Report of the
WHO Expert Consultation on
Foodborne Trematode Infections
and Taeniasis/Cysticercosis

Vientiane, Lao People’s Democratic Republic
12-16 October 2009
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>AE</td>
<td>adverse event</td>
</tr>
<tr>
<td>CCA</td>
<td>cholangiocarcinoma</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>CLTS</td>
<td>community-led total sanitation</td>
</tr>
<tr>
<td>CT</td>
<td>computerized tomography</td>
</tr>
<tr>
<td>DDHDIHD</td>
<td>diffuse dilatation of the intrahepatic bile ducts</td>
</tr>
<tr>
<td>EITB</td>
<td>enzyme-linked immunoelectrotransfer blot assay</td>
</tr>
<tr>
<td>ELISA</td>
<td>enzyme-linked immunosorbent assay</td>
</tr>
<tr>
<td>epg</td>
<td>eggs per gram (of faeces)</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FBT</td>
<td>foodborne trematode</td>
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<tr>
<td>FECT</td>
<td>formol ethyl acetate concentration technique</td>
</tr>
<tr>
<td>FEFGB</td>
<td>floating echogenic foci in the gallbladder</td>
</tr>
<tr>
<td>FES-Ag</td>
<td>Fasciola excretory-secretory antigen</td>
</tr>
<tr>
<td>GALVmed</td>
<td>Global Alliance for Livestock Veterinary Medicines</td>
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<tr>
<td>GIS</td>
<td>geographical information system</td>
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<tr>
<td>GNP</td>
<td>gross national product</td>
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<tr>
<td>Hb</td>
<td>haemoglobin</td>
</tr>
<tr>
<td>IBE</td>
<td>International Bureau for Epilepsy</td>
</tr>
<tr>
<td>IEC</td>
<td>information, education and communication</td>
</tr>
<tr>
<td>ILAE</td>
<td>International League Against Epilepsy</td>
</tr>
<tr>
<td>InDepth</td>
<td>International Network for Demographic Surveillance of Populations and their Health in Developing Countries</td>
</tr>
<tr>
<td>IPDE</td>
<td>increased periductal echogenicity</td>
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<tr>
<td>LQAS</td>
<td>lot quality assurance sampling</td>
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<tr>
<td>MDA</td>
<td>mass drug administration</td>
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<td>MIF</td>
<td>minute intestinal flukes</td>
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<td>MoH</td>
<td>Ministry of Health</td>
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<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
</tr>
<tr>
<td>NATO</td>
<td>North Atlantic Treaty Organization</td>
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<tr>
<td>NCC</td>
<td>neurocysticercosis</td>
</tr>
<tr>
<td>NERN</td>
<td>Neurocysticercosis and Epilepsy Research Network</td>
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<tr>
<td>NTD</td>
<td>neglected tropical diseases</td>
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<tr>
<td>OD</td>
<td>open defecation</td>
</tr>
<tr>
<td>ODF</td>
<td>open-defecation-free</td>
</tr>
<tr>
<td>OIE</td>
<td>World Organization for Animal Health</td>
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<tr>
<td>PCR</td>
<td>polymerase chain reaction</td>
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<tr>
<td>PZQ</td>
<td>praziquantel</td>
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<tr>
<td>RFLP</td>
<td>restriction fragment length polymorphism</td>
</tr>
<tr>
<td>RNAS+</td>
<td>Regional Network for Asian Schistosomiasis and other Helminth Zoonoses</td>
</tr>
<tr>
<td>SAE</td>
<td>serious adverse event</td>
</tr>
<tr>
<td>TB</td>
<td>tuberculosis</td>
</tr>
<tr>
<td>TCZ</td>
<td>triclabendazole</td>
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<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
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<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<tr>
<td>US</td>
<td>ultrasound</td>
</tr>
<tr>
<td>VPH</td>
<td>veterinary public health</td>
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<td>WHO</td>
<td>World Health Organization</td>
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1. Introduction

The foodborne trematode (FBT) infections and taeniasis/cysticercosis are among the most neglected tropical diseases due to helminths. While major progress has been made in recent years in reaching populations in need of treatment for lymphatic filariasis, onchocerciasis, schistosomiasis and soil-transmitted helminthiasis, those affected by FBT infections and taeniasis/cysticercosis frequently have no access to adequate assistance.

This neglect is related to the scarce information on their geographical distribution and the lack of resources for their control. However, another reason has been the fact that there were no clear, practical, WHO-endorsed recommendations for use by disease control programme managers.

The main objective of the Expert Consultation on Foodborne Trematode Infections and Taeniasis/Cysticercosis, which took place in the Lao People’s Democratic Republic on 12–16 October 2009, was to formulate such recommendations, with the aim of supporting programme managers in endemic countries.

It is hoped that the disease-specific guidelines provided in this document will be instrumental in generating and supporting disease control activities, and in ensuring that all those in need of treatment receive timely and appropriate care.
Part A:
Report of the presentations given during the WHO Expert Consultation
2. Foodborne trematode infections

Over 100 species of foodborne trematodes are known to cause infections – trematodiasis – in humans. Clonorchiasis, opisthorchiasis, fascioliasis and paragonimiasis are the infections that pose the most significant public health and economic burden. Clonorchiasis and opisthorchiasis are confined to Asia, while paragonimiasis can be found in Africa, Asia and Latin America. Fascioliasis is a global disease, affecting a significant number of countries throughout the world.

At community level, transmission of these four infections is usually focal and it is not uncommon for a given disease to affect one particular village and not a neighbouring one. On a broader geographical scale, the distribution pattern of FBT infections is more diverse. For example, transmission of paragonimiasis is usually limited to a group of districts and the disease can still be described as focal. Clonorchiasis, opisthorchiasis and fascioliasis, on the other hand, tend to be more diffuse and to affect larger geographical areas.

2.1 Country experiences

2.1.1 Current situation

Region of the Americas

In animals, fascioliasis is transmitted throughout the Americas at various levels of endemicity. In humans, the highest burden is found among indigenous farming communities in Andean countries. Transmission to humans is favoured by the fact that most individuals living in affected areas do not understand the relationship between human and animal disease and do not appreciate the risk linked to the consumption of raw vegetables and their derivatives. Ingestion of metacercariae floating on water is also a possible mode of transmission, which might explain the high endemicity found in some communities. From a control perspective, action by the veterinary health services is generally inadequate. Control activities in the human population are equally limited, except in Bolivia and Peru, which are addressing the problem thanks to the triclabendazole (TCZ) donation programme.

Knowledge on the distribution and public health significance of paragonimiasis is limited, but the disease is known to occur in a number of countries. Most of the information available comes from Ecuador and Colombia. In Ecuador, 500,000 individuals were estimated to be infected in 1998. No estimates are available for Colombia, but foci of transmission have been detected in indigenous communities. Control interventions are generally limited. Clonorchiasis and opisthorchiasis are not transmitted in the American Region.

South-East Asian Region

In this region, clonorchiasis is transmitted only in the Democratic People’s Republic of Korea, while transmission of opisthorchiasis has so far been observed only in Thailand, where the main endemic area is in the north-east. Focal transmission of paragonimiasis has been documented in north-eastern states of India, such as Arunachal Pradesh, Manipur and Nagaland. Fascioliasis is uncommon in humans, but cases have been reported from the Democratic People’s Republic of Korea, India and Thailand.

Western Pacific Region

FBT infections are not notifiable diseases in any of the countries in the Western Pacific Region. The magnitude of the public health problem represented by these infections is largely unknown, because of the lack of information on geographical distribution and population infected or at risk. Indirect evidence from the veterinary public health (VPH) sector, however, suggests that the burden is significant. From a control perspective, the problem remains unaddressed or incompletely addressed in most countries.

FBT infections are known to occur in Brunei Darussalam, Cambodia, China, Japan, Lao People’s Democratic Republic, Malaysia, the Philippines, Republic of Korea and Viet Nam. The situation in the other countries of the region is unknown. The infections transmitted in the region include: clonorchiasis (China, Republic of Korea, Viet Nam); opisthorchiasis (Cambodia, Lao People’s Democratic Republic, Viet Nam); paragonimiasis (Cambodia, Lao People’s Democratic Republic, the Philippines, Viet Nam); fascioliasis (China, Viet Nam); heterophyiasis (the Philippines); and echinostomiasis (Cambodia).

Mapping of the geographical distribution of these infections has been completed in China, Lao People’s Democratic Republic and Viet Nam, and has been started in Cambodia. Mapping has not been done in other countries of the region.

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TCZ is donated to endemic countries, via WHO, by Novartis Pharma AG.
2.1.2 Lessons from previous meetings

WHO Study Group on the Control of Foodborne Trematode Infections, Manila, the Philippines, 18-26 October 1993
This was the first meeting ever convened by WHO on FBT infections and had the following objectives:
- to review recent advances in the study of FBT infections and to identify gaps in knowledge and ways of improving control;
- to assess the epidemiological status of foodborne trematode infections, with emphasis on clonorchiasis, fascioliasis, opisthorchiasis and paragonimiasis;
- to define control strategies that will be appropriate to the epidemiological situation, the potential for intersectoral collaboration, and the available human and financial resources in endemic countries.
The proceedings and conclusions of the meetings were published in a WHO Technical Report Series book that delineated strategies for control, identified technical issues related to control, and reviewed current knowledge and progress in epidemiology and control of FBT infections. Remarkably, the book also included a first attempt to quantify number of people infected and population at-risk for each of the four infections taken into account based on mid-year demographic data for 1991.

