Progress in epidemiology and control

15. Country experience

The epidemiology of foodborne trematode infections in most endemic countries has been incompletely described. China has provided an excellent recent example of how the data derived from a national epidemiological survey can be used to confirm the importance of foodborne trematode infections and assist a government in its decision to initiate a national control programme (*43*). In other endemic countries, limited epidemiological studies have already identified areas of high prevalence which justify the initiation of control measures. The collection and analysis of epidemiological data on a continuous basis are necessary for the planning and evaluation of control programmes.

The Study Group noted that several programmes for the control of foodborne trematodes had met with success in several countries. The approaches used in the past in Japan and the Republic of Korea and that now being used in Thailand have served as models for the development of the integrated strategy endorsed by the Study Group.

15.1 Countries where *Opisthorchis viverrini* is endemic

Of the countries along the Mekong River basin where *O. viverrini* is endemic, only Thailand has initiated and is maintaining a national control programme. Recently, the Lao People's Democratic Republic has begun a programme for the control of opisthorchiasis linked to control of schistosomiasis.

15.1.1 *Lao People's Democratic Republic*

The current estimates of the prevalence of *O. viverrini* in the Lao People's Democratic Republic are based on faecal examination surveys of schoolchildren in 18 localities (municipalities, provinces, etc.) in 1992. About 1744000 persons are estimated to be infected. In the population as a whole, the overall prevalence of infection in 1992 was 40%, but was higher in the southern provinces. It is noteworthy that a number of minute heterophyid parasites are endemic in the same areas and their eggs are similar to those of *O. viverrini*, which can make diagnosis difficult.

In 1989, the WHO Regional Office for the Western Pacific in collaboration with the Ministry of Health of the Lao People's Democratic Republic initiated a schistosomiasis control programme in Khong District in the Mekong River basin of southern Lao People's Democratic Republic. At the outset it was noted that the prevalence of *Schistosoma mekongi* was about 30% in schoolchildren, while the prevalence of opisthorchiasis was as high as 80% in some schools. The control approach emphasized mass treatment and health education through the schools and community leaders. Initially, if the prevalence of trematode infections in a village was above 50% in 7-14-year-old schoolchildren, all the inhabitants of the village were treated; if the prevalence was 25-50%, only the schoolchildren were treated; and if the prevalence was less than 25%, all children who were egg-positive in the survey were offered treatment with a single dose of praziquantel of 40 mg/kg. This dose was confirmed to be effective against both opisthorchiasis and schistosomiasis. Other stratified chemotherapy approaches were also evaluated. One year after the programme had been initiated, the prevalence of schistosomiasis and opisthorchiasis was 5% among schoolchildren on Khong Island and 15% on several of the adjacent islands. Currently the lower limit of prevalence required for mass treatment is 25%: if the prevalence is below 10%, only the children diagnosed as being infected in the survey are treated. No snail control or treatment of the reservoir hosts (dogs or cats) has been undertaken.

15.1.2 *Thailand*

Thailand is the most highly endemic country for opisthorchiasis due to *O. viverrini*. Several popular Thai dishes are high-risk foods, e.g. *koi-pla* or *lab-pla* (raw fish in spicy salad) and *pla-ra* or *pla-som* (salted semi-fermented fish). Opisthorchiasis was first reported in 1953 in north-east Thailand where its overall prevalence was estimated to be 25%. At that time, the total population was about 20 million Thais, of whom it was estimated that approximately 2 million were infected. A national epidemiological survey in 1984 demonstrated that the overall prevalence of *O. viverrini* infection in the north-east had increased to about 35%. In recognition of its public health impact, the Ministry of Public Health of Thailand decided to implement an intervention programme to control the infection. In 1991, the prevalence in the population at risk was reported as 15.2%, i.e. about 7 million people were infected out of some 45 million at risk. The prevalence was 24.0% in the north-east, 22.8% in the north, 7.3% in the central region, and only 0.3% in the south. High prevalences were recorded in the provinces of Nan (53.2%), Lampang (37.6%), and Chiang Mai (26.8%) in the north, Sakon Nakhon (29.2%), Loei (27.4%), and Chaiyaphum (26.6%) in the north-east, and Sara Buri (28.0%) in the central region.

The infection is observed in all age groups, increasing from childhood to adulthood, equally in both sexes. The peak age group for cholangiocarcinoma associated with opisthorchiasis is 25-44 years of age.

The opisthorchiasis control programme in Thailand has developed in three phases. Between 1951 and 1968, pilot control programmes using chloroquine for treatment of infected people were unsuccessful in reducing the prevalence and maintaining it at a low level. An intensive health education effort began in 1968 as the second phase of control; this lasted until 1987. At the beginning of this phase, health education was aimed at persuading villagers to cook their favourite raw fish dishes, through mass distribution of cooking pots together with demonstration of cooking techniques. Praziquantel became available in 1984 and was incorporated into the control programme. By 1987, the prevalence of opisthorchiasis had declined considerably, but not below the level of public health importance.

Since 1988 a national control programme has been organized, and support for it continues under the seventh National Public Health Development Plan (1992-1996). The control model was developed by the Faculty of Tropical Medicine, Mahidol University. The control strategies started by increasing the awareness of all members of the public of the impact of opisthorchiasis on public health and its economic implications. The approaches used in the large pilot project carried out in seven provinces in north-east Thailand included health education, introduction of community participation by employing health care approaches aimed at community self-reliance, annual selective treatment, and improvement of sanitation and nutritional status. The programme was centrally planned, with the participation of the provincial medical officers, and in the target provinces stool surveys were undertaken by trained mobile teams. Local health authorities participated in the management of the mobile teams, community preparation, and health education, and individual members of the community contributed a small fee for the examination and the cost of drug treatment. The project covered about 3 million people, and 96% of those who submitted egg-positive stool samples for examination were treated.

The control programme is now continuing with the aim of providing diagnosis and treatment for all infected people after individual faecal examination using the Kato-Katz technique. The programme has been implemented in all provinces in the north-east and is currently being extended into the northern provinces of Thailand. An interim evaluation showed that the prevalence of opisthorchiasis in the north-east had decreased from 34.6% in 1988 to 24.1% in 1991. An increased awareness of opisthorchiasis has been observed in people from every walk of life, from the ministerial cabinet to the mass media, and from local administration officials to all members of the community. In addition, a trend away from the consumption of high-risk foods, such as raw fish, raw fish salad, fresh fish paste, and semi-fermented fish, to low-risk foods, such as grilled and boiled fish, has been documented among the population in the target areas.

Two major problems were encountered during the pilot project in north-east Thailand: inadequate community preparation for control activities and a lack of effective educational methods and tools. In villages, where the community was poorly prepared, low rates of stool submission were frequently observed. Nevertheless, those who did submit stool samples were always willing to pay for their drug treatment. The health education of large groups of people had to be carried out by health officials in various subdistricts of the seven provinces, and the outcome generally varied according to the degree of commitment of the officials.

15.2 Countries where *Opisthorchis felineus* is endemic – former USSR

Opisthorchiasis in the former USSR is caused by *O. felineus*. The disease is endemic with involvement of humans, domestic animals, and wild animals in an area that covers nearly all the territory of the former USSR with the exception of the northern part of central and eastern Siberia, the far-eastern region, the Caucasus, and the former Republics of middle-east Asia. About 1.6 million people are estimated to be infected in the former USSR. The distributions of *O. felineus* in freshwater fish and of human opisthorchiasis do not coincide; human infection occurs at some distance from the main endemic areas because of the natural fish migration patterns and transport of fish for sale. The endemicity of opisthorchiasis in the territories of the former USSR is classified according to the prevalence, the intensity of infection, and the degree of clinical manifestations as follows:

- Not endemic – imported cases of disease only.
- Hypoendemic – sporadic cases or a prevalence of < 10%; the mean number of eggs per gram of faeces is < 100; clinical manifestations are severe in < 10% of infected persons.
- Mesoendemic – prevalence is 10-40%; 100-300 eggs are found per gram of faeces; clinical manifestations are moderate or severe in 10-50% of infected persons.
- Hyperendemic – prevalence rate is > 40%; > 300 eggs are found per gram of faeces; clinical manifestations are moderate or severe in > 50% of infected persons.

Opisthorchiasis is a public health problem in Kazakhstan, the Russian Federation, and Ukraine. In the Russian Federation, the largest endemic area is in western Siberia (the Ob and Irtysh river valleys and their tributaries). In the central part of this large area (the Tyumen and Tomsk districts) the mean prevalence ranges between 40% and 95%. Prevalences of up to 46% have been reported in some communities in Omsk district and in the Komi-Permiak national district, prevalence ranges from 45% to 65%. In other districts and territories of the Russian Federation, wide variations in prevalence between communities have been noted: 5-60% in Sverdlovsk district; 2-30% in Altai territory; and 1-5% in Voronezh and Archangelsk districts. The prevalence rate varies from 0.5% to 15% in some localities of Krasnoyarsk territory and Irkutsk district in eastern Siberia.

Forty-six per cent of the territory of Russian Federation is endemic for opisthorchiasis and nearly 84% of the population of the country reside in these areas. In 1992, opisthorchiasis was endemic in 24 out of 77 administrative territories; imported cases were registered in 38 others, and in 15 territories no infected people were found. The only places where there is a risk of acquiring infection are the river basins where 10%

of the total population (approximately 12 million people) reside. The health services examine about 200 000 people each year; 40 000–95 000 cases of opisthorchiasis were registered annually between 1986 and 1992 in the river basin areas.

In Ukraine, opisthorchiasis is limited to the Sumy, Poltava, and Chernigov districts of the Dnepr River basin where the prevalence ranges between 5% and 40%. The population at risk is about 1.15 million people and of these 312 000 people are estimated to be infected. Opisthorchiasis has been controlled in the Sumy district by means of chemotherapy, health education, and sanitation. The prevalence has remained stable at a low level for many years. In Kazakhstan, opisthorchiasis is endemic in the Aktyubinsk, Dzhezkazgan, Karaganda, Pavlodar, Tselinograd, and Turgay districts. The population at risk is 227 000 people, and of these the estimated number infected is about 49 000. Foci of opisthorchiasis have also been found in the Brest, Gomel, and Grodno provinces of Belarus.

The Kato-Katz technique and sedimentation techniques with various modifications have been used for clinical diagnosis of opisthorchiasis in the field and in hospitals in the former USSR. Serological tests, mainly ELISA, have been used in clinical diagnosis and for epidemiological surveys. Epidemiological surveillance methods have been developed, whose main goals are:

- detection of new foci,
- monitoring of the epidemiological situation,
- detection of risk groups,
- evaluation of control activities.

The strategy of control of opisthorchiasis is based on integration of control activities into primary health care systems, with the main goal of reducing the prevalence of disease, but in some districts of the former USSR it has never been fully operational. In highly endemic areas the achievements of pilot control projects have been difficult to sustain and the prevalence has usually returned to the original levels over a five-year period because people have continued to eat fish that is raw, slightly salted, frozen (*stroganina*) or poorly cooked. The migration of infected fish and its consumption by the local people even in non-endemic areas contribute to the relative ineffectiveness of control measures.

From 1962 until 1986, the drug hexachloro-*p*-xylene was used for the treatment of opisthorchiasis; however, because of its toxicity close medical supervision or even hospitalization was required, and large-scale chemotherapy was not possible. Praziquantel was first imported in 1986, and is now manufactured locally in the Russian Federation.

15.3 Countries where *Paragonimus* species are endemic

The distribution of human paragonimiasis is highly focal in endemic countries. These focal areas can be identified as those in which the local inhabitants eat raw crabs; control approaches could therefore be targeted to these people.

