not only food animals (e.g. pigs and fish), but also animals that are part of the transmission cycle as, for example, cats (liver flukes).
- **Promoting WASH activities.** Food safety authorities could work in conjunction with other ministries and organizations to encourage, promote and facilitate the end of open defecation, and access to safe water and basic sanitation, and create awareness in the community of the importance of good hygiene.

Table 3. Some specific suggested training on foodborne parasites according to the target audience

Target	Specific suggested training activities
Community	<ul style="list-style-type: none"> • Basic sanitation and hygiene (WASH). Importance of stopping open defecation • Food handling & processing • Cooking competitions using cooked pork/fish/vegetables – dissemination of best recipes
Farmers	<ul style="list-style-type: none"> • Good farming practices (especially pig and fish farmers) • Prevention in animals • Importance of stopping open defecation to avoid contamination of pastures and water sources
Animal health workers	<ul style="list-style-type: none"> • Good farming practices (especially for pig and fish farmers) • Prevention in animals • Identification of parasites • Notification to the relevant authorities (as appropriate)
Community health workers	<ul style="list-style-type: none"> • Identification & management of human cases (referrals as appropriate) • Disease notification (as appropriate)
Livestock traders	<ul style="list-style-type: none"> • Identification of infected animals • Notification to relevant authorities
Butchers	<ul style="list-style-type: none"> • Identification of infected meat • Disposal of infected meat
Meat inspectors	<ul style="list-style-type: none"> • Identification of infected meat • Disposal of infected meat • Traceability (identification of the source) of infected animals
Street vendors	<ul style="list-style-type: none"> • Identification of infected meat • Food handling & processing
ALL GROUPS	<ul style="list-style-type: none"> • Disease awareness • Disease prevention (appropriate to the target audience)



5

Resources

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5.2. Other reading

Codex Alimentarius

The Codex Alimentarius, or “Food Code” is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. The Commission is the central part of the Joint FAO/WHO Food Standards Programme and was established by FAO and WHO to protect consumer health and promote fair practices in food trade. The text of the different standards, guidelines and codes of practice is available online. Some of the most relevant to the topic are:

Standards:

a) Standard for smoked fish, smoke-flavoured fish and smoked dried fish – CXS 311-2013

Guidelines:

b) Guidelines on the application of general principles of food hygiene to the control of foodborne parasites – CAC/GL 88-2016.

- c) Guidelines for the control of *Trichinella* spp. in meat of Suidae – CAC/GL-86-2015:
Code of Practice:
- d) Code of hygiene practice for meat – CAC/RCP 58-2005
- e) Code of Practice for fish and fishery products – CAC/RCP 52-2003.

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OIE Terrestrial Code

The OIE is the World Organisation for Animal Health. They produce the OIE Terrestrial Animal Health Code, which provides standards for the improvement of animal health and welfare and veterinary public health worldwide, including standards for safe international trade in terrestrial animals and their products. The standards in the Terrestrial Code are adopted by the World Assembly of Delegates, which constitutes the organisation's highest decision-making body. Some specific chapters of interest are:

- Chapter 8.17 – Infection with *Trichinella* spp.
- Chapter 15.4 – Infection with *Taenia solium* (porcine cysticercosis)

OIE resources:

Coordinating surveillance policies in animal health and food safety “from farm to fork”. Scientific and Technical Review 32 (2)

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WHO Resources

WHO built the Five Keys to Safer Food Programme to assist member states in promoting safe food handling behaviour and educating all food handlers, including consumers, with tools that are easy to adopt and adapt. Some of the documents developed under this programme are:

1. Five keys to safer food (poster, brochure and manual)
2. Five keys to safer aquaculture products to protect public health
3. Five keys to growing safer fruits and vegetables
4. A guide to healthy food markets
5. Basic steps to improve safety of street-vended food

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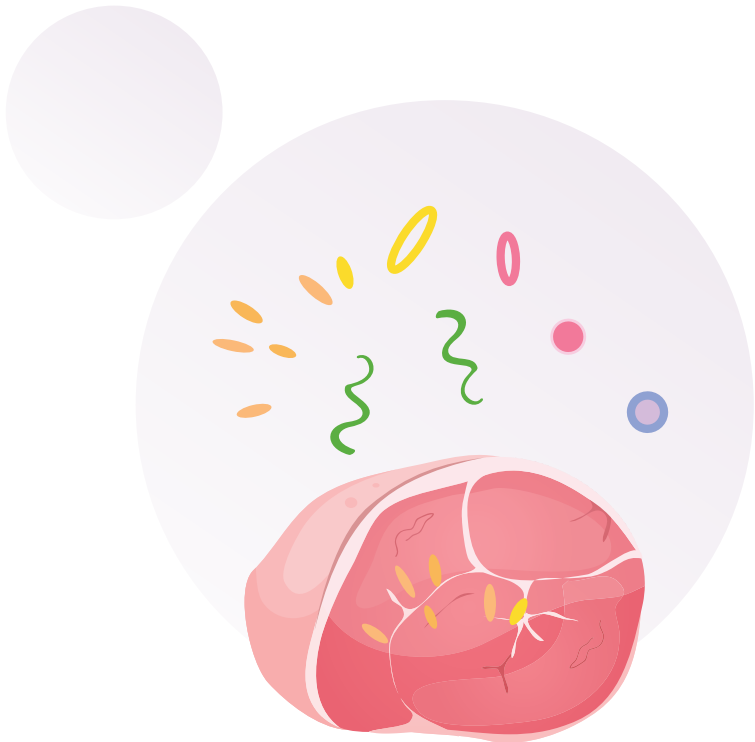
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Parasites in food

An invisible threat

7



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