Joint WHO/FAO Workshop on Food-Borne Trematode infections in Asia, Hanoi, Viet Nam, 26–28 November 2002
The workshop was convened with the following objectives:
- review knowledge of FBT infections in relation to control strategies;
- assess the current public health significance of FBT infections in Asia;
- propose practical measures for controlling morbidity due to FBT infections;
- propose practical measures for reducing and preventing transmission of FBT infections; and
- propose practical measures for the prevention and control of FBT infections in the aquaculture industry.
The main outcome of the meeting, whose proceedings were later published, was the identification of "large-scale chemotherapy" as the most appropriate public health approach to control FBT infections. More detailed conclusions and recommendations were also made by the participants in the workshop: together with the actions taken since 2002 to address them, they are outlined below.
- Governments of countries where FBT infections occur should ensure access to essential drugs for the treatment of these infections in all health systems in all endemic areas. Given the involvement of Opisthorchis viverrini and Clonorchis sinensis in cholangiocarcinoma and the difficulties encountered in the early diagnosis of this malignancy, it is imperative that access to anthelminthic treatment be available for all people living where these infections are known to be or are found to be endemic.
  o Action taken: in most of the countries of the Western Pacific where FBT infections are a public health problem, praziquantel (PZQ) is widely available. Availability of triclabendazole (TCZ) has also improved thanks to the TCZ donation programme or through direct procurement; even if TCZ is not registered for treatment of humans in any of these countries, its use is permitted by the relevant Governments under special arrangements.
- Governments should take immediate steps to register triclabendazole for use in their countries.
  o Action taken: very limited. No countries have registered triclabendazole as a follow-up to the meeting. TCZ is currently registered for human use in only four countries: Egypt (1997), Ecuador (2001), Venezuela (2001) and France (2002).
- Governments of countries where FBT infections occur should authorize the design and implementation of national control programmes for FBT infections if these do not already exist.
  o Action taken: FBT infections are covered by programmes targeting neglected tropical diseases (NTDs) in most of the Western Pacific countries in which they represent a public health problem (Cambodia, China, Lao People’s Democratic Republic, Viet Nam).
- Each government should establish an intersectoral working group to ensure efficient and effective measures for FBT prevention and control.
  o Action taken: only ad hoc working groups have been established; coordination among sectors is difficult.
- Governments should integrate FBT control programmes into existing primary health care systems and continue active surveillance and treatment in all endemic areas.
  o Action taken: very limited.
- Health education, sanitation and safe waste disposal should be promoted as important elements in FBT control.
  o Information, education and communication (IEC) materials have been developed in most of the countries of the Western Pacific Region where FBT infections are a public health problem (Cambodia, China, Lao People’s Democratic Republic, Viet Nam) but distribution of materials and implementation of health education interventions are still limited.
Governments with overall responsibility for a commercial freshwater aquaculture industry should establish and legislate for best practice for eliminating the risk of FBT infections from aquaculture systems and products.

- Action taken: only ad hoc mechanisms have been developed. No official mechanism is in place.

The technical issues raised by the participants in the 2002 workshop are reproduced below, together with an outline of the actions taken since 2002 to address them.

- The research-based pharmaceutical industry should be urged to develop and market new drugs to extend the choice available for the treatment of Opisthorchis viverrini, Clonorchis sinensis and intestinal flukes and so provide options for dealing with drug resistance.
  - Action taken: no new drugs against FBTs have been developed to date.

- Where needed, guidelines for designing and implementing epidemiological surveys should be prepared in order to obtain accurate and reliable information about the distribution and abundance of FBT infections.
  - Action taken: detailed guidelines are not available. There is a critical need for them.

- Methods should be developed for the detection, monitoring and prevention of the emergence of drug resistance in FBTs.
  - No methods specific to FBTs have been developed. WHO is, however, developing a framework for the detection and follow-up of drug resistance in helminth infections, which can be adapted to FBTs.

- Training sessions should be established for health workers with the objective of improving diagnostic quality and reducing the occurrence of misdiagnosis.
  - Action taken: training activities have been implemented in some endemic countries (e.g. China, Lao People’s Democratic Republic and Viet Nam). A standard set of training materials on diagnosis is required.

- Surveillance for pulmonary tuberculosis should be integrated with surveillance for paragonimiasis.
  - Action taken: a few sporadic investigations have been conducted under tuberculosis control programmes in Lao People’s Democratic Republic and Viet Nam. This activity needs to be scaled up.

- Health education messages should be prepared and disseminated to inform people about the risks of becoming infected with FBTs through eating raw freshwater fish, crustaceans and plants.
  - IEC materials have been developed in China, Lao People’s Democratic Republic and Viet Nam.

- Health education messages should be prepared and disseminated to inform people about the risks of maintaining and spreading FBT infections if untreated human and animal faeces are allowed to contaminate freshwater ponds where fish are cultured.
  - IEC materials have been developed in China, Lao People’s Democratic Republic and Viet Nam.

Informal Consultation on Foodborne Trematode Infections, Hanoi, Viet Nam, 14-16 May 2007b

The objectives of the meeting were to:

- provide status of country-specific burden of FBT infections;
- provide examples of control interventions taking place in the different Mekong countries (Cambodia, Lao People’s Democratic Republic, Viet Nam);
- formulate strategic frameworks for the prevention and control of FBT infections, including country-specific strategies and guidelines; and
- allocate a budget for control of FBT infections to different countries.

The conclusions and recommendations made by the participants in the 2007 workshop are given below, together with the actions taken since 2007 to address them.

- Lao People’s Democratic Republic and Viet Nam, for which sufficient data were available, were recommended to review all existing parasitological data with the aim of selecting high-risk areas where control of FBT infections should be focused.
  - Action taken: data have been reviewed.

- Cambodia, which did not have sufficient data to assess the risk of FBT infections, was recommended to carry out a rapid assessment survey to generate information on the epidemiology of FBT infections in the country.
  - Action taken: a survey has been conducted.

- Each country was recommended to implement health education activities in conjunction with preventive chemotherapy interventions.
  - Action taken: IEC materials have been developed but implementation of health education activities is still limited.

b The relevant report was not published
Each country was recommended to address the public health problem represented by FBT infections through an intersectoral approach. In particular, with regard to control of fascioliasis, the Government of Viet Nam was recommended to complement preventive chemotherapy interventions in humans with activities aimed at reducing the burden of infection in the animal reservoir.

- Action taken: some ad hoc mechanisms have been implemented in Viet Nam as a coordinated effort by the Ministry of Health and the Ministry of Agriculture. No official coordination mechanism is in place, however. The avian influenza and the H1N1 influenza pandemics have contributed to significant progress in promoting inter-agency and intersectoral coordination.

2.1.3 Lessons from country and pilot initiatives

Thailand

Control of opisthorchiasis

The geographical distribution of opisthorchiasis in Thailand is fairly well known. Transmission of opisthorchiasis is linked to the consumption of raw or fermented freshwater fish. Traditional dishes include koi-pla (raw fish salad), plasom (short-fermented fish) and plara (fish fermented for about a year). Disease control activities started in 1950. Today, there are three main integrated approaches: (1) regular stool screening by mobile teams of the population at risk, followed by treatment of positive cases with a single dose of 40 mg PZQ per kg of body weight; (2) health education promoting consumption of cooked fish; and (3) improvement of defecation practices, to decrease environmental contamination. The long-term aim is to reduce the public health significance of opisthorchiasis by reducing the prevalence of *O. viverrini* infection and consequently the incidence of cholangiocarcinoma (CCA), its most severe long-term complication. Strategies to achieve this goal include: decentralization of programme management to provincial level; enhanced community participation and empowerment; use of school-based and community-based approaches to ensure maximum screening coverage; multi-target activities, focused on humans, freshwater fish, snails and animal reservoirs (e.g. dogs and cats); elimination of opisthorchiasis in areas of low endemicity.

Between 1984 and 2001, more than 6 million individuals were screened or re-screened for infection with *O. viverrini*. The liver fluke control programme currently targets all the 61 provinces in the Northeast, North and Central regions (out of a total of 75 in Thailand). As a result of these activities, the prevalence of infection in endemic areas was reduced from 63.6% in 1984 to 9.4% in 2001. In spite of this, however, a national survey in 2009 found that opisthorchiasis was still the most common helminth infection in the country, with a reported prevalence of 8.7%. The prevalence increases with age, reaching a peak in the age group 50–59 years (10.5%) (Table 2.1). The prevalence of paragonimiasis was 1.7%, fascioliasis 1.2% and small intestinal flukes 1.6%. The same survey found that, in 21 provinces, there were still foci where prevalence of *O. viverrini* infection was above 20%. Passive case-detection of patients with symptoms is unable to detect most infections, as shown by a comparison with active surveys. High-level support for control of opisthorchiasis is still lacking, and the disease is not perceived as a significant public health problem.

The national survey also confirmed that the most important foci are in the Northeast region, where the prevalence in some villages reaches 85%. The overall prevalence in the region is estimated at 16.6% in the general population and 9.6% among school-age children. Overall prevalence of infection in the North region is 10%, in the Central region 1.3%, and in the South region 0.1%. Research is continuing to fine-tune the mapping of transmission down to village level, through the use of geographical information system (GIS) resources. In spite of widespread sanitation, transmission of *O. viverrini* appears to be still intense in Thailand; it should be noted however that while latrines are commonly available in houses, farmers in the rural endemic areas still have the habit of defecating in the open while working in the fields.

The 2009 survey also showed that almost all infections have an intensity of less than 1000 eggs per gram (epg) of faeces.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>&lt;5</th>
<th>5–9</th>
<th>10–14</th>
<th>15–19</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>&gt;59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence of <em>O. viverrini</em> infection (%)</td>
<td>0.5</td>
<td>1.2</td>
<td>1.9</td>
<td>4.9</td>
<td>7.9</td>
<td>8.3</td>
<td>9.8</td>
<td>10.5</td>
<td>8.4</td>
</tr>
</tbody>
</table>

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d This country outline includes data presented by country officers from the Thai Ministry of Health during the Technical Forum on Control and Elimination of Parasitic Diseases in the Mekong Sub-region, Vientiane, Lao People’s Democratic Republic, 21–22 October 2009.
The Northeast region of Thailand also has the highest incidence of CCA in the world. Estimates for 2004 show that, for the country as a whole, there were about 28 000 deaths due to liver and bile duct cancer each year. Of all the individuals diagnosed with liver or bile duct cancer, 44.8% suffer from CCA, 48.8% from hepatocellular carcinoma, and 6.4% from other forms. In the Northeast region, however, the proportion of cases of CCA reaches 85.5% in Nakhon Phanom province, 83.2% in Khon Kaen province, and 68.5% in Udon Thani province. In spite of a marked reduction in prevalence of O. viverrini infection over the past few years, the number of cases of CCA appears to be steady in endemic areas. One possible explanation is that regular screening by Kato-Katz thick smear detects only a proportion of the infections (the “tip of the iceberg”, i.e. high-intensity infections). This would not affect transmission of opisthorchiasis in the endemic areas and consequently the occurrence of reinfection, which in turn would allow infections to become chronic and CCA to develop. A second possible explanation is that CCA is such a chronic process that many years of disease control activities are needed before the number of cases decreases. This hypothesis is based on the fact that the average age of patients diagnosed with CCA is about 50 years and, considering that the first infection occurs in childhood, at least 40–45 years of successful control and absence of reinfection are needed before an observable change in epidemiological trends takes place.