15.3.1 *Cameroon*

Cameroon is only one of the areas in Africa where the epidemiology of paragonimiasis is determined by whether raw crabs are traditionally eaten by members of specific ethnic groups. The life cycle of the parasite has not been fully described; however, two species appear to be present: *P. africanus* and *P. uterobilateralis*. In the villages of the lower Bakosi area of the Kumba and Meme divisions of South West Province, prevalences of between 5% and 10% have been reported. The 10–19-year-old age group and women are most frequently affected. In the same area, active pulmonary tuberculosis has been estimated to occur in at least 1.5% of the population. Four foci of human paragonimiasis exist in south-west Cameroon, where primates are naturally infected: these are the Mount Kupe area and the foci of Mbam, Nyong, and Ntem. In west Cameroon, naturally infected drills (*Mandrillus leucophaeus*) are the reservoirs for lung flukes, but human infection has not yet been reported in this area.

15.3.2 *China*

The first endemic focus of *P. westermani* in China was found in Zhejiang Province in 1930. Although more than 20 species and subspecies have been reported from China, only four species are of medical importance, i.e. *P. westermani, P. skrjabini* (synonym: *P. szechuanensis*), *P. heterotremus* (synonym: *P. tuanshanensis*), and *P. hueitungensis.*

P. westermani has been reported from 17 provinces (Taiwan Province is not included in this total although paragonimiasis due to *P. westermani* was an important disease there). *P. skrjabini* which is endemic mainly in the mountainous areas of 14 provinces, is the second most important species; in humans it is involved primarily in a cutaneous type of paragonimiasis.

Human paragonimiasis has been reported from a total of 21 provinces in China (not including Taiwan, where human infection has also occurred). The cumulative number of documented cases is more than 1000 in each of 5 provinces, and between 100 and 1000 in 8 other provinces. Epidemiological investigations have demonstrated metacercariae-encysted second intermediate hosts (crabs or crayfish) in 422 counties. From these data it is estimated that the population at risk of paragonimiasis is about 185 million.

Until 1992 control activities were actively carried out only in highly endemic areas by provincial or county institutions for disease control sponsored by local governments. Health education and chemotherapy were the two important control measures. Health education was particularly important in the 1950s when there was no safe and effective drug treatment available for paragonimiasis. For example, in Lanting

Township of Shaoxing County, Zhejiang Province, which was a highly endemic area of paragonimiasis, health education was successful in changing the villagers' eating habits away from consumption of raw crabs. In conjunction with later chemotherapy with bithionol, the prevalence of paragonimiasis measured by egg-positive sputum decreased from 31.1% in 1951 to 0.05% in 1979; the infection rate in dogs and cats decreased from 55.5% to 4.3%, and in crabs, from between 31.5% and 100% to 7.8%. In 1975, in some villages of Kuandian County, Liaoning Province, 30-50% of schoolchildren had a positive response to the intradermal test, and evidence of clinical disease was found in 10-20% of schoolchildren. However, over the past 18 years, no cases of active infection have been detected in Kuandian County. The prevalence of metacercariae in crayfish has been reduced from between 50% and 80% to 5-10%, and the intensity of infection has dropped from 10-200 to 1-2 metacercariae per crayfish.

Paragonimiasis nevertheless remains an uncontrolled public health threat in most areas of China, particularly in mountainous areas where the disease is endemic and access to diagnosis and treatment is poor. In 1992, a national control programme was proposed by an expert committee and accepted by the Ministry of Public Health, based on health education and selective chemotherapy as the major approaches. The programme aims to eliminate the risk of epidemics of paragonimiasis by 1995 in the existing endemic areas and, in places where paragonimiasis is sporadically reported, to eliminate transmission by the year 2000.

15.3.3 *Ecuador*

Since 1980, infected freshwater crabs have been found in 15 of the 22 provinces of Ecuador, particularly in the Amazonian region; these 15 provinces represent more than 70% of the total national territory. The population at risk is approximately one-fifth of the total population of the country or about half of those living in rural areas. Of the population at risk 24.3% are seroreactive and/or egg-positive and 12.3% are egg-positive; thus, at least 494 000 people are estimated to be infected. There have as yet been no pilot control projects, but the Ministry of Public Health has included diagnosis of paragonimiasis within the case-finding activities of the current National Control Programme for Pulmonary Infections.

15.3.4 *Japan*

Paragonimiasis has been reported in most parts of Japan. The average positivity in skin-test surveys was 3.5% among 146 698 people from seven prefectures tested between 1954 and 1968. The egg-positive rate was 10.4% in people who were both serologically and skin-test positive. The Japan Association of Parasite Control has carried out national surveys every five years since 1949, with individual case treatment and control measures according to the Parasitosis Prevention Laws of the Ministry of Health. The prevalence of paragonimiasis has decreased to the point where these surveys have reported no eggs of *Paragonimus* spp. in stool specimens since 1981. On the other hand, sporadic cases of *P. westermani* and of *P. miyazakii* infection have been diagnosed after screening by serological tests in clinical or parasitological laboratories in the past few years. In 1991 about 1000 people were estimated to be infected, or less than 1 per 100 000 population. Infected freshwater crabs (*Eriocheir japonicus*) are found focally in Miyazaki prefecture, Shizuoka, Kyushu, Ehime, Shikoku, and Honshu.

15.3.5 *Peru*

Crabs infected with metacercariae of different species of *Paragonimus* are present in 5 out of the 23 departments of Peru; the species found in these departments are as follows:

- Cajamarca: *P. mexicanus = P. peruvianus, P. caliensis;*
- Huánuco: *P. amazonicus, P. inca;*
- Amazonas: *P. inca;*
- Junín: *P. inca;*
- Ucayali: *Paragonimus* subspecies.

Human paragonimiasis is endemic mainly in rural areas of the Condebamba Valley of the Department of Cajamarca. Serological surveys indicate that 9.6% or about 27 000 people are infected in the rural areas where people eat raw crabs. Paragonimiasis is also suspected to occur in the Amazon regions of Peru, but no epidemiological studies have been undertaken in this area. There is no established control programme.

15.3.6 *Republic of Korea*

About 6 million people in four provinces (Chejudo, Chollanamdo, Chollabukdo, and Kangwondo – about 25% of the population of the Republic of Korea) are currently at risk of paragonimiasis due to *P. westermani* or, rarely, *P. iloktsuenensis*. In the 1920s the egg-positive rate was 9.4% among 180 351 persons examined. In 1959, a national survey using a *P. westermani* antigen for intradermal testing suggested that the overall prevalence was about 13%. In the 1960s, bithionol was introduced to the Republic of Korea and extensively prescribed by medical practitioners. The first pilot control project used bithionol in mass treatment of the inhabitants of the endemic villages of Chejudo, but the long-term evaluation of this project was confounded by later degradation of the environment and disruption of the ecosystems in the 1970s, when rice paddies, streams, and rivers throughout the highly endemic areas became heavily polluted with herbicides, pesticides, and industrial waste. The pollution caused a reduction of freshwater crab and crayfish populations. In parallel with the ecological changes, the egg-positive cases of *P. westermani* were reduced from 1482 in 1970, to 241 in 1980, and 16 in 1990 out of 16 million stool examinations done annually. In metropolitan Seoul between 100 and 150 seroactive people are detected annually by ELISA at a hospital referral laboratory.

15.4 Countries where *Clonorchis sinensis* is endemic

The experience of Japan and the Republic of Korea has demonstrated that clonorchiasis can be controlled, but it remains a major public health problem in China. Since it is a fishborne trematode infection, its potential for spread and introduction into new areas cannot be ignored.

15.4.1 *China*

The discovery of *C. sinensis* eggs in an excavated corpse from the Chu Dynasty (206 BC) in Hubei Province demonstrates that this trematode has a history of more than 2000 years in China. No systematic surveys of clonorchiasis were made in China until the mid-1950s and the infection cycle was then traced only in the hyperendemic areas of the disease, where raw or half-cooked freshwater fish was customarily eaten (e.g. the provinces of Guangdong, Taiwan, Liaoning, and Jilin).

According to cumulative data from past surveys, clonorchiasis was found to be endemic in 23 out of 30 provinces (Taiwan Province not included). Epidemiological investigations from the late 1960s to the early 1980s revealed the following average infection rates: 1.5% in Shandong, 1.8% in Beijing, 3.1% in Henan, 4.5% in Sichuan, 7.0% in Jilin, 15.5% in Guangdong, 15.7% in Liaoning, and 16.8% in Heilongjiang. The Korean community in the north-eastern province exhibited the highest prevalence; for instance, 24.6% of the 20396 Korean inhabitants of Heilongjiang province were infected. Nine species of snail were identified as the first intermediate host of *C. sinensis*; *Parafossarulus manchouricus, Bithynia fuchsiana*, and *Alocinma longicornis* are among the most important. Encysted metacercariae of *C. sinensis* were observed in 72 species of freshwater fish from 13 families. *Pseudorasbora parva* and *Ctenopharyngodon idellus* are recognized as the most important fish hosts.

A nationwide survey on the prevalence of human helminth infections was conducted on a random population sample between 1988 and 1992 using the Kato–Katz technique. The survey covered a sample population of 1477742 from 2848 pilot study areas in 726 counties representing all 30 Chinese provinces. The highest prevalences of clonorchiasis were reported in the provinces of Guangdong, Heilongjiang, Anhui, Guangxi, Sichuan, and Jilin. This survey showed 594 counties to be endemic; the population at risk is 265 million people and of these 4.7 million people are infected.

Since the 1960s, the major control approaches have been health education, case detection, and selective chemotherapy. Safe night-soil disposal has been advocated, primarily in areas where villagers use human excreta to feed fish or have built toilets on fish-ponds. As a result of a five-year programme for the control of clonorchiasis in Sichuan Province sponsored by the United Nations Children's Fund from 1985 to 1989, the prevalence of infection in humans decreased from 21-24% to less than 1% in the experimental areas, the snail infection rate dropped from 1.85% to 0.35%, and the infection rate in fish (*Pseudorasbora parva*) decreased from 53-69% to 8-11%. At the end of the project, 95% of the children and adults had gained a basic knowledge of liver fluke control. In Henan Province a remarkable reduction in the prevalence of clonorchiasis in the community from 10.6% in 1973 to 0.7% in 1983 was achieved by treatment of infected people and health education.

The national control programme for clonorchiasis was announced by the Ministry of Public Health in 1992 with specific objectives: in "administrative" villages with a prevalence of more than 20%, prevalence should be reduced to 10% or less by 1995 and to 5% or less by the year 2000; in villages with an initial prevalence of 10-20%, it should be reduced to 5% or less by 1995 and to 2% or less by the year 2000; in areas with a prevalence of less than 10%, levels of less than 3% by 1995 and less than 1% by the year 2000 should be achieved. Community participation has declined during recent years because of socioeconomic changes in the country and the sustainability of the control activities is now being re-evaluated.

15.4.2 *Japan*

Between 1947 and 1950 *C. sinensis* infection was present in 19 prefectures of Japan. In Okayama, the Tone River valley of Chiba, Saitama, and Ibaraki the overall prevalence of clonorchiasis was 2.9%. In 1960, the Japan Association of Parasite Control adopted a control programme that depended on land reclamation, snail control, and health education. Snail control was achieved by physical and biological methods and as a result of incidental chemical pollution of streams.

Clonorchiasis has now been successfully controlled in Japan; infection is no longer detected in children, and only sporadic cases are found among adults (in whom the parasite has been reported to live for over 26 years). The introduction of praziquantel has facilitated treatment. In national surveys, only 780 cases were diagnosed in 1971; in 1976 there were 26 cases; one case occurred in 1986; and in 1991 no *C. sinensis* infections were detected in any of the 1 million stool samples examined.