Bolivia and Peru

Control of fascioliasis

Following the recommendations made by the Informal Meeting on the Use of Triclabendazole in Fascioliasis Control, which took place in Geneva in 2006, and considering the high prevalence of infection in indigenous communities living in the Andean range, the Governments of Bolivia and Peru decided to implement pilot interventions to test the feasibility of large-scale distribution of TCZ without individual diagnosis. This was considered essential before treatment activities could be scaled up. Similar protocols were developed independently by the two countries, based on the template agreed during the Informal Meeting. The protocols focused on surveillance for adverse events (AEs) following treatment, since these are the main limiting factor for preventive chemotherapy interventions. School-age children were selected as the population group to be included in the pilot intervention since, because of the small diameter of the bile ducts in this age group, they were more likely to experience AEs caused by mechanical obstruction of the ducts by the dying worms. The pilot interventions took place in April 2008 in Bolivia, in an endemic community in the Northern Altiplano, and in December 2007 to January 2008 in Peru, in three endemic communities in Cajamarca. Each child was tested for fascioliasis using different techniques (Kato-Katz thick smear and detection of Fasciola excretory-secretory coproantigen (FES-Ag) on stool samples in Bolivia; Kato-Katz thick smear and rapid sedimentation on stool samples and Fas-2 antigen enzyme-linked immunosorbent assay (ELISA) on blood samples in Peru). All infected children were treated with a single dose of 10 mg of TCZ per kg of body weight. Children with an egg load of 400 epg or higher were hospitalized, as they were considered to be at high risk of adverse events following treatment. The main observations from the pilot interventions were:

- AEs were infrequent (12% in Bolivia and 6% in Peru);
- observed AEs were mild and temporary;
- no severe adverse events (SAEs) occurred;
- the prevalence of infection was reduced from 27% to 5% one year after treatment.

Preventive chemotherapy was therefore considered a feasible option and was adopted by the health authorities in the two countries as the key public health measure against human fascioliasis. Following the successful completion of the pilot interventions, large-scale preventive interventions were implemented in both countries thanks to the TCZ donation programme. In Bolivia, the intervention took place in October 2008 in 13 municipalities in the Northern Altiplano: 160 000 tablets were used to treat 71 456 individuals aged 10 to 59 years. Passive surveillance was in place and no AEs were detected. In Peru, a large-scale intervention was implemented in September and October 2008 in several municipalities in Cajamarca and Junín regions: 122 000 tablets of triclabendazole were used to treat more than 40 000 children and adults. Few AEs were detected, none of which was severe. Following the completion of the preventive chemotherapy intervention, a bilateral meeting between Bolivian and Peruvian health authorities took place in December 2008 to review the activities, share experiences and plan future coordinated interventions.

Viet Nam

Control of fascioliasis

Fascioliasis was rarely reported in humans in Viet Nam until 1997. Since then, the number of cases has increased so significantly that fascioliasis is considered an emerging disease in the country. Currently, between 2000 and 4000 cases are diagnosed every year; while most cases occur in the central part of the country, the disease is transmitted throughout Viet Nam, in 47 of the 63 provinces, with a resident population of over 65 million. Fascioliasis is intensely transmitted in animals and the prevalence of infection...
among herbivores (e.g. cattle, buffaloes, sheep and goats) is between 40% and 90% in different provinces. Studies have confirmed that the worms transmitted in Viet Nam belong to the *Fasciola gigantica* species. In endemic foci, the prevalence of infection in humans can be as high as 5.4%. Infected patients are usually women aged between 17 and 45 years; in some areas, about three times as many women are infected as men. Most cases are diagnosed in the acute phase because of the severe symptoms experienced (abdominal pain, mild fever, fatigue, often associated with internal haemorrhage). Diagnostic tests used include: blood test for eosinophilia, ELISA for *F. gigantica* antibodies, ultrasound (US) scan, computerized tomography (CT) scan.

TCZ was officially recommended by the Ministry of Health in August 2006 as the only drug for treatment of human fascioliasis, because of its efficacy, tolerability, ease of use and affordability. The recommended dosage is 10–20 mg/kg of body weight. Other drugs were used previously, such as PZQ and emetine. Artesunate has been tested in some hospitals with controversial results.

TCZ, however, is not registered for human use in the country and is not included in the national list of essential medicines. WHO has been providing TCZ since 2004 through a donation programme; this was reported to have generated a “dependence effect”, which has occasionally resulted in drug shortages at peripheral health levels. For this reason, since September 2009, the Ministry of Health has allowed hospitals at national and provincial levels to procure TCZ directly from the private market. Insurance companies have also accepted to cover the drug costs for their clients.

A number of studies of fascioliasis have been implemented in Viet Nam, covering clinical manifestations, DNA characterization of the worms, prevalence of fascioliasis in humans and cattle, and efficacy of the different drugs used.

From a disease control perspective, the Ministry of Health relies mainly on case management of affected individuals. Clinical guidelines for diagnosis and treatment of fascioliasis, issued in 2006, recommend the adoption of a simplified, more inclusive case definition, so as to ensure that the highest number of infected or suspected individuals are treated. The diagnostic capacity of health staff at the peripheral level is crucial to ensure early treatment of all individuals in need. The availability of TCZ at peripheral level is also important for the full implementation of the strategy. Recommendations have been made to register the drug for human use in Viet Nam and to include it in the list of essential medicines, so as to improve access to treatment. Increasing awareness of fascioliasis among the general population through appropriate IEC activities has also been recognized as an important activity. An official fascioliasis control programme does not yet exist, but its creation has been recommended. It has also been suggested that control activities in humans should be coordinated with veterinary public health measures implemented by the relevant authorities.

Disease control specialists and health officials have suggested that, in each province, the number of endemic communes and the number of individuals at risk and infected should be estimated. A map of each province showing the endemic communes should be developed. The burden of the disease should be estimated by reviewing records from district and provincial hospitals, and field surveys should be implemented in order to provide more detailed epidemiological information. Advocacy measures should invite leaders to support fascioliasis control activities. IEC activities should be implemented to (a) inform the public about the risks associated with eating raw aquatic plants, (b) discourage open defecation in fishponds or fields, (c) encourage the proper cooking of vegetables, and (d) provide information on the key symptoms of the disease with the aim of increasing case detection and treatment. For this last aspect, a key message would be that diagnosis is easy, and that treatment is safe and affordable. Health staff at all levels should be trained in prevention, diagnosis and treatment of fascioliasis. Those at the peripheral level should be adequately instructed on referral of patients to upper levels. In order to minimize the risk of drug resistance, TCZ should be appropriately prescribed and its use should be limited to provincial and district levels only. However, pilot community-based interventions could be tested in selected endemic communes. An appropriate reporting system should be put in place with the aim of monitoring and evaluating disease control activities; appropriate indicators should be identified.

The following veterinary public health measures have also been suggested:

- identification and mapping of the areas where fascioliasis is transmitted in animals;
- improvement of the capacity of veterinary staff at district level to diagnose fascioliasis by stool examination and serological tests;
- improvement of cattle breeding techniques;
- coordination of preventive chemotherapy interventions targeting humans with those targeting animals;
- improvement of the management of animal faeces used as fertilizers;
- promotion of cultivation of aquatic vegetables in water free from faecal pollution;
- setting up of a reporting system for infected animals.
Control of other FBT infections

The distribution of clonorchiasis, opisthorchiasis and paragonimiasis in Viet Nam is well known. Of 63 provinces in the north and central parts of the country, 32 are endemic for clonorchiasis or opisthorchiasis (resident population: over 33 million). Paragonimiasis is endemic in 9 provinces in the north of the country (resident population: over 13 million). Surveys conducted in endemic communities, using stool and sputum examinations, have found prevalence rates of around 1%. However, surveys using ELISA on blood samples have found prevalence rates of about 10%.

National guidelines for diagnosis and treatment of clonorchiasis, opisthorchiasis and paragonimiasis have been developed by the Ministry of Health. Recommendations include: to carry out field surveys to identify and map all the endemic areas of the country; to improve passive case-detection at health centres; and to carry out IEC campaigns in affected areas. Large-scale treatment for clonorchiasis and opisthorchiasis is also included in the national policy: universal treatment or mass drug administration (MDA) is recommended in areas where prevalence of infection is ± 20% and/or the proportion of individuals eating raw freshwater fish is ± 50%. Following this strategy, in 2008-09, about 100 000 people were treated. It should be noted, however, that while the Ministry of Health recommends PZQ 75mg/kg of body weight, given in three equivalent doses in one day, for individuals diagnosed with clonorchiasis or opisthorchiasis, there are no official recommendations on treatment regimens to be used in large-scale interventions without individual diagnosis. Since 2007, the National Institute of Malariology, Parasitology and Entomology (NIMPE), which is responsible for public health control of endemic diseases, including FBT infections, has adopted a standard regimen of PZQ 50mg/kg of body weight, administered as two divided doses in one day. This has replaced the previous dose of PZQ mg/kg of body weight in a single administration, which reportedly caused more frequent adverse events. Collaboration between the Ministry of Health and the veterinarian and aquaculture authorities is ongoing. Regional collaboration with the Lao People’s Democratic Republic and Cambodia is being pursued, especially with regard to control of infections in border areas.

A small number of patients were treated for paragonimiasis in 2007. In selected endemic communities in northern Viet Nam, the entire primary school-age population, as well as adults with chronic cough, were given 40 mg of PZQ per kg of body weight per day for 2 days.

Lao People’s Democratic Republic

Control of opisthorchiasis

Information on the geographical distribution of opisthorchiasis in the Lao People’s Democratic Republic is available, and each province in the country has been classified according to the estimated prevalence of opisthorchiasis. The areas of highest endemicity are found in the south and centre-south of the country. Overall, more than 70% of the resident population lives in areas where the prevalence is at least 5%, i.e. approximately 4.4 million individuals, of which about 1.7 million are estimated to be infected. Epidemiological information on CCA is not available, but this malignancy is known to occur frequently in the country. Estimates suggest that approximately 5% of those infected develop CCA at some stages of their life. Infection is linked to the deep-rooted habit of eating raw fish dishes and to poor hygiene and sanitation. A survey in 2004 in a number of endemic villages in Saravane province found that more than 75% of the participants habitually ate raw fish, that only one in 13 families had a latrine, and that more than 80% were not aware of the risk of infection with *O. viverrini*.

Opisthorchiasis is recognized as a priority by the government. In 2008, the Ministry of Health released a revised control policy based on a stratification of areas according to prevalence of infection. In districts with high prevalence (20%), the recommendation is to implement preventive chemotherapy with PZQ once a year, targeting the entire population (MDA), coupled with health education. In districts with medium prevalence (5–20%), the same interventions should be applied, but preventive chemotherapy should be implemented every two years. In areas with low prevalence (<5%), individual case-management of infected individuals should be the main strategy. Sanitation should also be improved. Preventive chemotherapy started in the country in 2002–2003, when two districts were targeted. In 2008, with assistance from the Asian Development Bank (ADB), MDA was carried out in Champassak province, and about 493 000 individuals were treated. In 2009, the target areas were expanded to include the provinces of Savannakhet (150 000 individuals treated with support from WHO, the Korea Association of Health Promotion, the Swiss Tropical and Public Health Institute, and Hiroshima University) and Khammouan (29 000 individuals treated with support from WHO). In total, approximately 672 000 individuals were treated in 2009, about 15% of the population at risk.

The strengths of the control activities against opisthorchiasis in Lao People’s Democratic Republic are: the existence of a clear policy; the ability to integrate opisthorchiasis control activities into existing health interventions, such as school deworming activities and national vaccination days; and the existence of established partnerships already engaged in helminth control. Some challenges are the heavy dependence on external donor support, the small size of the support made available by the national government, and...
the slow progress in sanitation improvement, reflecting the poor socioeconomic status of affected populations.

**Republic of Korea**

**Control of clonorchiasis**
The Republic of Korea is the country where PZQ was first tested against clonorchiasis. Control of helminth infections, including clonorchiasis, started in 1969. The strategy applied was selective chemotherapy: the entire school-age population, estimated at more than 8 million, was screened by Kato-Katz thick smear twice a year and those found positive were treated. The role of Shin Poong Pharmaceutical Company was crucial to the successful implementation of disease control activities in the Republic of Korea, as, in addition to PZQ, they also supplied piperazine derivatives, pyrantel, and mebendazole to be used against soil-transmitted helminth infections. Overall, the prevalence of helminth infections decreased significantly from 84.3% in 1969 to 2.4% in 1997. This reduction was mirrored by a steady increase in the gross national product (GNP) and the GNP per capita. The prevalence of clonorchiasis decreased from 4.6% in 1971 to 2.4% in 2004. Rural areas are still the most affected, as the prevalence decreased from 5.3% to 4.8% in 2004, while in urban areas it fell from 3.4% to 2.0%. Males are most affected, with a prevalence of 3.2% in 2004 (1.6% in females). In 2004, it was estimated that 1 174 224 individuals were still infected with clonorchiasis. The endemic areas are well known, and the most affected are located along rivers. There is some overlap between endemicity of clonorchiasis and occurrence of CCA.

In spite of the control efforts deployed, the prevalence of *C. sinensis* infection is still high in the Republic of Korea. This has been attributed to: the enduring habit of eating raw freshwater fish; the inadequacy of the sewerage system in rural areas; confusion in the parasitological diagnosis between eggs of *C. sinensis* and minute intestinal flukes (MIF); and the presence of reservoir hosts among domestic and wild animals (e.g. dogs, cats and rats).

The current objective of the clonorchiasis control programme is to decrease the prevalence of infection to 1% by 2013. This is expected to be achieved by: (a) carrying out more surveys to identify the most affected foci; (b) using more sensitive diagnostic tools; and (c) targeting individuals living along the main rivers. This will be coupled with measures aimed at preventing environmental contamination with human faeces, with interventions aimed at avoiding the cultivation and selling of fish in areas known to be endemic, and with health education discouraging the consumption of raw or undercooked freshwater fish. It is expected that *C. sinensis* infection will be eliminated in the Republic of Korea within the next few years.

**Cambodia**

**Control of FBT infections**

In 1997–98, a survey in the provinces of Kratié and Stung Treng showed that the prevalence of opisthorchiasis (determined by detecting the parasite’s eggs in stool samples) was higher than 10%. In 2005–06, another study in Takéo province showed that the prevalence of *O. viverrini* infection among adolescent women was 27%. In 2007–08, an epidemiological survey in 18 provinces found that the prevalence of opisthorchiasis (by stool examination for parasite eggs) was between 1% and 25%, and that of infection with *Echinostoma* spp. between 0.3% and 16%. All infected individuals detected were treated with PZQ.

The opisthorchiasis control strategy developed by the Ministry of Health is similar to that of the Lao People’s Democratic Republic: universal treatment (MDA) once a year of the entire resident population in districts where prevalence of infection is 20% or more; MDA once every 2 years in districts where prevalence of infection is 5–20%; and individual management of all suspected cases of opisthorchiasis reporting to a health unit. Available information suggests that opisthorchiasis is transmitted in seven districts, with an estimated population at risk of 559 750. The epidemiology and burden of opisthorchiasis are not yet fully defined, and more surveys are needed, particularly since the infection is prevalent in all the neighbouring countries (Lao People’s Democratic Republic, Thailand and Viet Nam). There is also a need to investigate the epidemiology and burden of other FBT infections, such as paragonimiasis and fascioliasis, which are also likely to be transmitted in Cambodia. Disease control interventions implemented so far are limited: school-age children and adults in 10 highly endemic villages in two provinces were treated in 2008. Activities planned for the future include: mapping, control (training, community surveys, treatment and health education), monitoring and evaluation. Regional cooperation is important in this regard: the creation of a forum where information and experiences from different countries could be shared, the organization of regular meetings for programme managers, the mutual provision of technical support among countries, and the development of a regional fund-raising mechanism would facilitate control of FBT infections in the region.

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e This section summarizes data presented by country officers from the Cambodian Ministry of Health during the Technical Forum on Control and Elimination of Parasitic Diseases in the Mekong Sub-region, Vientiane, Lao People’s Democratic Republic, 21–22 October 2009.
China

Control of FBT Infections

According to a national survey of parasitic diseases in the early 2000s, the overall prevalence of infection with clonorchiasis (based on detection of eggs in stool samples by Kato-Katz thick smear) is 0.58%. In endemic areas, however, the highest prevalence recorded was 17.5% (in Guangdong). Clonorchiasis is especially prevalent in the west of China, in the provinces of Guangdong, Anhui and Jilin, and in the Guangxi Zhuang Autonomous Region. The national survey also found the highest infection rates in ethnic minorities such as the Hezhen (14.0%), the Zhuang (8.2%), and the Koreans (5.2%). Adults (aged 30–54 years) are the most affected age group, and males are usually more affected than females. Fishermen are generally the most affected occupational group, but the fact that some categories of workers not related to food processing – such as businessmen – are also frequently affected draws attention to the risk linked to the expansion of aquaculture and the commercial distribution of infected fish.

Paragonimiasis was also included in the national survey, and the estimated prevalence of infection, based on serological positivity, was 1.7%. The most affected provinces are Shanghai (5.1%) and Chongqing (4.1%). The Miao and the Tong are the most affected ethnic groups (20% and 14%, respectively). Young children are the most affected age group (prevalence 2.8% in children under 4 years and 2.41% among 5–9-year-olds). Males and females are almost equally affected.

No data are available on fascioliasis.

The Ministry of Health is currently focusing on the following strategic approaches to combat FBT infections: health education, chemotherapy and integrated control measures, such as improvement of water supply, sanitation, and environmental management.

2.2 Core intervention packages

Core interventions against FBT infections include preventive chemotherapy and a series of complementary measures.

2.2.1 Preventive chemotherapy

Preventive chemotherapy is the large-scale distribution of anthelminthic drugs. The expansion of preventive chemotherapy to include FBT infections is considered possible, given the biological and epidemiological characteristics of the FBTs, many of which are similar to those of other helminths already targeted by this strategy. Preventive chemotherapy against FBT infections is in fact already a reality, as a number of countries are currently implementing interventions based on this strategy. Different modalities of application of preventive chemotherapy are possible:

- Universal treatment or MDA (the treatment of all the individuals living in a target area) is already implemented, for example, for control of opisthorchiasis in Lao People’s Democratic Republic and for control of fascioliasis in Bolivia and Peru.
- Targeted treatment of individuals reporting regular consumption of raw freshwater fish is already implemented in communities endemic for clonorchiasis in northern Viet Nam.
- Selective chemotherapy (“test and treat”) is implemented for control of opisthorchiasis in Thailand and control of clonorchiasis in the Republic of Korea.
- Public health interventions based on individual case management are implemented in Viet Nam for the control of fascioliasis.

What is lacking, however, is a concerted, standardized strategy that translates country experiences into policies and recommendations applicable in different epidemiological settings.

Drugs

PZQ and TCZ are the only two drugs recommended against FBT infections: PZQ is effective against C. sinensis, O. viverrini and Paragonimus spp. TCZ is effective against Paragonimus spp. and Fasciola spp. The following regimens are recommended by WHO:

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1 This section summarizes data presented by country officers from the Chinese Ministry of Health during the Technical Forum on Control and Elimination of Parasitic Diseases in the Mekong Sub-region, Vientiane, Lao People’s Democratic Republic, 21–22 October 2009. It also includes data from the Report on the national survey of current situation of major human parasitic diseases in China, published by the National Institute of Parasitic Diseases, China CDC, Ministry of Health, China, in May 2005.