15.4.3 *Republic of Korea*

The prevalence of clonorchiasis in the first nationwide stool examination survey undertaken in the 1950s, including seven endemic river basins of the Republic of Korea, was 11.7%. The prevalence ranged from a maximum of 40.2% in the Nakdong River basin to 30.8% in the Yeongsan River basin, 17.3% in the Seomjin River basin, 15.9% in the Tamjin River basin, 15.7% in the South Han River basin, 12.0% in the Kum River basin, and a minimum of 8.0% in the Mangyong River basin. In 1981, the overall prevalence in the Nakdong River basin was 21.5%.

Clonorchiasis is now endemic in at least five provinces (Kyŏngsangnamdo, Kyŏngsangbukdo, Chollanamdo, Chollabukdo, and Chungchongbukdo), whereas the prevalence in Kyŏnggido, Kangwondo, and Chungchongnamdo is low. The current population at risk in the Republic of Korea is about 19 million of whom 0.95 million are estimated to be infected according to the fifth national survey for intestinal parasites carried out in 1992.

Clonorchiasis is recognized as a public health problem by the Government and the Korea Association of Health, the agency responsible for control of foodborne trematodes in the Republic of Korea. Until 1982, control activities were limited to health education. Large-scale chemotherapy with praziquantel (a single dose of 40 mg/kg) began in endemic areas in 1984. During the period 1984-1990, 3 million stool samples were examined and 100 000 egg-positive patients were treated. Large-scale selective treatment after individual faecal examination is continuing in high-risk farming areas. Diagnosis and treatment are now available at hospitals and clinics throughout the Republic of Korea and are coordinated by both the public and the private sectors.

Nationwide surveys of randomly selected samples of the population in urban and rural areas were conducted in 1971, 1976, 1981, 1986, and 1992, and showed overall prevalences of 4.6%, 1.8%, 2.6%, 2.7%, and 2.2% respectively. Therefore, the overall prevalence of *C. sinensis* infection has decreased only slightly in absolute terms over 20 years despite the development of praziquantel. However, mean faecal egg counts (eggs/gram) and the number of foci of transmission have also decreased. The continued prevalence of clonorchiasis is due to consumption of raw freshwater fish. Elimination of transmission in the long term appears feasible, especially as managed aquaculture of freshwater fish is likely to replace wild freshwater fishing.

15.5 Countries in which human fascioliasis occurs

15.5.1 *Bolivia*

Fascioliasis due to *F. hepatica* is a widespread veterinary problem in Bolivia. Infection rates vary between 25% and 92% in sheep and cattle, resulting in tremendous economic losses. The major focus of human infection is in the Altiplano, extending for 80 km between the city of La Paz and Lake Titicaca and covering an area of 6400 km^2 at between 3820 and 4000 m above sea level. In some villages the prevalence of egg-positive people reaches 65% and up to 92% are serologically positive. This highly endemic area comprises 3 of the 111 provinces of Bolivia. The 3.3% of the population at highest risk live in 0.8% of the total land area. The prevalence among schoolchildren as measured in a recent faecal examination/serological survey in the northern Altiplano lake region was 71.9%.

The two major cities of El Alto and La Paz, in which about one-sixth of the total population of the country live, are the markets for aquatic plants from the endemic area. However, watercress consumption is limited mainly to the local inhabitants of the endemic area and the plant is not generally exported to the urban market. Human infection has been reported in both El Alto and La Paz by clinicians, but reporting is neither systematic nor obligatory.

It is estimated that 360000 people currently have fascioliasis in Bolivia. So far, no national control programme has been initiated.

15.5.2 *Ecuador*

Human fascioliasis due to *F. hepatica* has been found among the people living in the highland region of Ecuador where the prevalence of infection in cattle ranges between 20% and 60% and the habit of eating watercress is widespread. The percentage of the total population living in the endemic areas is 23.6%, or 52.9% of the total rural population; about 1% of the population at risk or approximately 20000 people are estimated to be infected.

15.5.3 *Egypt*

In Egypt, the detection of eggs in a mummy has confirmed that human fascioliasis has existed since Pharaonic times. Until 1978, only sporadic cases were diagnosed; these were usually considered spurious. Since then, an increasing number of human infections with both *F. hepatica* and *F. gigantica* have been diagnosed by clinical services and laboratories in certain provinces of the Nile delta, in one province in upper Egypt, and in the city of Alexandria. In some rural areas prevalence rates vary between 2% and 17%. The population at risk is 27.7 million people and the number infected is at least 830000, based on an estimated overall prevalence of 3% in the population at risk. Since there is as yet no effective drug registered for treatment of fascioliasis, a national control programme cannot be envisaged for the time being.

15.5.4 *Islamic Republic of Iran*

The population at risk in the three provinces where fascioliasis is prevalent, Gīlān and Māzandarān in the north and Eşfahān in the central part of the country, is estimated to be 6 million persons, of whom 10000 are currently infected.

The prevalence rate in livestock ranges between 20% and 40% in different areas. *F. hepatica* is found in the highlands and *F. gigantica* in the plateau area. The snail host of *F. gigantica* is mainly *Lymnaea auricularia*; in some areas, *L. peregra* and *L. palustris* are also implicated in transmission. Only *L. truncatula* transmits *F. hepatica* in the Islamic Republic of Iran.

Human infections were sporadic until 1989 when an outbreak that affected more than 10 000 persons occurred in Gīlān Province. The main source of infection was watercress eaten in salad. Clinical diagnosis, stool examination for eggs, and serodiagnosis were used to detect infection. Fascioliasis was effectively treated with triclabendazole at 10 mg/kg of body weight given in two split doses (each of 5 mg/kg) after meals; the cure rate after a dose of 10 mg/kg was over 85%. A second dose for treatment failures was recommended 30 days after the first treatment.

The annual peak of transmission occurs from late February to June. During this period the inhabitants of the Caspian region eat fresh wild-grown watercress, other green leafy *Nasturtium* spp., and *Mentha* spp. The raw plants are ground, mixed with spices and olive oil, and served as an appetizer or condiment. A paste may also be prepared from these aromatic plants and stored for use over several months. Animals in which there is a high prevalence of animal fascioliasis are a direct source of human infection; the risk arises from the use of animal manure as fertilizer or of wastewater effluent for irrigating the aquatic or semiaquatic vegetable crops.

Animal fascioliasis is currently the cause of extensive economic losses from decreased yields of meat, milk, and wool in domestic animals. The high risk of human infection requires that a fascioliasis control programme be considered in the Islamic Republic of Iran. The early stages of this programme have been initiated by the governmental Veterinary Department. An annual programme of mass chemotherapy of animals has been organized throughout the country, and eradication of snails using molluscicides has begun in some areas. Until triclabendazole becomes widely available, the only control measures aimed specifically at combating human fascioliasis are health education and raising the awareness of the inhabitants of the Caspian area of the mode of transmission of the disease.

15.5.5 *Peru*

Fascioliasis due to *F. hepatica* is a well known veterinary problem in the cattle-breeding areas of Peru, mainly in the highland region near the Andes mountains where 10–100% of cattle are infected. The main endemic area is believed to cover 11 departments where the prevalence in cattle is greater than 20%. This area represents 48% of the total territory of Peru, with a rural population of 7 759 000 people who are at risk of infection.

The mean prevalence of human infection in 5 of the 11 high-risk departments is estimated to be 9.7%, which means that approximately 742 000 people are infected in the endemic areas. No control programme has been established. The economic impact of the disease in domestic animals has been estimated to result in a loss of about US$ 11 million annually.

16. Conclusions

Global public health burden

The Study Group concluded that foodborne trematode infections are emerging as major public health problems throughout the world. More than 40 million people are affected, particularly in WHO's South-East Asia and Western Pacific Regions, and over 10% of the world population is at risk of infection. Extensive economic losses have been documented in terms of lost productivity, absenteeism, direct health care costs, and the costs associated with animal infections.

Food-related behaviour

Food-related behaviour was identified by the Group as the major source of risk of acquiring foodborne trematode infections. A thorough understanding of food-related behaviour is therefore a key to the prevention and control of these infections. However, a change in food habits through health education and information has not yet been achieved in the short term, and control programmes have not yet used the knowledge available from social science studies regarding food-related behaviour for planning control measures for foodborne trematode infections.

Development and environment

The priorities of Agenda 21, adopted in 1992 by the United Nations Conference on Environment and Development held in Rio de Janeiro, support the control of foodborne trematode infections. Water resources development increases the potential for freshwater fish production even when the water bodies have not been specifically designed for fisheries; well designed and managed aquaculture systems have a low risk of transmission of foodborne trematode infections. The use of integrated livestock-aquaculture systems is increasing, but their effect on the risk of foodborne trematode infections is as yet unknown.

Health education

The Study Group endorsed health education through public information and communication as the most important feature of all control strategies and the area of greatest opportunity. Health education messages conveyed through women's and community groups are to be encouraged. Community-based health education in safe food preparation, for example in appropriate cleaning, washing, drying, cooking, and fermentation methods, will help to reduce the risk of infectivity of food. The means available for public communication and social marketing techniques at the disposal of endemic countries have never been greater; yet the mass media (such as radio and television) and schools have not been fully utilized for health education. Politicians and government policy-makers should understand that foodborne trematode infections are preventable.

The Group noted that, although medical and veterinary curricula include teaching on foodborne trematode infections, the new integrated strategy for controlling foodborne trematodes – as endorsed in this report – is not fully understood by all professionals. The feasibility of the strategy should be emphasized in future WHO- and FAO-assisted training in aquacultural fisheries, tropical diseases, and food safety.

Community participation

The past lack of community participation in the control of foodborne trematode infections was highlighted by the Study Group. Community participation at all levels, including schoolchildren and women's and other groups, is a challenge for the future and is essential from the planning through to the implementation and maintenance phase of control activities. In Thailand, community involvement has been strengthened by charging a small fee for treatment provided to infected people.

Tools and approaches available

The tools and approaches currently available for controlling foodborne trematode infections are adequate and are suitable for adaptation to national control strategies. Epidemiological data on the distribution of foodborne trematodes, though incomplete, are sufficient to focus control on high-risk endemic areas. The high-risk foods – raw infected freshwater fish and shellfish and contaminated plants – are recognized. Basic health education and public communication messages on safe food habits have been developed and tested. Food control and inspection techniques (e.g. the Hazard Analysis and Critical Control Point approach – HACCP) are available for effective control of food risks.

Feasible strategies

Control of foodborne trematode infections is feasible with the tools that are available, as several countries, Japan and the Republic of Korea in particular, have shown. Different sectors, including health, agriculture (animal health, aquaculture, and fisheries), and education, can integrate their activities to reduce the prevalence of infection, morbidity, and the risk of transmission by improvement of food habits. An integrated strategy should be flexible and adaptable to the epidemiological situation, make appropriate use of the available human and financial resources, and incorporate specific objectives. These objectives should range from reduction of morbidity in highly endemic areas to prevention of transmission and, in all countries, elimination of the risk of infection through food-safety measures.

Gaps in knowledge

The Study Group noted that a general lack of public awareness and knowledge about foodborne trematodes has been the major constraint in the implementation of control measures. At both international and national level, agencies concerned with coordination of food safety, agriculture, and aquaculture have rarely recognized either the problem or the feasibility of control.

There are gaps in knowledge about the distribution and epidemiology of foodborne trematode infections in some countries, the biology and ecology of the intermediate snail hosts, the diseases caused by the parasites, and interactions with diseases such as cholangiocarcinoma, schistosomiasis, and tuberculosis. Further information is also needed on the effect of certain food processing techniques on the parasites and on their potential for transmission in fisheries and integrated agriculture-aquaculture systems.

Food safety

Foodborne trematode infections can to a large extent be prevented and controlled through appropriate food-safety measures. The limitations of current food processing technologies have not been defined. As new information becomes available, food legislation can be adopted or modified to provide guidance for, and promote compliance by, the food industry, and to promote public understanding and safe food habits.

Intersectoral collaboration

The Study Group recognized that the control of foodborne trematode infections is a complex task requiring coordination and the full participation of all relevant sectors. However, little effort is being made either by individual sectors to address the problem of foodborne trematodes through intersectoral and interministerial communication or by existing interministerial organizations whose mandate is to coordinate food-safety efforts.

Funding

The Study Group noted that, in spite of the global distribution and public health importance of foodborne trematode infections, financial support for research and for the control of human infections is rare even in the most affected countries. International and national research agencies could support innovative studies on this topic. National control activities could be initiated or strengthened by allocation of new funds or reallocation of resources within the budgets of individual sectors.

Shared responsibility

In general, responsibility for the control of foodborne trematode infections should be shared between international and government agencies, with participation of the community at local level, especially women's and community groups. The responsibility for food safety in particular should be shared between governments, the food industry (from food production through processing to retailing), and consumers. The Study Group noted that responsibility for coordinating and supporting the control of foodborne trematode infections has not been assigned to a specific body in most endemic countries.

17. Recommendations

1. The health and economic consequences of foodborne trematode infections should be addressed in each endemic country by a high-level intersectoral coordinating committee; such a body may already exist or may need to be newly established. The objective of the committee, which should have executive power and manage an appropriate budget, should be to initiate and coordinate countrywide measures to prevent and control foodborne trematode infections. The health, agriculture, aquaculture, and education sectors and the food, fish, pharmaceutical, and chemical industries should be represented, as well as relevant nongovernmental organizations (consumers, women's groups, etc.) and research groups. A permanent technical secretariat should be designated with links to national and international organizations involved in the control of foodborne trematode infections.

2. WHO, in collaboration with FAO, should:
   - open a dialogue with international and national development agencies and with other appropriate partners, including the parasitology research community, with the purpose of mobilizing resources to pursue the research and control priorities identified by the Study Group;
   - prepare technical documentation to support the new integrated strategy for the control of foodborne trematode infections.

3. Health risk assessment regarding foodborne trematode infections should be included in the terms of reference of pre-feasibility and feasibility studies of water resources development, fisheries, and aquaculture projects. Appropriate measures to prevent and control foodborne trematode infections should be specifically integrated into project documents and budgeted at the time of financial planning of projects and negotiations with external agencies.

4. The governments of endemic countries should strengthen existing health education programmes so that they can respond fully to the

impact of foodborne trematode infections. In this context, particular emphasis should be placed on changing unhealthy food habits and sanitation practices. Women should be a particular target group for health education efforts.

5. Epidemiological surveys should be encouraged and national epidemiological surveillance and monitoring systems should include the reporting of foodborne trematode infections. Coordination between health, agriculture, and aquaculture sectors will be facilitated by the use of geographical information systems to integrate epidemiological and environmental databases.

6. WHO should encourage the Codex Alimentarius Commission, through its committees on fish and fishery products and on food hygiene, to review and revise, as appropriate, the Recommended International Codes of Practice for fish, shellfish, and derived products and other relevant codes, in order to make them more easily applicable in tropical countries and elsewhere as an aid in the control of fish- and shellfish-borne parasites. The draft Code of Hygienic Practice for the Products of Aquaculture should be prepared with due consideration to freshwater aquaculture in tropical areas and the specific health concerns related to this industry.

7. The Hazard Analysis and Critical Control Point (HACCP) system, a multifactorial approach to the control of food hazards (through surveillance of diseases, foods, and operations and by education), should be included in an action-oriented programme to identify and control foodborne trematode infections.

8. Scientific conferences, symposia, and workshops on foodborne trematode infections should be convened and networks developed to facilitate information exchange between members of the research community.

9. Intersectoral collaboration among governments, industry (e.g. food producers, processors, and importers), educators, researchers, and consumer groups should be pursued and promoted as a means of identifying risks, enhancing food safety, and controlling foodborne trematode infections.

10. Foodborne trematode infections and their control should be included in curricula for medical, veterinary, food science, and aquaculture training, the specific material for study being based on the national situation and experience.

11. Countries affected by foodborne trematodes should seize the opportunity to involve the food control and inspection and the fisheries and aquaculture sectors in the control programmes conducted by health services.

12. Research in the priority areas listed in Annex 7 should be supported to facilitate the development of effective control strategies.

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Annex 1
Estimates of the distribution of foodborne trematode infections

This is a list of the endemic countries that provided data to the Study Group. Unless otherwise stated, the total population estimates are mid-year estimates for 1991 from the United Nations *Demographic yearbook* (43rd edition, United Nations, New York, 1992). The population at risk is a "best estimate" made by the Study Group of the population of the endemic area within each country. These data as well as the estimated number of people infected are subject to confirmation by national surveys.

Annex 1 should be reviewed in conjunction with sections 4.3.1 and 15 of the main report. It should be noted that not all the countries listed in Table 2, pages 20–23, and referred to in section 4.3.1 provided data for inclusion in the annex. Moreover, while the Commonwealth of Independent States is counted as a single entity for the purposes of Table 2 and for estimating the total number of countries and areas affected by each trematode infection, the endemic countries have been listed individually in the annex.

Country or area	Total population	Population at risk	Number of people infected
Fascioliasis			
Bolivia	7 612 000	1 800 000	360 000
China	1 155 790 000	120 600 000	160 000
Ecuador	10 815 000	2 227 000	20 000
Egypt	54 609 000	27 670 000	830 000
Islamic Republic of Iran	55 762 000	6 000 000	10 000
Peru	21 998 000	7 759 000	742 000
Portugal	10 582 000	4 680 000	267 000
Spain	39 025 000	9 517 000	1 000
Subtotal	1 356 193 000	180 253 000	2 390 000

Country or area	Total population	Population at risk	Number of people infected
Clonorchiasis			
China	1 155 790 000	264 818 000	4 701 000
Hong Kong	5 912 000		333 000
Macao	497 000		21 000
Republic of Korea	43 268 000	19 100 000	950 000
Russian Federation	148 263 000[a]	341 000	3 000
Viet Nam	68 183 000	5 000 000	1 000 000
Subtotal	1 421 913 000	289 259 000	7 008 000
Opisthorchiasis			
Kazakhstan	16 742 000[a]	227 000	49 000
Lao People's Democratic Republic	4 262 000	4 360 000	1 744 000
Russian Federation	148 263 000[a]	12 703 000	1 223 000
Thailand	56 923 000	45 163 000	7 000 000
Ukraine	51 872 000[a]	1 151 000	312 000
Subtotal	278 062 000	63 604 000	10 328 000
Paragonimiasis			
China	1 155 790 000	184 974 000	20 000 000
Ecuador	10 815 000	2 035 000	494 000
Lao People's Democratic Republic	4 262 000	1 559 000	153 000
Peru	21 998 000	315 000	27 000
Republic of Korea	43 268 000	6 000 000	1 000
Subtotal	1 236 133 000	194 883 000	20 675 000

[a] Population figure for mid-1990.

Country or area	Infection	Number of people infected
Intestinal fluke infections		
China	Fasciolopsiasis	204 600
	Echinostomiasis	150 000
	Heterophyiasis	230 000
Egypt	Heterophyiasis	10 138
Japan	Metagonimiasis	148 837
Republic of Korea	Metagonimiasis	500 000
Russian Federation	Metagonimiasis	12 530
	Nanophyetiasis	18 500
Thailand	Fasciolopsiasis	10 000
Total		1 284 605

Annex 2
Global distribution of human intestinal trematodes[1]

Trematode species	Countries, areas, or regions where:		
	the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Fasciolidae			
Fasciolopsis buski	Bangladesh		
	Cambodia		
	China		
	India		
	Indonesia		
	Lao People's Democratic Republic		
	Taiwan, China		
	Thailand		
	Viet Nam		
Echinostomatidae			
Artyfechinostomum mehrai			India
Echinochasmus fujianensis		China	
Echinochasmus japonicus		China	Republic of Korea
Echinochasmus jiufoensis			China
Echinochasmus liliputanus		China	
Echinochasmus perfoliatus			China
Echinoparyphium paraulum			China

[1] For reference sources of information, see introduction to Annex 5, page 125.

Trematode species	Countries, areas, or regions where: the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Echinoparyphium recurvatum			Egypt Indonesia Taiwan, China
Echinostoma angustitestis			China
Echinostoma cinetorchis			Indonesia Japan Republic of Korea Taiwan, China
Echinostoma hortense			China Japan Republic of Korea
Echinostoma ilocanum	Philippines Thailand		China Indonesia
Echinostoma lindoense	Indonesia (before 1980)		
Echinostoma macrorchis			Japan
Echinostoma malayanum	Thailand		Indonesia Malaysia Philippines Singapore
Echinostoma revolutum	Thailand	Taiwan, China	China Indonesia
Episthmium caninum			Thailand
Euparyphium melis			China
Himasthla muehlensi			Colombia? (not confirmed)
Hypoderaeum conoideum		Thailand	
Paryphostomum sufrartyfex			India

Trematode species	Countries, areas, or regions where:		
	the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Heterophyidae			
Appophalus donicus			United States
Centrocestus armatus			Republic of Korea
Centrocestus caninus			Taiwan, China
Centrocestus cuspidatus			Egypt Taiwan, China
Centrocestus formosanus			China Philippines Taiwan, China
Centrocestus kurokawai			Japan
Centrocestus longus			Taiwan, China
Cryptotyle lingua			Greenland
Diorchitrema amplicaecale			Taiwan, China
Diorchitrema formosanum			Taiwan, China
Diorchitrema pseudocirratum			Hawaii Philippines
Haplorchis microrchis			Japan
Haplorchis pleurolophocerca			Egypt
Haplorchis pumilio			China Egypt Islamic Republic of Iran Philippines Taiwan, China Thailand

Trematode species	Countries, areas, or regions where:		
	the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Haplorchis taichui			Bangladesh Lao People's Democratic Republic Islamic Republic of Iran Taiwan, China Thailand
Haplorchis vanissimus			Philippines
Haplorchis yokogawai			China Indonesia Philippines Taiwan, China
Heterophyes dispar			Republic of Korea Thailand
Heterophyes heterophyes	Egypt Islamic Republic of Iran	Sudan	China Indonesia Japan Philippines Taiwan, China Tunisia Turkey
Heterophyes nocens	Republic of Korea		Japan
Heterophyopsis continua			China Japan Republic of Korea
Metagonimus minutus			Taiwan, China
Metagonimus takahashii			Republic of Korea
Metagonimus yokogawai	Republic of Korea	China Indonesia Japan Russian Federation Taiwan, China	Balkan States Israel Spain

Trematode species	Countries, areas, or regions where:		
	the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Phagicola sp.		Brazil	
Procerovum calderoni			Philippines
Procerovum varium			Japan
Pygidiopsis summa			Japan Republic of Korea
Stellantchasmus falcatus			Hawaii Japan Republic of Korea Philippines Thailand
Stictodora fuscatum		Republic of Korea	
Gastrodiscidae			
Gastrodiscoides hominis		India	China Kazakhstan Myanmar Philippines Thailand Viet Nam
Diplostomidae			
Alaria americana			United States
Neodiplostomum seoulensis[a]		Republic of Korea	
Strigeidae			
Cotylurus japonicus			China

[a] Previously *Fibricola seoulensis*; see Hong S-T, Shoop WL. *Neodiplostomum seoulensis* N. Comb. (Trematoda: Neodiplostomidae). *Journal of parasitology*, 1994, 80:660–663.