2 This section summarizes information compiled in a background document circulated before the meeting.
- clonorchiasis and opisthorchiasis: PZQ 25 mg per kg of body weight, 3 times a day on 2 consecutive days or PZQ 40 mg per kg of body weight in a single administration;
- fascioliasis: TCZ 10 mg per kg of body weight in a single administration;
- paragonimiasis:
  - PZQ 25 mg per kg of body weight, 3 times a day on at least 2 consecutive days or 40 mg per kg of body weight in a single administration for at least one day (both regimens may need to be extended for several days);
  - TCZ 10 mg per kg of body weight twice in 1 day.

A number of other regimens have also been tested in field studies.

Retreatment interval
Information on the most appropriate retreatment interval to be adopted in preventive chemotherapy interventions is scarce; the intervals most frequently adopted for control of clonorchiasis and opisthorchiasis in endemic countries are 6 months or 12 months, and for fascioliasis 12 months or 24 months. No data are currently available for paragonimiasis.

Identification of target population
Population groups defined by a specific age, gender or reported food habit (identified through questionnaire surveys) can in principle be considered as high-risk groups and therefore targeted by the preventive chemotherapy intervention.

An association has been found between clonorchiasis/opisthorchiasis and the reported regular consumption of raw freshwater fish and fermented fish. There is also a link with reported alcohol consumption in countries where fish often accompanies drinks (e.g. Republic of Korea and Viet Nam). The most affected population groups are typically adults (in some countries young adults, in others older adults); in some areas, males are more affected than females but this pattern is not consistent.

An association has been found between fascioliasis and the reported regular consumption of raw aquatic plants or their derivatives, such as juices or infusions. In some areas, females are more affected than men, but this pattern is not consistent.

An association has been found between paragonimiasis and the reported regular consumption of raw freshwater crabs and crustaceans. In some areas, raw freshwater crabs and crustaceans are mostly eaten by children and consumption decreases with age, but this pattern is not consistent.

Co-administration of anthelmintic drugs
PZQ and albendazole have been co-administered in areas where both opisthorchiasis/clonorchiasis and soil-transmitted helminth infections are prevalent. No major adverse events following treatment have been reported, thus suggesting that such co-administration is safe. It is worth remembering that co-administration of PZQ and albendazole or mebendazole is recommended by WHO in areas where both schistosomiasis and soil-transmitted helminth infections are prevalent.

2.2.2 Complementary public health interventions
The following public health measures have been identified as effective in decreasing risk of infection with FBT infections:

Clonorchiasis/opisthorchiasis
- Rapid-impact interventions
  - Measures to decrease human faecal contamination of aquaculture systems and cultured fish ponds (sanitation).
- Long-term measures
  - Improved food safety measures for aquatic products in the premarketing stage, including the development of a certification system of fish farms by the national agriculture or aquaculture authorities.
  - Information, education and communication on safe food practices.
  - Improved sanitation, aimed at decreasing contamination of freshwater streams with human faeces.
  - Control or containment of the intermediate snail hosts.

Fascioliasis
- Rapid-impact interventions
Veterinary public health measures, including treatment of domestic animals (preferably with fasciolicides other than TCZ in areas where the disease is common in humans, in order to avoid the emergence of resistance) and fencing off of suspected infected grazing lands.

- **Long-term measures**
  - Information, education and communication promoting: separation between animal grazing lands and human living and cultivation areas; cultivation of vegetables in water free from faecal pollution; and thorough cooking of vegetables before consumption
  - Control or containment of the intermediate snail hosts.
  - Drainage of grazing lands.

### Paragonimiasis

- **Rapid-impact interventions**
  - Measures to decrease human faecal contamination of aquaculture systems and cultured crustacean ponds (sanitation).

- **Long-term measures**
  - Information, education and communication on safe food practices.
  - Sanitation to decrease contamination of freshwater streams with human faeces and sputum.
  - Control or containment of the snail intermediate hosts
  - Improved food safety measures for aquatic products in the premarketing stage, including the development of a certification system for crustacean farms by the national agriculture or aquaculture authorities.
  - Veterinary public health measures, such as treating dogs with PZQ.

#### 2.2.3 Aquaculture and control of foodborne trematode infections

The importance of fish and crustaceans produced in aquaculture is increasing. It is well accepted that increased aquaculture production contributes significantly to a country's socioeconomic development and is a major source of protein. Small-scale aquaculture does not seem to have any negative impact on the environment. It is, however, important that cultured fish and crustaceans should not present a risk to human health, and the risk linked to transmission of FBT infections should therefore be appropriately addressed. Interventions conducted in nursery ponds and surrounding areas in Viet Nam have included: regular treatment of people working in the ponds and in neighbouring villages; treatment of reservoir final hosts possibly involved in transmission, such as dogs and cats; provision of health education to farmers; pond improvements, such as mud removal; and snail control.

### 2.3 Community diagnosis

Considering the focal nature of FBT infections, identification of endemic areas is crucial. Once this has been done, an operational decision on the most appropriate intervention can be taken, based on the level of endemicity and therefore on the magnitude of the public health problem represented by such infections in the target area.

If universal treatment (MDA) is chosen, the entire population in the selected area is treated. If targeted treatment or selective chemotherapy is chosen, the population groups or the individuals at highest risk of infection or already infected individuals need to be identified.

The identification of both the geographical areas to be targeted by the disease control intervention and the population groups - or the individuals - to be treated requires appropriate diagnostic tools.

#### 2.3.1 Diagnostic tools

A number of different tools can be used, as follows.

**Medical case reports**

This approach aims to identify endemic areas based on the districts or communities of provenance of confirmed or suspected cases of a given disease. This information is compiled from reports by health or statistical institutions in the country, or from hospital records. A disease distribution map can then be drawn. This approach has a lower selection bias than active surveys, which usually target areas where the infection is known to be transmitted.

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h This section summarizes information compiled in a background document circulated before the meeting.
Demographic characteristics
In principle, when infection is known to occur more frequently in a given age or sex group, then – once endemic communities have been identified – these high-risk groups can be targeted without further investigation. This kind of clustering is frequently encountered in specific communities; however, the characteristics vary from country to country or even from area to area: as a consequence a universal standardized approach does not seem feasible. Demographic characteristics are principally linked to traditional food habits, and therefore screening based on behaviour and habits appears as a more reliable option.

Behaviour and habits
When a significant association is observed between infection and the reporting of a particular behaviour or habit, such as the consumption of a specific food, individuals reporting such behaviour or habit can be identified through population-based questionnaire screening surveys and targeted without further investigation. A few examples are given below.

- **Clonorchiasis and opisthorchiasis.** Infection has been shown to be associated with the reported regular consumption of raw or undercooked freshwater fish. In the Republic of Korea and Viet Nam, where raw fish dishes are often enjoyed together with alcoholic drinks, infection is also associated with the reported regular alcohol consumption.
- **Fascioliasis.** Infection has been shown to be associated with the reported regular consumption of a number of aquatic and semi-aquatic vegetables and their derivatives, such as juices and infusions.
- **Paragonimiasis.** Infection has been shown to be associated with the reported regular consumption of raw freshwater crabs and other crustaceans.

Signs and symptoms
Signs and symptoms can be useful in identifying suspected infected individuals. The more a sign or symptom is specific to a given medical condition, the more useful it is in this regard.

- **Clonorchiasis and opisthorchiasis.** Symptoms are non-specific and late.
- **Fascioliasis.** Severe abdominal pain during the acute phase, even though not specific, is likely to prompt the patient to seek health care. In areas where fascioliasis is known to be transmitted, it can therefore be used to identify individuals in need of treatment.
- **Paragonimiasis.** Chronic cough (for more than 3 weeks) and blood in sputum can be used to identify individuals suffering from paragonimiasis in endemic areas. A differential diagnosis with tuberculosis is needed. The inclusion of sputum examination for paragonimiasis in routine screening activities for tuberculosis is an option. Both cough and bloody sputum are, however, late-stage symptoms and early infections are therefore likely to be missed.

Parasitological examination
The Kato-Katz thick smear detects the worms’ eggs in stool samples. It is relatively inexpensive, rapid and simple to perform, and hence is suitable for use in field conditions. However, it has a low sensitivity; the standard kit, by default, does not detect infections with an egg concentration of less than 24 epg. Species-specific diagnosis is difficult in the case of clonorchiasis and opisthorchiasis, whose eggs can be confounded with those produced by MIF. It is, by definition, unable to detect infections caused by worms that do not lay eggs in the human intestine, such as, for example, some Fasciola spp. that do not achieve sexual maturity in the human host, or those associated with ectopic location of the parasite. The Kato-Katz is the most widely used technique in epidemiological surveys and for monitoring interventions for helminth control.

- The ether-concentration method is more sensitive than the Kato-Katz technique, but is more complex to perform.
- The McMaster technique is widely used in veterinary practice; it is simple to perform but is less sensitive than the Kato-Katz technique.
- FLOTAC is a technique based on flotation and centrifugation. It has a higher sensitivity than the Kato-Katz and McMaster techniques, but is more complex to perform and requires some specific laboratory equipment (e.g. a large centrifuge).
- Sputum examination is useful for detection of eggs of Paragonimus spp. in patients with productive cough. Execution is simple, but its sensitivity is not high because of the low egg excretion rates in many patients.

Eosinophilia
Eosinophilia can be detected by performing a complete blood count. This laboratory test can easily be performed on suspected infected individuals, as the necessary facilities are usually available at district health centres. Eosinophilia, defined as a blood eosinophil count > 500–1000 per µl of blood, is however not very specific, as it is considered among the most characteristic features of any helminth infections.
Immunodiagnosis
Immunodiagnosis detects worm-specific antibodies or antigens in serum or stool.