Trematode species	Countries, areas, or regions where: the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Plagiorchiidae			
Plagiorchis harinasutai			Thailand
Plagiorchis javensis			Indonesia
Plagiorchis muris			Japan
Plagiorchis philippinensis			Philippines
Paramphistomatidae			
Fischoederius elongatus			China
Watsonius watsoni			West Africa
Microphallidae			
Spelotrema brevicaeca			Philippines
Lecithodendriidae			
Paralecithodendrium glandulosum		Thailand	
Paralecithodendrium obtusum		Thailand	
Phaneropsolus bonnei			Indonesia Thailand
Phaneropsolus spinicirrus		Thailand	

Trematode species	Countries, areas, or regions where:		
	the disease is endemic	limited focus/ foci exist(s)	human infection has been reported
Prosthodendrium molenkampi			Indonesia Lao People's Democratic Republic Thailand
Gymnophallidae			
Gymnophalloides seoi		Republic of Korea	
Nanophyetidae			
Nanophyetus salmincola			United States
Nanophyetus s. schikhobalowi		Russian Federation	

Annex 3

The WHO Golden Rules for Safe Food Preparation

The following rules have been drawn up by the World Health Organization to provide guidance to members of the community on safe food preparation in the home. They should be adapted, as appropriate, to local conditions.

1. **Choose foods processed for safety**

While many foods, such as fruits and vegetables, are best in their natural state, others simply are not safe unless they have been processed. For example, always buy pasteurized as opposed to raw milk and, if you have the choice, select fresh or frozen poultry treated with ionizing radiation. When shopping, keep in mind that food processing was invented to improve safety as well as to prolong shelf-life. Certain foods eaten raw, such as lettuce, need thorough washing.

2. **Cook food thoroughly**

Many raw foods, most notably poultry, meats, eggs, and unpasteurized milk, may be contaminated with disease-causing pathogens. Thorough cooking will kill the pathogens, but remember that the temperature of *all parts of the food* must reach at least 70 °C. If cooked chicken is still raw near the bone, put it back in the oven until it is done – all the way through. Frozen meat, fish, and poultry must be thoroughly thawed *before* cooking.

3. **Eat cooked foods immediately**

When cooked foods cool to room temperature, microbes begin to proliferate. The longer the wait, the greater the risk. To be on the safe side, eat cooked foods as soon as they come off the heat.

4. **Store cooked foods carefully**

If you must prepare foods in advance or want to keep leftovers, be sure to store them under either hot (near or above 60 °C) or cool (near or below 10 °C) conditions. This rule is of vital importance if you plan to store foods for more than four or five hours. *Foods for infants should preferably not be stored at all.* A common error, responsible for countless cases of foodborne disease, is putting too large a quantity of warm food in the refrigerator. In an overburdened refrigerator, cooked foods cannot cool to the core as quickly as they must. When the centre of food remains warm (above 10 °C) too long, microbes thrive, quickly proliferating to disease-causing levels.

5. **Reheat cooked foods thoroughly**

This is your best protection against microbes that may have developed during storage (proper storage slows down microbial growth but does not kill the organisms). Once again, thorough reheating means that *all parts of the food* must reach at least 70 °C.

6. **Avoid contact between raw foods and cooked foods**

Safely cooked food can become contaminated through even the slightest contact with raw food. This cross-contamination can be direct, as when raw poultry meat comes into contact with cooked foods. It can also be more subtle. For example, do not prepare a raw chicken and then use the same unwashed cutting board and knife to carve the cooked bird. Doing so can reintroduce the disease-causing organisms.

7. **Wash hands repeatedly**

Wash hands thoroughly before you start preparing food and after every interruption – especially if you have to change the baby or have been to the toilet. After preparing raw foods such as fish, meat, or poultry, wash again before you start handling other foods. And if you have an infection on your hand, be sure to bandage or cover it before preparing food. Remember, too, that household pets – dogs, cats, birds, and especially turtles – often harbour dangerous pathogens that can pass from your hands into food.

8. **Keep all kitchen surfaces meticulously clean**

Since foods are so easily contaminated, any surface used for food preparation must be kept absolutely clean. Think of every food scrap, crumb or spot as a potential reservoir of germs. Cloths that come into contact with dishes and utensils should be changed frequently and boiled before reuse. Separate cloths for cleaning the floors also require frequent washing.

9. **Protect foods from insects, rodents, and other animals**

Animals frequently carry pathogenic microorganisms which cause foodborne disease. Storing foods in closed containers is your best protection.

10. **Use safe water**

Safe water is just as important for food preparation as for drinking. If you have any doubts about the water supply, boil water before adding it to food or making ice for drinks. Be especially careful with any water used to prepare an infant's meal.

Annex 4
List of Codex Alimentarius Recommended International Codes of Practice for fish and shellfish

The following Recommended International Codes of Practice have been elaborated by the Codex Alimentarius Commission and are available from the Secretariat of the Joint FAO/WHO Food Standards Programme, c/o Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100 Rome, Italy, and from Food Safety, World Health Organization, 1211 Geneva 27, Switzerland. The Codes of Practice are advisory in nature, and are intended to assist national food regulatory and control agencies and the food industry to produce food under hygienic conditions. They represent an international consensus on good manufacturing practice for particular food products.

Fresh fish	Second edition	CAC/RCP 9-1976; 1983
Canned fish	Second edition	CAC/RCP 10-1976; 1984
Frozen fish	Second edition	CAC/RCP 16-1978; 1984
Shrimps or prawns	Second edition, with supplement and corrigendum	CAC/RCP 17-1978; 1984
Molluscan shellfish	Second edition	CAC/RCP 18-1978; 1983
Lobsters	First edition	CAC/RCP 24-1979; 1983
Smoked fish	First edition	CAC/RCP 25-1979; 1983
Salted fish	First edition, with supplement	CAC/RCP 26-1979; 1983
Minced fish prepared by mechanical separation	First edition	CAC/RCP 27-1983; 1983
Crabs	First edition	CAC/RCP 28-1983; 1983
Frozen battered and/or breaded fishery products	First edition	CAC/RCP 35-1985; 1988
Cephalopods	First edition	CAC/RCP 37-1989; 1990
Products of aquaculture	Draft	CL 1991/28-FFP

Annex 5
Intermediate hosts of foodborne trematodes

The Study Group agreed that a single comprehensive reference source of information on the intermediate hosts of foodborne trematodes was not currently available. This compilation derives from: Beaver PC, Jung RC, Cupp EW. *Clinical parasitology,* 9th ed., Philadelphia, Lea & Febiger, 1984; Chen MG et al. Progress in assessment of morbidity due to *Clonorchis sinensis* infection: a review of recent literature. *Tropical diseases bulletin,* 1994, 91: R7-R65; Coombs I, Crompton DWT. *A guide to human helminths.* London, Taylor & Francis, 1991; Malek E. *Snail hosts of schistosomiasis and other snail-transmitted diseases in tropical America: a manual.* Washington, DC, Pan American Health Organization, 1985 (Scientific Publication No. 478); Yamaguti S. *Systema helminthum, vol. 1. The digenetic trematodes of vertebrates, part 1.* New York, Interscience Publishers, 1958; and working papers provided by N. Cumberlidge and R. Sachs; G.M. Davis; T.K. Kristensen and H. Madsen; V.R. Southgate and D. S. Brown.

This is a working list of sufficient detail to permit confirmation or refutation by investigators in the endemic areas. In the case of doubt about spelling or location, the term most frequently cited in the available literature was used.

	Country or area
First intermediate hosts of *Clonorchis sinensis*	
Alocinma longicornis (synonym: *Bithynia longicornis*)	China
Bithynia fuchsiana	China
B. misella	China
Parafossarulus anomalosiralis	China
P. manchouricus (synonym: *P. striatulus*)	China, Japan, Republic of Korea, Russian Federation
Melanoides tuberculata	China
Semisulcospira libertina	China
Assiminea lutea	China

	Foodborne trematode	Country or area
First intermediate hosts of *Clonorchis sinensis* (continued)		
Thiara granifera		China (Province of Taiwan)
First intermediate hosts of *Opisthorchis* spp.		
Bithynia siamensis goniomphalus (synonym: *B. s. siamensis*)	*O. viverrini*	Thailand
B. s. funiculata	*O. viverrini*	Thailand
B. s. laevis	*O. viverrini*	Thailand
Codiella inflata (synonym: *Bithynia inflata*)	*O. felineus*	former USSR
C. troscheli	*O. felineus*	former USSR
C. leachi	*O. felineus*	former USSR
First intermediate hosts of *Paragonimus* spp.		
Aroapyrgus alleei	*P. mexicanus*	Mexico
A. colombiensis	*P. caliensis*	Colombia
	P. mexicanus = *P. peruvianus*	Peru
A. costaricensis	*P. mexicanus*	Costa Rica
Pomatiopsis lapidaria	*P. kellicotti*	USA
	* * *	
Afropomus balanoides[a]	*P. uterobilateralis*	West Africa
Potadoma sanctipauli[a]	*P. uterobilateralis*	West Africa
P. freethii[a]	*P. africanus*	Central Africa
P. nyongensis[a]		Central Africa
	* * *	

[a] No evidence yet exists that these species are, in fact, the first intermediate hosts of *Paragonimus* spp.; however, they have all been suspected of serving as first intermediate hosts of *Paragonimus* (N. Cumberlidge, personal communication 1993).

	Foodborne trematode	Country or area
First intermediate hosts of *Paragonimus* spp. (continued)		
Akiyoshia chinensis	*P. skrjabini*	China
A. kawannensis	*P. miyazakii*	Japan
Assiminea lutea	*P. skrjabini*	China
Brotia asperata	*P. westermani*	Philippines
B. costula	*P. westermani*	Malaysia
Bythinella nipponica	*P. miyazakii*	Japan
Erhaia[a] *chinensis*	*P. skrjabini*	China
E. jianouensis	*P. skrjabini*	China
E. gongjianguoi	*P. skrjabini*	China
E. liui	*P. skrjabini*	China
E. shimenensis	*P. skrjabini*	China
E. wantanensis	*P. skrjabini*	China
E. wufengensis	*P. skrjabini*	China
Melanoides tuberculata	*P. westermani*	China
Neotricula cristella	*P. hueitungensis* *P. skrjabini*	China
Oncomelania hupensis hupensis	*P. skrjabini*	China
O. hupensis nosophora	*P. miyazakii*[b]	Japan
Semisulcospira amurensis	*P. westermani*	China, Russian Federation
S. calculus	*P. westermani*	China
S. cancellata	*P. westermani*	China
S. extensa	*P. westermani*	Republic of Korea
S. gottschei	*P. westermani*	Republic of Korea
S. libertina (synonym: *S. toucheana*)	*P. westermani*	China, Japan, Republic of Korea

[a] Previously *Bythinella* in China (G. M. Davis).
[b] Experimental infection.

	Foodborne trematode	Country or area
First intermediate hosts of *Paragonimus* spp. (continued)		
Semisulcospira mandarina (synonym: *S. wegckiangensis*)	*P. westermani*	China
S. multicincta	*P. westermani*	Republic of Korea
S. nodiperda	*P. westermani*	Republic of Korea
S. nodiperda quinaria	*P. westermani*	Republic of Korea
S. paucincta	*P. westermani*	Republic of Korea
S. peregrinomum	*P. westermani*	China
Tarebia granifera	*P. westermani*	China
Tricula fuchsi (synonym: *T.*[a] *guangxiensis*)	*P. skrjabini*	China
T.[a] *fujianensis*	*P. skrjabini*	China
T. gredleri	*P. skrjabini*	China
T. gregoriana	*P. heterotremus*	China
T.[a] *gushuiensis*	*P. skrjabini*	China
T.[a] *hsiangi*	*P. skrjabini*	China
T. maxidens	*P. skrjabini*	China
T.[a] *microstoma*	*P. skrjabini*	China
T. odonta	*Paragonimus* sp.	China
T.[a] *pingi*	*P. skrjabini*	China
T.[a] *xiaoqiaoensis*	*P. skrjabini*	China

[a] Generic status must be determined (G. M. Davis).

	Foodborne trematode	Country or area
First intermediate hosts of *Fasciola* spp.		
Fossaria cubensis (synonyms: *Lymnaea cubensis aspirans, Lymnaea techella, Lymnaea bulimoidae techella)*	*F. hepatica*	Caribbean, Central America, Venezuela
Lymnaea viatrix	*F. hepatica*	Argentina, Brazil, Bolivia, Chile, Peru, Uruguay
L. diaphana	*F. hepatica*	Argentina, Chile, Peru
Pseudosuccinea columella	*F. hepatica*	Canada, Caribbean, Central and South America, USA
Lymnaea auricularia complex	*F. gigantica*	Asia, EMR[a], Europe, North-West Africa
L. cailliaudi	*F. gigantica* *F. hepatica*	Egypt
L. columella	*F. gigantica* *F. hepatica*	Africa, EMR[a], Europe
L. glabra	*F. hepatica*	Europe, North-West Africa
L. natalensis	*F. gigantica*	Africa (except North-West), EMR[a]
L. palustris	*F. gigantica*	EMR[a], Europe, North-West Africa
L. peregra	*F. hepatica*	Europe, North-West Africa

[a] WHO's Eastern Mediterranean Region.

	Foodborne trematode	Country or area
First intermediate hosts of *Fasciola* spp. (continued)		
Lymnaea stagnalis	*F. hepatica*	Europe, North-West Africa
L. tomentosa	*F. hepatica*	Europe, North-West Africa
L. truncatula	*F. hepatica*	EMR[a], Europe, Africa
	* * *	
L. philippinensis	*F. hepatica*	Philippines
L. swinhoei	*F. gigantica*	Philippines
Austropeplea ollula	*F. hepatica*	Japan
Fossaria truncatula	*F. hepatica*	Japan
Lymnaea parvia	*Fasciola* sp.	China
L. truncatula	*Fasciola* sp.	China
L. swinhoei	*Fasciola* sp.	China
L. auricularia complex	*Fasciola* sp.	China
L. picatula	*Fasciola* sp.	China
L. ovita	*Fasciola* sp.	China
L. qinghai	*Fasciola* sp.	China
L. japonicus	*F. hepatica*	Japan
First intermediate hosts of intestinal trematodes		
Austropeplea ollula	*Echinostoma hortense*	Japan, Republic of Korea
	E. revolutum	China (Province of Taiwan)
Cerithideopsilla cingulata	*Heterophyes nocens*	Japan

[a] WHO's Eastern Mediterranean Region.

	Foodborne trematode	Country or area
First intermediate hosts of intestinal trematodes (continued)		
Gyraulus chinensis	*Fasciolopsis buski*	China
	Echinostoma macrorchis	Asia
G. convexiusculus	*Echinostoma malayanum*	Malaysia, Thailand
Helisoma spp.	*Alaria americana*	North America
Hippeutis cantori	*Fasciolopsis buski*	India
H. umbilicalis	*Echinostoma ilocanum*	Philippines
Indoplanorbis exustus	*Echinostoma malayanum*	Malaysia, Philippines
Lymnaea japonicus	*Echinostoma hortense*	Japan
	E. ilocanum	Asia
	E. revolutum	Asia
Parafossarulus manchouricus	*Echinochasmus perfoliatus*	China
Pirenella conica	*Heterophyes heterophyes*	Egypt
Polypylis hemisphaerula	*F. buski*	China (Province of Taiwan)
	Echinostoma cinetorchis	Japan, Republic of Korea
	E. macrorchis	Asia
Semisulcospira cancellata	*Nanophyetus salmincola schikhobalowi*	Russian Federation
S. laevigata	*N. s. schikhobalowi*	Russian Federation
S. libertina	*Metagonimus yokogawai*	Japan, Republic of Korea, Russian Federation

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae	
Abbottina psegma	Japan
A. rivularis (synonym: *Pseudogobio rivularis*)	China, Japan, Republic of Korea, Russian Federation
A. sinensis	China
Acanthobrama simoni	China
Acanthorhodeus cyanostigma	China
A. gracilis	Republic of Korea
A. taenianalis (synonym: *A. asmussi*)	China Republic of Korea
Acheilognathus cyanostigma	Japan
A. himantegus	China (Province of Taiwan)
A. lanceolata (synonym: *A. signifer*)	Japan, Republic of Korea
A. limbata	Republic of Korea
A. moriokae	Japan
A. rhombea (synonym: *Paracheilognathus rhombea*)	Japan, Republic of Korea
A. yamatsutae	Republic of Korea
Aphyocypris kikuchii	China (Province of Taiwan)
A. sinensis	China, Republic of Korea

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae (continued)	
Aristichthys nobilis	China
Biwia zezera	Japan
Carassius auratus	China
C. auratus gibelio	Russian Federation
C. carassius	China (Province of Taiwan), Japan, Republic of Korea, Russian Federation
Cirrhina molitorella	China
Coreoleuciscus splendidus	Republic of Korea
Ctenopharyngodon idellus	China
Culter alburnus (synonym: *C. brevicauda*)	China, Republic of Korea
C. mongolicus (synonym: *Erythroculter mongolicus*)	China
Cultriculus kneri (synonyms: *Hemiculter kneri, H. clupeoides, H. leucisculus*)	China, Republic of Korea, Russian Federation
C. eigenmanni	Republic of Korea
Cyprinus carpio	China, Japan, Republic of Korea, Russian Federation
Elopichthys bambusa	China
Erythroculter erythropterus	Republic of Korea

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae (continued)	
Erythroculter oxycephalus	China (Province of Taiwan)
Gnathopogon atromaculatus (synonym: *Leucogobio atromaculatus*)	Republic of Korea
G. coreanus	Republic of Korea
G. elongatus	Japan
G. herzensteini	China
G. majimae	Republic of Korea
G. strigatus	China, Republic of Korea
Gobio gobio	China
G. minulus (synonym: *Sarcocheilichthys soldatovi*)	China
Hemibarbus barbus	Japan
H. labeo	Republic of Korea, Russian Federation
H. longirostris	Republic of Korea
H. maculatus	China
Hemiculter akoensis	China (Province of Taiwan)
H. bleekeri	China
H. eigenmanni	China
H. macrolepis	China (Province of Taiwan)
Hemigrammocypris rasborella	Japan
Hypophthalmichthys molitrix	China

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae (continued)	
Hypophthalmichthys nobilis (synonym: *Aristichthys nobilis*)	China
Labeo collaris	China
L. kontius	China
Leuciscus waleckii	Russian Federation
Leucogobio politaenia	China
Microphysogobio koreensis	Republic of Korea
M. yaluensis	Republic of Korea
Mugil cephalus	China (Province of Taiwan)
Mylopharyngodon piceus	China
Opsariichthys biolens	Republic of Korea
O. uncirostris	China, Japan
O. uncirostris amurensis	China
Parabramis bramula	China
Parapelecus argenteus	China
P. eigenmanni	Republic of Korea
P. tingchowensis	China
Phoxinus percnurus	China
P. percnurus mantschuricus	China
Pseudobagrus sp.	China
Pseudogobio esocinus	China, Japan, Republic of Korea
Pseudoperilampus light	China
P. notatus	Republic of Korea

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae (continued)	
Pseudoperilampus typus	Japan
Pseudorasbora parva	China, Japan, Republic of Korea, Russian Federation
Puntungia herzi	Republic of Korea
Rhodeus atromius	China
R. notatus	China
R. ocellatus	China, Japan, Republic of Korea
R. sericeus	China, Russian Federation
R. sinensis	China
Sarcocheilichthys kobayashii (synonyms: *S. wakivae, S. morii*)	Republic of Korea
S. lacustris	China
S. nigripinnis	China
S. sinensis	China, Republic of Korea
S. variegatus	China, Japan, Republic of Korea
Saurogobio dabryi	China
Sinilabeo sp.	China
Sinogobio biwae	Japan
Squaliobarbus curriculus	China, Republic of Korea
Toxabramis hoffmanni	China
Tribolodon hakonensis	Japan, Republic of Korea

	Country or area
Second intermediate hosts of *Clonorchis sinensis*	
Cyprinidae (continued)	
Zacco platypus	China (Province of Taiwan), Japan, Republic of Korea
Z. temminckii	China (Province of Taiwan), Japan, Republic of Korea
Other families of fish	
Coreobagrus brevicorpus	Republic of Korea
Tilapia mossambica	China (Province of Taiwan)
Ilisha elongata	Republic of Korea
Misgurnus anguillicaudatus	China
Oryzias latipes	China
Eleotris sp.	China
E. swinhonis (synonym: *Hypseleotris swinhonis*)	China
Mogurnda obscura	Japan
Odontobutis obscurus	China
Rhingobius giurius	China
Malthopsis luteus	China
Ophiocephalus argus	China, Japan
O. maculatus	China (Province of Taiwan)

	Foodborne trematode	Country or area
Second intermediate hosts of *Clonorchis sinensis*		
Other families of fish (continued)		
Hypomesus olidus		Japan
Macropodus chinensis		China, Republic of Korea
M. opercularis		China
Parasilurus asotus		China
Crustacea		
Caridinia nilotica gracilipes		China
Macrobrachium superbum		China
Palaemonetes sinensis		China
Second intermediate hosts of *Opisthorchis* spp.		
Cyclocheilichthys apagon	*O. viverrini*	Thailand
C. armatus	*O. viverrini*	Thailand
C. repasson	*O. viverrini*	Thailand
C. siaja	*O. viverrini*	Thailand
Esomus metalicus	*O. viverrini*	Thailand
Puntius gonionotus	*O. viverrini*	Thailand
P. leiacanthus	*O. viverrini*	Thailand
P. orphoides	*O. viverrini*	Thailand
P. partipentazona	*O. viverrini*	Thailand
P. protozysron	*O. viverrini*	Thailand
P. richoever	*O. viverrini*	Thailand
Hampala dispa	*O. viverrini*	Thailand
Osteochilus sp.	*O. viverrini*	Thailand
Labiobarbus lineatus	*O. viverrini*	Thailand
Puntioplites sp.	*O. viverrini*	Thailand

	Foodborne trematode	Country or area
Second intermediate hosts of *Opisthorchis* spp. (continued)		
Abramis balerus		
A. bramae		
A. sapa		
Alburnus alburnus		
Aspius aspius		
Barbus barbus borysthenicus		
Blicca bjoerkna		
Carassius carassius		
Chondrostoma nasus		
Cobitis taenia		
Cyprinus carpio[a]	*O. felineus*	former USSR
Gobio gobio		
Leucaspius cephalus		
L. delineatus		
Leuciscus idus		
L. leuciscus		
Phoxinus chekanowskii		
P. phoxinus		
Polecus cultratus		
Rutilus rutilus		
Scardinius erythrophthalmus		
Tinca tinca		
Second intermediate hosts of *Paragonimus* spp.		
Cambaroides daurucus	*P. westermani*	China, Russian Federation
C. schrenchii	*P. westermani*	China, Russian Federation
C. similis	*P. westermani*	Republic of Korea
Cambarus clarkii	*P. westermani*	Japan

[a] Experimental infection of *Cyprinus carpio* with *O. felineus* has not been successful.