- Detection of antibodies against FBTs is possible in acute and chronic infections and in ectopic cases; the technique is more sensitive than the commonly used parasitological techniques but cannot differentiate between current, recent and past infections. Available tests are subject to some degree of cross-reactivity with a number of helminth infections, which decrease their specificity; the ability to quantify intensity of infection is also disputed. Examples of antibody-detection tests include CL1, DRG-ELISA, Fas2-ELISA, MM3-SeroELISA for detection of circulating immunoglobulin G against fascioliasis; their commercialization is limited. No tests are currently commercialized to detect other FBT infections.
- Detection of FBT antigens by using monoclonal antibodies is highly specific but possibly less sensitive than detection of antibodies; these tests cannot quantify intensity of infection. Detection of antigens indicates current infection, and tests can be performed on serum and stool specimens. Stool tests are easier to perform and reportedly better accepted by individuals in endemic areas. Most of the available tests are for diagnosing fascioliasis: FES-Ag ELISA in stool (such as the FasciDIG test developed in Cuba), MM3CoproELISA, and BioK201. Other examples include the 89kDa antigen stool test for diagnosis of *O. viverrini*.

Molecular methods
DNA from eggs or other biological components or products of the worms can be extracted from stool samples using kits (usually called copro-DNA) and amplified by polymerase chain reaction (PCR). Highly sensitive and specific primers (strands of nucleic acid that serve as starting points for DNA synthesis) have been developed for the major FBT infections, but the large-scale application of the PCT technique is limited by its high costs and requirements, as reagents and primers are not easily accessible in decentralized settings. Molecular techniques are also unable to quantify intensity of infection.

Imaging
Ultrasound (US) scans are widely used as complementary diagnostic tools in clinical practice, in both central and peripheral health facilities. Computerized tomography (CT) scans require more sophisticated and expensive equipment, which is usually found only in specialized hospitals. The same is true of magnetic resonance imaging (MRI), whose role in the diagnosis of FBT infections is however still under debate. Chest X-ray has a role in diagnosis of paragonimiasis.

- **Clonorchiasis and opisthorchiasis**
  While adult worms in smaller intra-hepatic ducts are difficult to visualize, those in larger ducts can easily be detected by US scans; US scans can also identify ductal thickening and periportal inflammation in advanced cases of disease. CT or MRI scans can typically identify the diffuse, uniform dilatation of the intrahepatic ducts in absence of lesions in the lumen or surrounding tissues.

- **Fascioliasis**
  In the acute phase, US scans can identify worms migrating through the liver as hyper-echogenic mobile structures that leave behind them hypo-echogenic cavities and abscesses; in the chronic phase, they can easily detect the typical dilatation and thickening of the bile ducts and gallbladder. While US scans are probably the most specific imaging tool in such phase, CT scans are the best in the acute one, in which they put in evidence hepatic lesions and "tunnel-like" migration paths.

- **Paragonimiasis**
  Paragonimiasis is the only FBT infection in which chest X-ray films can have a diagnostic role; they detect nodules and opacities in the lung parenchyma as well as signs of pleurisy and pneumothorax. Such findings can easily be confounded with those of pulmonary tuberculosis. CT scans put in evidence nodules in parenchyma and focal thickening of the pleura.

2.4 The way forward

2.4.1 Pilot interventions

WHO intends to support pilot interventions focused on the control of FBT infections. These interventions will test the feasibility of implementing the guidelines on disease prevention and control made by the Expert Consultation (see section 5) and investigate the practicability of preventive chemotherapy interventions as a mean to reduce the burden of these infections.

The pilot interventions should be implemented by the national disease control authority (usually the Ministry of Health), possibly with support from a national or international scientific institution for the monitoring and evaluation component, which is expected to assess the performance and impact of the intervention.

The pilot interventions should aim to reach the highest possible number of individuals in need of treatment in the target areas and should piggy-back on, and be integrated with, existing public health interventions.
The countries and areas listed below were identified by the participants as appropriate for the pilot tests. For each country, the diseases transmitted in the target area are listed.

- Bolivia (Altiplano): fascioliasis and soil-transmitted helminth infections;
- China (Yunnan): clonorchiasis, paragonimiasis, taeniasis/cysticercosis;
- Cambodia/Lao People’s Democratic Republic border (Stung Treng/Champasack): opisthorchiasis, taeniasis/cysticercosis, soil-transmitted helminth infections, lymphatic filariasis and schistosomiasis mekongi;
- Philippines (Mindanao): paragonimiasis;
- Viet Nam (Binh Dinh): fascioliasis and opisthorchiasis.

2.4.2 Operational research

WHO also intends to support operational research studies, aimed at solving practical, operational problems directly related to control of FBT infections.

The following questions have been identified as those most in need of attention.

- What is the best intervention option for areas where prevalence of clonorchiasis or opisthorchiasis is below 20%:
  - Universal treatment (MDA) at more spaced intervals than in areas where prevalence of infection is 20% (i.e. every second year)?
  - Targeted treatment of individuals who report habitually eating raw fish? (An appropriate methodology would need to be developed).

- What is the best rapid assessment tool for detection and appropriate classification of areas at risk of clonorchiasis and opisthorchiasis:
  - the classical method, i.e. sampling a representative number of individuals in a defined number of schools or villages in the suspected area?
  - the lot-quality assurance sampling method: developed and used in the manufacturing sector for product quality control, this method allows a smaller number of individuals to be sampled in a larger number of sites.

- Do veterinary indicators, such as presence of worms in the livers or lungs of dogs, or infection levels in fish or crab intermediate hosts, have a role in the assessment of transmission of clonorchiasis, opisthorchiasis and paragonimiasis?

- Does preventive chemotherapy have a role in the control of paragonimiasis? In other words, is treatment useful in the early stages of infection or only when the disease is established? If the latter, is individual case management sufficient to detect all cases and tackle the disease?

- What is the impact of CLTS on transmission of helminth infections, and particularly FBT infections?
  - Three countries were identified where such studies could be implemented: Bolivia, Lao People’s Democratic Republic and Zambia. The protocol would be a case–control study, in which the impact of preventive chemotherapy is compared in villages where CLTS is implemented, and in villages where CLTS is not implemented. In both the control and intervention settings, treatment would be given at the onset of the investigations (for ethical reasons), and hence prevalence and incidence of infection would serve as the primary outcome measures.
3. Taeniasis and cysticercosis due to *Taenia solium*

Taeniasis and cysticercosis caused by the zoonotic pork tapeworm, *Taenia solium*, occur worldwide, primarily in poor rural communities in developing countries of Latin America, sub-Saharan Africa and Asia where pigs are raised, pork consumed and poor sanitation allows pigs access to human faeces. In humans, cysticercosis can lead to epilepsy and death. In pigs, it reduces the market value of the animal and makes the pork unsafe to eat. Thus the infection is of both public health and agricultural importance.

Human and porcine cysticercosis are focal in nature, which has important implications for prevention and control strategies. Human *T. solium* taeniasis will not occur in the absence of the intermediate host, the pig, and human and porcine cysticercosis cases are usually clustered around human tapeworm carriers. People harbouring tapeworms who migrate can take the infection to non-endemic areas and infect other humans who do not normally consume pork. Distribution of infected pork may also spread the infection outside of an endemic area.

The major public health impact of *T. solium* infections is neurocysticercosis, which is frequently responsible for chronic debilitating illness, including epilepsy, and can be fatal. In endemic countries, the proportion of neurocysticercosis among people with epilepsy has been found to be more than 29%.

3.1 Country experiences

3.1.1 Current situation

**Region of the Americas**
Cysticercosis is endemic in much of Latin America, with “hot spots” of the disease in Mexico (e.g. Yucatan, Guanajuato, Guerrero, Morelos, Puebla), several Central American countries, such as Guatemala, Honduras and Nicaragua, the Andean countries of Bolivia, Ecuador and Peru (e.g. Tumbes), Colombia, Venezuela and northern Brazil. Haiti is also known to be endemic. Human cases of taeniasis and cysticercosis have been detected in the USA, mostly in immigrants from endemic Latin American countries; no cases of porcine cysticercosis have been reported. Neurocysticercosis is a significant public health problem in the entire region, while porcine cysticercosis is a constraint to food security and a major cause of income loss in Latin America.

Porcine cysticercosis is recognized as a problem by the veterinary authorities in Latin America, but control is piecemeal and hampered by the lack of concerted public health action, except in Mexico, where official national guidelines for control and prevention of *T. solium* infections were published in 1994 and revised in 2004. In some countries, human taeniasis/cysticercosis in endemic communities is treated with praziquantel, but the approach is non-systematic and not extensive. Neurocysticercosis is mainly managed on a case-by-case, non-systematic basis. A 7-year project to eliminate *T. solium* infections from an area of northern Peru (Tumbes) is currently under way, funded by the Bill and Melinda Gates Foundation.

**South-East Asian Region**
Bhutan, India, Nepal, Thailand and certain parts of Indonesia where pork is consumed (e.g. Papua province) are known to be endemic for *T. solium* taeniasis/cysticercosis. The Democratic People’s Republic of Korea and Myanmar are suspected to be endemic, but no data are available. Bali (Indonesia) was previously endemic, but transmission of cysticercosis appears to have been interrupted. Surveys in India, Nepal, Thailand, and Papua Province of Indonesia have indicated “hot spots” of transmission. During 2004–2008, 390 (14%) of 2748 parasitic infections diagnosed at the Centre of Excellence for Food Borne Parasitic Zoonoses, Faculty of Tropical Medicine, Mahidol University in Thailand were cysticercosis. Single brain lesions caused by neurocysticercosis are a common manifestation in India, where many vegetarians are infected, probably through contaminated food (i.e. food handled by people infected with *T. solium* taeniasis) and possibly water. Currently, there are no large-scale surveillance, prevention or control programmes for *T. solium* infections in this region.

**Western Pacific Region**
Taeniasis/cysticercosis is known to be transmitted in Cambodia, China, Lao People’s Democratic Republic, the Philippines, Viet Nam and certain parts of Malaysia where pork is consumed. Papua New Guinea is suspected to be endemic. The Republic of Korea was formerly endemic, but transmission has been interrupted.

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1. In India most symptomatic cases of NCC occur in people with only one larval *T. solium* cyst in the brain whereas in most other endemic sites symptomatic people usually have multiple cysts in the brain.
interrupted and, while human cysticercosis cases are still occasionally detected, *T. solium* taeniasis and porcine cysticercosis are no longer found. During 1996–2005, 472 (9.1%) of 5169 human serum samples tested by ELISA at the National University Laboratory in the Republic of Korea were positive for cysticercosis.