	Foodborne trematode	Country or area
Second intermediate hosts of *Paragonimus* spp. (continued)		
Eriocheir japonicus	*P. westermani*	China, Japan, Republic of Korea, Russian Federation
E. sinensis	*P. westermani*	China, Republic of Korea
Geothelphusa dehaani	*P. miyazakii*	Japan
Isolapotamon nacicum	*P. westermani*	China
I. papilionaceus	*P. hueitungensis* *P. westermani*	China
I. sinensis	*P. hueitungensis* *P. skrjabini* *P. westermani*	China
Macrobrachium nipponensis	*P. westermani*	Republic of Korea
Malayopotamon fukienensis	*P. westermani* *P. skrjabini*	China
Nanhaipotamon angulatum	*P. westermani* *P. skrjabini*	China
Parathelphusa rugosa	*P. westermani*	Malaysia, Sri Lanka
P. ceylonensis	*P. westermani*	Sri Lanka
P. dugasti	*P. heterotremus*	Thailand
Potamiscus cognatus	*P. westermani*	Malaysia
P. johorensis	*P. westermani*	Malaysia
Potamon dehaani	*P. westermani*	Japan
P. denticulatus	*P. westermani* *P. skrjabini*	China
P. dugasti	*P. westermani*	China
P. hispidum	*P. westermani* *P. skrjabini*	China
P. hokouense	*P. westermani*	China
P. johorensis	*P. westermani*	China

	Foodborne trematode	Country or area
Second intermediate hosts of *Paragonimus* spp. (continued)		
Potamon maculata	*P. westermani*	China
P. rathbuni	*P. westermani*	China
P. smithianus	*P. westermani* *P. heterotremus*	China
Procambarus clarkii	*P. westermani*	China
Ranguna smithiana	*P. westermani* *P. heterotremus*	Thailand
Sinolapotamon patellifer	*P. westermani* *P. heterotremus*	China
Sinopotamon chekiangensis	*P. westermani*	China
S. denticulatum	*P. westermani* *P. skrjabini* *P. hueitungensis* *P. heterotremus*	China
S. depressum	*P. westermani*	China
S. honanese	*P. westermani*	China
S. joshueiense	*P. hueitungensis*	China
S. kwanhsiensis	*P. westermani* *P. skrjabini*	China
S. shensiense	*P. westermani* *P. skrjabini*	China
S. yaanense	*P. skrjabini* *P. westermani*	China
S. yangtsekiense	*P. westermani*	China
Sunddathelphusa philippina	*P. westermani*	Philippines
	* * *	
Hypolobocera aequatorialis	*P. mexicanus*	Ecuador
H. chilensis	*P. mexicanus*	Peru
H. eigenmanni	*P. mexicanus* = *P. peruvianus*	Peru
Potamocarcinum magnus	*P. mexicanus*	Costa Rica
P. richmondi	*P. mexicanus*	Panama

	Foodborne trematode	Country or area
Second intermediate hosts of *Paragonimus* spp. (continued)		
Pseudothelphusa dilatata	*P. mexicanus*	Mexico
P. cobanensis	*P. mexicanus*	Guatemala
P. garmani	*P. mexicanus*	Venezuela
P. propinqua	*P. mexicanus*	Guatemala
Ptychophallus tristani	*P. mexicanus*	Costa Rica
P. montanus cocleensis	*P. mexicanus*	Panama
P. exilipes	*P. mexicanus*	Panama
	* * *	
Liberonautes l. latidactylus	*P. uterobilateralis*	Côte d'Ivoire, Guinea, Liberia
L. l. paludicolis	*P. uterobilateralis*	Liberia
L. l. nanoides	*P. uterobilateralis*	Liberia
L. l. chaperi	*P. uterobilateralis*	Liberia
Sudanonautes africanus	*P. uterobilateralis*	Cameroon, Gabon, Nigeria
	P. africanus	Cameroon, Equatorial Guinea[a]
S. aubryi	*P. uterobilateralis*	Nigeria
	P. africanus	Cameroon, Equatorial Guinea[a]
S. floweri	*P. uterobilateralis*	Cameroon, Gabon, Nigeria
	P. africanus	Cameroon, Equatorial Guinea[a]
S. granulatus	*P. uterobilateralis*	Cameroon, Nigeria
	P. africanus	Cameroon

[a] Suspected, not confirmed.

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Fish		
Acanthogobius flavimanus	*Heterophyes nocens*	Japan
	Pygidiopsis summa	Japan, Republic of Korea
Acanthogobius sp.	*Heterophyes heterophyes*	Japan
	Haplorchis pumilio	Asia
Acheilognathus rhombea	*Centrocestus armatus*	Japan
A. moriokae	*Echinostoma hortense*	China, Japan, Republic of Korea
Aphanius fasciatus	*Heterophyes heterophyes*	Egypt
Barbus sp.	*Heterophyes dispar*	Asia
Blicca sp.	*Appophalus donicus*	USA
Brachymystax lenok	*Nanophyetus salmincola schikhobalowi*	Russian Federation
Carassius auratus	*Haplorchis taichui* *Metagonimus takahashii*	Republic of Korea
C. carassius	*Metagonimus takahashii*	Republic of Korea
Channa formosana	*Centrocestus caninus*	China (Province of Taiwan)
Coregonus ussuriensis	*Nanophyetus salmincola schikhobalowi*	Russian Federation

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Fish (continued)		
Cottus perplexus	*Nanophyetus salmincola*	North America
Creisson sp.	*Procerovum calderoni*	China, Philippines
Ctenopharyngodon idellus	*Haplorchis taichui*	Asia
Cyprinus auratus	*Centrocestus caninus*	China (Province of Taiwan)
C. carpio	*Centrocestus caninus*	China (Province of Taiwan)
	Haplorchis taichui	Asia
	Heterophyopsis continua	China, Japan, Republic of Korea
	Metagonimus takahashii	Japan, Republic of Korea
Cyprinus sp.	*Haplorchis pumilio*	China
Dicamptodon ensatus	*Nanophyetus salmincola*	North America
Epinephelus sp.	*Heterophyes dispar*	Asia
Gambosia affinis	*Haplorchis taichui*	Asia
	Haplorchis pleurolophocerca	Egypt
Glossogobius giuris	*Heterophyes nocens*	Japan
	Procerovum calderoni	Philippines
Glossogobius sp.	*Haplorchis pumilio*	China

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Fish (continued)		
Gnathopogon elongatus	*Centrocestus caninus*	China (Province of Taiwan)
G. strigatus	*Echinochasmus japonicus*	China
Gnathopogon sp.	*Metagonimus takahashii*	Japan, Republic of Korea
Gobius ruthensparri	*Cryptotyle lingua*	Greenland
Hucho taimen	*Nanophyetus salmincola schikhobalowi*	Russian Federation
Hypomesus olidus	*Echinochasmus japonicus*	China
Labrus bergylta	*Cryptotyle lingua*	Greenland
Lampetra richardsoni	*Nanophyetus salmincola*	North America
Lateolabrax japonicus	*Metagonimus yokogawai*	Japan
Lichia sp.	*Heterophyes dispar*	Asia
Liza haematocheila	*Heterophyes nocens*	Japan
L. menada	*Pygidiopsis summa*	Japan, Republic of Korea
Lusioperca sp.	*Appophalus donicus*	USA
Mesocottus haitej	*Nanophyetus salmincola schikhobalowi*	Russian Federation
Misgurnus anguillicaudatus	*Centrocestus armatus*	Japan

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Fish (continued)		
Mugil affinis	*Haplorchis pumilio*	China (Province of Taiwan), Tunisia
	Haplorchis taichui	China, Japan
	Haplorchis yokogawai	China, Japan, Philippines
	Heterophyopsis continua	Japan
	Procerovum varium	Japan
Mugil auratus	*Heterophyes dispar* *Heterophyes heterophyes*	Egypt
Mugil capito	*Echinochasmus liliputanus*	China
	Echinochasmus perfoliatus	China
	Haplorchis pumilio	Israel, Tunisia
	Heterophyes heterophyes	Egypt, Japan
	Stellantchasmus falcatus	Egypt, Japan, Philippines
Mugil cephalus	*Centrocestus caninus* *Heterophyes heterophyes* *Heterophyes nocens* *Heterophyes katsuradai* *Haplorchis yokogawai* *Heterophyopsis continua*	Widely distributed

	Foodborne trematode	Country or area

Second intermediate hosts of intestinal trematodes and *Fasciola* spp.

Fish (continued)

Mugil cephalus (continued)	*Metagonimus minutus* *Metagonimus takahashii* *Stellantchasmus falcatus* *Pygidiopsis summa* *Stictodora fuscatum*	Widely distributed
Mugil sp.	*Phagicola* sp.	Brazil
	Procerovum calderoni	China, Philippines
Odontobutis obscurus	*Metagonimus yokogawai*	Asia
Oncorhynchus tshawytscha	*Nanophyetus salmincola*	North America
O. kisutch	*Nanophyetus salmincola*	North America
O. keta	*Nanophyetus salmincola*	North America
	N. s. schikhobalowi	Russian Federation
O. gorbuscha	*N. s. schikhobalowi*	Russian Federation
Ophiocephalus striatus	*Haplorchis pumilio*	China, Philippines
	Procerovum calderoni	Thailand
Perca sp.	*Appophalus donicus*	USA
Phoxinus phoxinus	*Nanophyetus salmincola schikhobalowi*	Russian Federation
Plecoglossus altivelis	*Metagonimus yokogawai*	Japan, Republic of Korea

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Fish (continued)		
Pseudorasbora parva	*Centrocestus armatus*	Japan
	Echinochasmus japonicus	China, Republic of Korea
Richardsonius balteatus	*Nanophyetus salmincola*	North America
Salmo clarki clarki	*Nanophyetus salmincola*	North America
S. gairdneri	*Nanophyetus salmincola*	North America
S. perryi	*Metagonimus yokogawai*	Asia
Salvelinus fontinalis	*Nanophyetus salmincola*	North America
Scardinius sp.	*Appophalus donicus*	USA
Thymallus arcticus	*Nanophyetus salmincola schikhobalowi*	Russian Federation
Tilapia nilotica	*Heterophyes heterophyes*	Egypt
Tilapia sp.	*Heterophyes dispar*	Eastern Mediterranean
Tribolodon hakonensis	*Metagonimus yokogawai*	Japan, Republic of Korea
T. taczanowskii	*Metagonimus yokogawai*	Russian Federation
Tridentiger obscurus	*Heterophyes nocens*	Japan
Zacco platypus	*Centrocestus armatus*	Japan, Republic of Korea
Z. temminckii	*Centrocestus armatus*	Japan

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp. (continued)		
Crustacea		
Cararius maenas	*Spelotrema brevicaeca*	Philippines
Macrobrachium sp.	*Spelotrema brevicaeca*	Philippines
Penacus sp.	*Metagonimus yokogawai*	Republic of Korea
Molluscs		
Austropeplea ollula	*Echinostoma revolutum*	China (Province of Taiwan)
Cipangopaludina japonica	*Echinostoma macrorchis*	Japan
C. malleata	*Echinostoma macrorchis*	Japan
Corbicula lindoensis	*Echinostoma lindoense*	Indonesia
C. producta	*Echinostoma revolutum*	China (Province of Taiwan)
C. sucplanta	*Echinostoma lindoense*	Indonesia
Crassostrea gigas	*Gymnophalloides seoi*	Republic of Korea
Gyraulus chinensis	*Echinostoma cinetorchis*	Asia
	Echinostoma macrorchis	Asia
G. convexiusculus	*Echinostoma malayanum*	Indonesia, Malaysia, Singapore, Thailand
Idiopoma javanica	*Echinostoma lindoense*	Indonesia

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Molluscs (continued)		
Indoplanorbis exustus	*Echinostoma malayanum*	Indonesia, Malaysia, Singapore, Thailand
	Artyfechinostomum mehrai	India
Lymnaea japonicus	*Echinostoma cinetorchis* *Echinostoma macrorchis*	Japan
L. lumingiana	*Echinostoma malayanum*	Philippines
Lymnaea sp.	*Plagiorchis muris*	Japan
Mya sp.	*Himasthla muehlensi*	Colombia?[a]
Mytilus sp.	*Himasthla muehlensi*	Colombia?[a]
Parafossarulus manchouricus	*Echinostoma macrorchis*	Japan
Pila conica	*Echinostoma ilocanum*	Philippines
P. scutata	*Echinostoma malayanum*	Malaysia, Thailand
Polypylis hemisphaerula	*Echinostoma cinetorchis* *Echinostoma macrorchis*	Japan
Segmentina nitidella	*Echinostoma macrorchis*	Japan
Viviparus javanicus	*Echinostoma ilocanum*	Indonesia, Philippines
V. malleatus	*Echinostoma macrorchis*	Japan
Viviparus sp.	*Echinostoma cinetorchis*	Japan

[a] Not confirmed.

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp. (continued)		
Amphibians		
Bufo melanostictus	*Centrocestus formosanus*	China, Philippines
	C. caninus	China (Province of Taiwan)
Rana limnocharis	*C. formosanus*	China, Philippines
	C. caninus	China (Province of Taiwan)
Rana nigromaculata	*Fibricola seoulensis*	Republic of Korea
Rana sp.	*Echinostoma macrorchis*	Japan
Insects		
Chironomus dorsalis	*Plagiorchis muris*	Japan
Libeluidae sp.	*Phaneropsolus bonnei*	Thailand
Plants		
Eliocharis tuberosa	*Fasciolopsis buski*	Asia
Lemna polyrhiza	*F. buski*	Asia
Nasturtium officinale	*F. buski* *Fasciola* sp.	Widely distributed
Salvinia natans	*Fasciolopsis buski*	Asia
Trapa natans	*F. buski*	China
T. bicornis	*F. buski*	Bengal, Thailand
Valisneria sp.	*F. buski*	Asia

	Foodborne trematode	Country or area
Second intermediate hosts of intestinal trematodes and *Fasciola* spp.		
Plants (continued)		
Mentha pipesota L.	*Fasciola* sp.	Islamic Republic of Iran
M. aquatica	*Fasciola* sp.	Islamic Republic of Iran
Eryngium coerulesce	*Fasciola* sp.	Islamic Republic of Iran
Eruca sativa[a]	*Fasciola* sp.	Egypt
Lactuca sativa[a]	*Fasciola* sp.	Egypt
Petroselinum sativum[a]	*Fasciola* sp.	Egypt
Trigonella faenugraecum[a]	*Fasciola* sp.	Egypt
Trifolium alexandrium[a]	*Fasciola* sp.	Egypt
Raphanus sativus[a]	*Fasciola* sp.	Egypt
Ipomoea aquatica	*Fasciola* sp. *Fasciolopsis buski*	Thailand

[a] Experimental infection.

Annex 6
Techniques for parasitological examination of second intermediate hosts (fish and crustacea)[1]

1. Inspection techniques for freshwater fish hosts of *Clonorchis sinensis*, *Opisthorchis* spp. and other fishborne trematodes

Identify the species of the fish to be examined and measure its weight and length.

1.1 *Compression method*

(a) Dissect the fish into four parts: fins, scales, subcutaneous tissue, and flesh. Each part is examined by compression to determine the distribution of encysted larvae. The addition of a few drops of tap water or saline may be necessary, in particular for fin and scale specimens. For *Clonorchis sinensis* and *Opisthorchis* spp., the subcutaneous tissue and flesh should be examined. For *Metagonimus* spp., the fins and scales should be examined first.

(b) *Fins.* After adding a few drops of tap water or saline, compress the individual fins between two large glass slides (50×90 mm). Examine them at low magnification (30× or 50×) using a binocular dissecting stereomicroscope with light transmitted from beneath the stage.

Scales. Remove the scales from the skin and place them in a single layer on a glass slide. After adding a few drops of tap water or saline, cover the specimen with another slide to compress it, and examine as specified above.

Subcutaneous tissue. Compress a piece of tissue of suitable dimensions between two glass plates; the compressed tissue should not protrude beyond the edges of the plates. Examine the specimen under a dissecting stereomicroscope as specified above.

Flesh. Compress a piece of flesh (0.5–1.0 g) between two large glass plates and examine as specified above.

(c) Differentiate the species of encysted larvae (metacercariae) morphologically by examining the size and shape of the cysts and the characteristic features of the internal organs.

(d) Estimate the total number of encysted larvae in the fish by multiplying the weight of the fish in grams by the number of encysted larvae observed per gram of flesh.

(e) Isolate the metacercariae from the flesh by using the digestion technique described in section 1.2 below. If only representative metacercariae are needed (e.g. for identification), they may be dissected from the specimens using forceps and dissecting needles.

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[1] Prepared by members of the Study Group.

1.2 *Digestion method*

(a) Divide the fish into five parts: head, anterior trunk, posterior trunk, tail, and subcutaneous tissue. Each part is digested separately with artificial gastric juice and the isolated metacercariae are counted to determine their distribution. The following steps should be applied to each part in turn.

(b) Grind a large piece of the fish (10–20 g) using a meat grinder, and mix it with 200–300 ml of artificial gastric juice (0.6% HCl and 1% pepsin in distilled water).

(c) Incubate the mixture in a flask with glass beads at 37 °C for 3–4 hours with occasional shaking, or use a stirring plate with a magnetic stirring rod placed in the flask. Note that if a stirring plate is used or if the flesh of the fish is soft, digestion may take less than 3 hours.

(d) Isolate the freed metacercariae from the debris by repeated sedimentation in tap water until the supernatant becomes clear (the liquid will usually need to be decanted at least three times). Detection of parasites may be facilitated by pouring the sediment into a dark coloured pan or by placing the glass container over a dark piece of paper. Collect the isolated metacercariae on a watch glass and count them under a binocular dissecting stereomicroscope. The total number of metacercariae in the fish can be estimated as described in section 1.1 (d).

(e) When necessary, metacercariae may be kept in 1.2% (hypertonic) saline at 4–5 °C for up to 30 days.

2. Inspection technique for crustacean hosts (crabs, crayfish) of *Paragonimus* spp.

(a) Identify the species of the crab or crayfish to be examined and measure its weight, length, and width.

(b) To determine the distribution of metacercariae, dissect the crab or crayfish into the following parts: liver, heart, gills, muscle from the cephalothorax, and muscle from the legs. Compress each part between two large glass slides (50×90 mm) and examine it with a binocular stereomicroscope at low magnification (20× or 30×). The presence and number of metacercariae can then be determined. Note that for crabs of the genus *Potamon*, metacercariae are generally found in the liver and sometimes in the muscle; crabs of *Eriocheir* spp. have metacercariae in the gill vessels and muscles.

(c) To determine only the presence of infection or to recover some metacercariae quickly, crush the whole crab or crayfish in a mortar. Place the mingled muscle, crusts, and viscera on two layers of gauze and wash three times with saline, retaining the washing solution each time (40- or 80-mesh screen or several layers of cheesecloth may be used in place of the gauze).

(d) Discard the crushed crustacean. Isolate the freed metacercariae from the saline washes by repeated sedimentation and decanting of the supernatant. Collect the isolated metacercariae on a watch glass, and count them under a stereomicroscope. The remaining sediment should be compressed so that any metacercariae left in the muscle debris can be counted.

(e) If necessary, the digestion method described in section 1.2 can be used to isolate metacercariae from the flesh once the crab or crayfish has been dissected or crushed. However, after examination of debris by compression as in (d) above, metacercariae may be isolated by the needle separation technique.

3. Candling method for fish flesh

The following description is derived from method 985.12 in Helrich K, ed. *Official methods of analysis of the Association of Official Analytical Chemists*, 15th ed. (Arlington, VA, Association of Official Analytical Chemists, Inc., 1990). The method is primarily intended for marine fish fillets, although fish steaks can also be analysed to detect *Anisakis* spp. It is not suitable for detection of metacercariae of *Opisthorchis* spp. or *Clonorchis sinensis* because of their small size.

The accuracy of the results can be limited by thickness, pigmentation, and high oil content of the flesh, and by the presence of skin on the fillet. Some larvae will remain undetected by this procedure, but its advantages are that it is quick and inexpensive, it does not destroy the product, and little training is required. The procedure requires a candling table, i.e. a "cool white" diffused light source within a box-like structure, topped by a translucent working surface (e.g. frosted glass plate or acrylic plastic).

(a) Place a skinned fillet (or fish steak) on the lighted working surface. Thick fillets can be cut lengthwise to facilitate the transmission of light through the flesh.

(b) Examine the fillet for parasites. Larvae close to, or on, the surface should be readily visible. Embedded larvae may appear as shadowed spots in the flesh. Removal of these "spots" can verify the presence of the parasites.

(c) An accurate count of the number of metacercariae present can be made following digestion of the infected fillet (section 1.2).

Annex 7
Priorities for research on foodborne trematode infections

Interdisciplinary research on the topics suggested here should be planned and undertaken with the collaboration of parasitologists, food safety experts, and other scientists as appropriate.

1. Identification of the intermediate hosts of the *Paragonimus* species responsible for human infection in endemic areas.
2. Investigation of the survival and infectivity of foodborne trematode metacercariae in second intermediate hosts.
3. Studies of the effects of traditional, domestic, and commercial food preparation and processing techniques on the infectivity of metacercariae (see Table 4, page 81).
4. Determination of the potential for cross-contamination with metacercariae during food processing and preparation.
5. Behavioural science research on the food habits of people in endemic areas, as a basis for developing culture-specific health education programmes.
6. Studies of the effects of foodborne trematode infections on nutritional status, in particular in children and women.
7. Study of the diagnosis, pathology, clinical manifestations, and management of diseases occurring concomitantly, such as hepatitis-opisthorchiasis, schistosomiasis-opisthorchiasis, schistosomiasis-fascioliasis, and paragonimiasis-tuberculosis.
8. Evaluation of the role of concomitant hepatitis B infection and of exposure to mycotoxins, nitrosamines, and other substances in the etiology of cholangiocarcinoma associated with foodborne trematode infections.
9. Molecular biological studies concerned with the taxonomy, antigenic structure, and immunology of foodborne trematodes.
10. Research into the immune mechanisms of human foodborne trematode infections in order to determine whether development of a vaccine against them is feasible.
11. Development of new techniques for community-based diagnosis and drugs for the treatment of foodborne trematode infections.
12. Research on the risk of foodborne trematode infections and other health risks associated with integrated livestock-fish production systems.
13. Assessment of the risk of transmission of foodborne trematodes with managed aquaculture systems of different types.

14. Study of ways to promote application of water quality guidelines for aquaculture systems.
15. Comparative evaluation of quantitative techniques for detecting and determining the viability of foodborne trematode eggs in wastewater, sewage, and sludge.

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