In China, the emergence of cysticercosis as a serious public health problem in certain regions of the country has been recognized by the government. Surveillance and intervention measures for taeniasis/cysticercosis have been conducted since the 1970s. In some endemic areas (e.g. Heilongjiang, Jilin, Henan and Fujian provinces), mass screening and treatment of taeniasis carriers, treatment of cysticercosis patients and pigs, improved meat inspection and population education programmes have been conducted. *T. solium* infections were included in the National Investigation of Human Parasitic Diseases, conducted in 1990, which found that cysticercosis was reported in all provinces, municipalities and autonomous regions of mainland China. Many of the cases in these provinces are associated with the preference of minority populations for eating raw pork, especially in the south-west of the country (e.g. Guizhou, Sichuan and Yunnan provinces).

In Viet Nam, cysticercosis/taeniasis is known to be transmitted in many of the northern provinces, but cases have also been reported in the south. However, the number of pigs found infected at official slaughterhouses has been very low. Porcine cysticercosis and human taeniasis have been detected in some provinces of Lao People’s Democratic Republic (e.g. Luang Prabang, Sekong and Khamuane provinces), while porcine cysticercosis has been detected in slaughterhouse surveys in Cambodia.

A number of activities have been undertaken to address the problem of taeniasis/cysticercosis in the Western Pacific Region:

- **Research**
  - Links have been established by WPRO and the Regional Network for Asian Schistosomiasis and other Helminth Zoonoses (RNAS+) with international research groups working on human and animal health.
  - Community surveys have been conducted in Cambodia, China, Lao People’s Democratic Republic, the Philippines and Viet Nam.

- **Surveillance**
  - *T. solium* infections were included in the national survey of human parasitic diseases in China.
  - Mapping of endemic areas has been completed in China and is under way in Cambodia, Lao People’s Democratic Republic, the Philippines and Viet Nam.

- **Prevention**
  - Health education campaigns have been conducted during active and passive case detection campaigns for other parasites in Viet Nam.

- **Control**
  - There has been limited case detection and treatment in China, the Philippines and Viet Nam.
  - A pilot project on community diagnosis of taeniasis/cysticercosis is planned in Viet Nam.

So far, there has been no progress regarding inclusion of taeniasis/cysticercosis prevention and control into existing systems (e.g. school health curricula) in the region. However, the Regional Network for Asian Schistosomiasis and other Helminth Zoonoses (RNAS+) has included taeniasis/cysticercosis in its research and control agenda.

### 3.1.2 Lessons from previous meetings

- **International Workshop on Cysticercosis, San Miguel de Allende, Guanajuato, Mexico, 1981**
  - The first large-scale international meeting on taeniasis/cysticercosis control.
  - A major output was publication of the proceedings as a book.

- **WHO Technical Consultation, Geneva, 1983**
  - Summarized existing knowledge on *T. solium* prevention and control measures.
  - Instigated field research studies and interventions in Mexico and Ecuador.
  - A major output was publication of the proceedings as a book.

- **“C-now” Symposium on Neurocysticercosis, Rotterdam, the Netherlands, 1988**
  - Discussed mainly progress in chemotherapy of neurocysticercosis (NCC).
  - Concluded that baseline data on control of taeniasis/cysticercosis were still scarce.
  - A major output was publication of the proceedings as a book.
PAHO Informal Consultation on Taeniasis/Cysticercosis, Porto Allegre, Brazil, 1990
- Concluded that immediate action was needed to reduce mortality and morbidity due to NCC in humans.
- Recommended short-term control measures in endemic areas.

International Task Force for Disease Eradication (ITFDE), Atlanta, Georgia, USA, 1993
- Targeted *T. solium* cysticercosis as one of six potentially eradicable diseases, on the basis of the following factors:
  - The life cycle of the parasite requires humans as definitive host.
  - Tapeworm infection in humans is the only source of infection for pigs, the natural intermediate hosts.
  - Domestic pigs, the intermediate hosts, can be managed.
  - No significant wildlife reservoir exists.
  - Practical intervention is available in the form of safe and effective drugs for treatment of human taeniasis and porcine cysticercosis.

PAHO/WHO Informal Consultation on the Taeniasis/Cysticercosis Complex, Brasilia, Brazil, 1995
- Reviewed the scientific advances in prevention, control, diagnosis and treatment of taeniasis/cysticercosis and made the following recommendations for prevention and control strategies:
  - Long-term, comprehensive measures:
    - enabling legislation;
    - health education;
    - modernization of swine husbandry practices;
    - improvement of efficiency and coverage of meat inspection;
    - provision of adequate sanitary facilities;
    - detection and treatment of human tapeworm carriers.
  - Short-term, targeted measures:
    - mass or selected taeniacidal treatment of humans with praziquantel (noted possible adverse reactions of treating people with NCC);
    - treatment of larval infection in pigs with oxfendazole;
    - vaccination of pigs and/or humans is theoretically possible.
  - Sustainability:
    - control activities integrated in primary health care;
    - aggressive educational campaigns;
    - improvement of personal hygiene and sanitation;
    - control strategies must consider costs and locally available resources.
- A major output was publication of the proceedings as a book.

International Symposium on Cysticercosis, Cysticercosis Working Group in Peru, Lima, Peru, May 1996
- The aim of the workshop was to create awareness of the importance of taeniasis/cysticercosis as a cause of seizures and epilepsy.

Consensus meeting on Cysticercosis Diagnosis and Treatment, Cysticercosis Working Group in Peru, Lima, Peru, August 2000
- The aim of the workshop was to develop standard criteria for diagnosis, treatment and control of taeniasis/cysticercosis among international experts.
- Major outputs were updated diagnostic criteria and treatment guidelines.

North Atlantic Treaty Organization (NATO) Seminar on Emergent Helminth Zoonoses, Pozna, Poland, 2000 (held in conjunction with a meeting of the European Multicolloquium of Parasitology)
- Major points in research and applicability of control measures for taeniasis/cysticer-cosis and echinococcosis were discussed.
- Major output was publication of the proceedings.

Fifty-fifth World Health Assembly, Geneva, Switzerland, May 2002
- The World Health Assembly took note of a report by the WHO Secretariat (document A55/23), which:
  - highlighted the need for comprehensive assessment of the burden of cysticercosis due to *T. solium* in terms of human suffering and economic losses in the veterinary field
  - encouraged national authorities to establish surveillance and reporting systems and adopt a more active approach towards prevention and control of taeniasis and cysticercosis through further research and trials of intervention methods
  - noted the need for conducting intervention trials through the formulation and validation of a simple package of cost-effective, appropriate and acceptable interventions, such as the strategic use of anthelmintics against the adult tapeworm in humans and the larval parasite in swine that will give optimal, long-term relief from the burden of cysticercosis.
The meeting brought together scientists, government authorities, and health and veterinary officials from around the world, as well as community leaders and delegates from international and regional support agencies.

The aim of the meeting was to assess the global cysticercosis situation and the availability of tools for diagnosis, treatment, and prevention, as well as potential technical and financial support available, in order to determine how surveillance and control capacity for cysticercosis and other parasitic zoonoses of agricultural and public health importance could be strengthened in the region and elsewhere.

The main outputs and outcomes of the meeting were:
- an action plan for research, surveillance, prevention and control of cysticercosis/taeniasis in eastern and southern Africa, which was published in a special edition of Acta Tropica;
- instigation of an international initiative to establish a global “driving force” to combat cysticercosis;
- instigation of revision of guidelines for surveillance, prevention and control of taeniasis/cysticercosis.

As a direct result of the meeting:
- an initial WHO-funded assessment of the global burden of cysticercosis was conducted;
- a review of the status of cysticercosis eradication was carried out by the International Task Force for Disease Eradication at the Carter Center in April 2003.

The workshop also provided key information for the 56th World Health Assembly in May 2003 when control of neurocysticercosis was considered.

A reconvened ITFDE II considered the status of *T. solium* cysticercosis and strengthened its recommendation that cysticercosis is a potentially eradicable disease. It noted, however, that the infection had not been eliminated from any region by a specific programme, and that no national control programmes were in place.

The Task Force considered that demonstration intervention studies needed to be conducted for verification (“proof of principle”). Its conclusions and recommendations included the following.
- Demonstration of effective control or elimination of *T. solium* transmission on a national scale would probably be the greatest single stimulus to further action against taeniasis/cysticercosis.
- A programme strategy that includes multiple interventions in flexible mass or targeted approaches would probably have the greatest chance of success.
- Economic factors should be considered in designing any control programme, given the importance of domestic pig husbandry to affected local subsistence economies in endemic areas.
- There is a need for better understanding of the global burden and transmission of the disease.
- In areas where taeniasis and cysticercosis are co-endemic with other parasitic diseases (e.g. schistosomiasis, lymphatic filariasis and soil-transmitted helminths), the impact of control programmes involving mass distribution of praziquantel and albendazole on the taeniasis/cysticercosis situation should be evaluated.

The aim of the workshop was to create awareness of the contribution of calcified NCC to neurological morbidity and the associated mechanisms.

A major output from the position paper on the contribution of calcified disease to the burden of seizures.

The overall objective of the conference was to consider the needs, justification and benefits of a global alliance for combating *T. solium* cysticercosis.

The major outcomes were:
- an international consensus to establish a global campaign for combating cysticercosis, covering advocacy and facilitation of research and control activities;
- drafting of a global action plan to implement and monitor the global campaign.
The aims of the symposium were to review the status of taeniasis/cysticercosis in the different endemic regions, with a focus on Asia and the Pacific, and to present new findings on diagnostics, taxonomy, epidemiology, clinical aspects, and prevention and control options.

A major output was publication of the proceedings in a special supplement of the Southeast Asian Journal of Tropical Medicine and Public Health in 2007.

The aim of the workshop was to review all evidence on mechanisms of disease and treatment options in neurocysticercosis.

A major output was an updated statement and guidelines.

The major conclusions and outputs were as follows.

- The Global Campaign for Combating Cysticercosis should serve as a platform for advocacy and networking efforts.
- High priority should be given to establishing and supporting regional cysticercosis working groups responsible for planning, implementing, monitoring and evaluating activities in research, training, surveillance, prevention and control, based on regional needs and priorities.
- A revised action plan was developed for the campaign.

The aim of the workshop was to lay the foundations for an international collaborative research network on neurocysticercosis and epilepsy, comprising a group of researchers with expertise in diverse related fields. The ultimate goal was to better understand epilepsy caused by NCC, its basic molecular and genetic mechanisms, and the medical, surgical, cognitive, and psychosocial aspects.

A major outcome was the establishment and publication of a Neurocysticercosis and Epilepsy Research Network - NERN.

WHO’s Department of Control of Neglected Tropical Diseases included taeniasis/cysticercosis in its Global Plan to Combat Neglected Tropical Diseases 2008–2009, as well as in a new initiative addressing integrated control of neglected zoonotic diseases. In addition, WHO’s Department of Food Safety and Zoonoses has included taeniasis/cysticercosis in an initiative aimed at assessing the global burden of foodborne diseases. The World Bank/UNDP/UNICEF/WHO Special Programme for Research and Training in Tropical Diseases, as part of its expanded mandate to address infectious diseases of poverty, has included taeniasis/cysticercosis as a priority disease under its Disease Reference Groups on Helminth Infections and Zoonoses and Marginalized Diseases. Also, the International League Against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE) are giving increased attention to neurocysticercosis as a major preventable cause of epilepsy, and an international Neurocysticercosis and Epilepsy Research Network has been formed. Cysticercosis working groups have also been formed in South-East Asia (Regional Network for Asian Schistosomiasis and other Helminth Zoonoses) and in Europe (Cysticercosis Working Group in Europe) to facilitate research and control efforts. Guidelines for surveillance, prevention and control of taeniasis/cysticercosis, initially published in 1983, were revised in 2005 in recognition of important advances over the previous 20 years.

3.1.3 Lessons from a pilot initiative in Peru

A demonstration project to eliminate *T. solium* taeniasis/cysticercosis from the major disease-endemic area of Tumbes in northern Peru was funded by the Bill and Melinda Gates Foundation from 2003 to 2010, with the ultimate aim of developing a model that could be used for disease eradication efforts in other parts of the world. The elimination strategy was devised according to the local cultural particularities, pig production system, and epidemiology. It was based on the results of systematic studies of multiple approaches to control, conducted in a stepwise fashion to determine the most feasible for blocking transmission in the targeted area. The following tools were used:
- niclosamide (adult oral dose of 2g) for mass or targeted human treatment for taeniasis;
- oxfendazole (30 mg/kg of body weight oral drench) for mass pig treatment;
- vaccination of pigs with TSOL18 antigen to build immunity in the porcine population and avoid reintroduction of infection;
- coproantigen detection immediately after mass treatment to confirm cure and identify treated human tapeworm carriers;
- necropsy/slicing of pig carcasses to confirm success of treatment and vaccination.

Other measures, i.e. improving sanitation and pig husbandry, were not included because of population increase, inadequate financing and management failures, which made it less likely that these two approaches would be successful.

The initial control strategies tested included:
- education;
- pig replacement;
- mass treatment of humans and pigs;
- targeted treatment of humans and pigs;
- treatment of 3-month-old pigs;
- economic incentives for corralling and “clean” pigs

These strategies were tested in 41 villages with a total population of 17 000 humans and 6000 pigs. The initial trials were followed by testing of combined interventions selected for efficacy and compliance (i.e. acceptability); all combinations included mass treatment of pigs. Mass versus targeted treatment of human taeniasis with niclosamide, assessed by post-treatment screening with coproantigen ELISA, was investigated. In half of the villages, pigs were vaccinated with TSOL18 (after initial treatment with several doses of oxfendazole to cure existing infections). At the end of the second round, all the pigs were tested serologically using enzyme-linked immunoelectrotransfer blot assay (EITB) and 658 were slaughtered and sliced to check for T. solium cysts. The slaughtered pigs included all those with a strong serological response, most of those with a weak response and some with no response. Only eight cysts were found in six pigs, none of which were viable. The process was repeated again a year later; among the vaccinated pigs, viable cysts were found in only one cluster in one village; among the unvaccinated pigs, cysts were found. Thus, treatment followed by vaccination was able to interrupt transmission in a sustained manner.

The Cysticercosis Elimination Project in Peru reports that it has managed to prove the principle that transmission of taeniasis/cysticercosis can be interrupted through large-scale treatment of taeniasis in humans with niclosamide and simultaneous treatment of pigs with oxfendazole and TSOL18 vaccine. However, an intense intervention schedule was needed, which may be difficult to transfer to routine settings elsewhere. Consideration is now being given to how to make the results of these efforts more sustainable and transferable. The project experience has indicated that there is still substantial room for improvement of elimination tools, especially on the veterinary side. For instance, the formulation and administration of oxfendazole and the TSOL18 vaccine could be improved. Investigations are also needed to determine if an increased dosage of niclosamide would have greater efficacy in treating taeniasis. The lessons learned from the initiative highlight the important need for understanding and categorizing the various pig production systems and livestock owner practices in endemic areas, in order to define the optimal interventions for each category. Inputs from livestock scientists and veterinarians, as well as from key experts in other relevant sectors, are needed to develop guidelines for sustainable control and possibly elimination of T. solium infections in different situations. The experience in Peru can be used as a basis for improving control tools and formulating best practice guidelines for interrupting transmission of cysticercosis, which can then be tested in pilot projects in selected endemic sites.

3.1.4 Opportunities for community-based initiatives

Community-led total sanitation

Transmission of T. solium from humans to pigs occurs when pigs have access to infected human faeces. Efforts to improve sanitation by eliminating open human defecation and thus removing the infective source (human waste) for pigs would be expected to have a great impact on transmission of cysticercosis. In spite of this, no studies have been published on the impact of improved sanitation on control of taeniasis/cysticercosis. A major reason for this may be the challenge involved in actually undertaking sanitation programmes since traditionally they have been hardware-driven, focused mainly on providing toilets, usually on a subsidized basis, rather than on motivating their use. As a result, a large proportion of subsidized toilets remain unused or are used for purposes other than sanitation (e.g. storage).
Community-led total sanitation (CLTS) is a relatively new approach to improving sanitation, which was pioneered by Dr Kamal Kar in Bangladesh in 1999. CLTS is a process whereby local communities are empowered to stop open defecation and to build and use latrines without any external hardware subsidy. A facilitator uses participatory rural appraisal methods to help community members recognize the links between open defecation and ill-health, such as diarrhoea, dysentery and other enteric diseases, taeniasis/cysticercosis and other helminth infections.

The facilitator then helps the local community to analyse their own sanitation profile, using a combination of CLTS tools, through a process called "triggering". The community then takes a collective decision and plans actions to stop the practice of open defecation (OD). The community mobilizes local resources, with members of a high economic standing helping the poor. A collective effort is therefore made to attain open-defecation-free (ODF) status. In this way, total sanitation can be achieved in a few weeks or months at relatively low cost. External support for hardware is not provided, although ideas for design of appropriate and affordable latrines may be shared. On the other hand, the availability of sanitary materials is promoted and private suppliers are allowed to respond to community demand.

The Handbook on community-led total sanitation, by Kamal Kar with Robert Chambers, describes in detail the process of triggering CLTS, the tools used, pre- and post-triggering activities, and scaling-up and spread of CLTS, with experiences from many countries across Africa, Asia and Latin America. The CLTS Handbook is now available in English, Spanish, French, Portuguese, Bengali and Hindi, and can be downloaded free from www.communityledtotalsanitation.org. A more recent publication by Kar, Workshops for community-led total sanitation, is available from the website of the Water Supply and Sanitation Collaborative Council (www.wsscc.org).

The key principles of CLTS are:

- People first: they can do it.
- Facilitate, don’t provide.
- No blueprint design (only people’s design).
- No household-level hardware subsidy for sanitation.
- Igniting behaviour change and totally eliminating open defecation, not just building toilets.
- The onus for progress is placed almost entirely on the community – local people are empowered to analyse the extent and risk of environmental pollution caused by open defecation.
- Focus on health outcomes, not on hardware inputs and sanitation infrastructure alone.
  - Collective action: mobilizing the community rather than establishing household contacts.
  - Local choice: accommodating a variety of technological options and getting people to access affordable technologies.
  - Setting up appropriate institutional frameworks: giving local governments a central role in scaling up and sustainability.
  - Incentives: directing incentives to the community and rewarding outcomes, rather than subsidizing household toilets.
  - Market development: promoting the availability of sanitary materials and allowing private suppliers to respond to demand.
- Policy implications
  - Financial subsidies from agencies should be used to facilitate and enhance community understanding of the risks of open defecation and to train community catalysts who can spread the programme, rather than being used to invest in material and physical infrastructure.
  - Agencies should employ a flexible approach in working with communities, allowing them to take the lead in addressing problems in their own way, instead of dictating practices.
  - Success should be measured in terms of the final outcome and sustainable behaviour change (elimination of open defecation) rather than of the final output (construction of only a few toilets of externally prescribed designs being used by only a few in the community).

The cost of CLTS to the communities, e.g. attending triggering sessions and building latrines (material costs, loss of productive time for agricultural work, etc.) needs to be considered. The impact of CLTS on taeniasis/cysticercosis, foodborne trematode infections, and soil-transmitted and other helminths has yet to be investigated. This could be done by measuring the incidence of these diseases some months or years after CLTS intervention and communities becoming open-defecation-free. A quick and easy way to measure taeniasis/cysticercosis transmission would be by measuring the incidence of porcine cysticercosis in the community.
3.2 Core intervention packages

Human tapeworm carriers and infected pigs are the only important actors in transmission of *T. solium*, and are thus the targets for prevention and control efforts. To be effective and sustainable, a practical, cost-effective combination of simple interventions, targeting both the intermediate and the definitive host, should be considered. The core interventions for taeniasis/cysticercosis include treatment of human taeniasis and treatment and vaccination of pigs, together with complementary measures, such as education, and improved sanitation, meat hygiene and pig husbandry practices.

The experience in Peru can be used as a basis for improving control tools and formulating best practice guidelines for interrupting transmission of cysticercosis. These can then be tested in pilot projects in selected endemic sites. The main components and lessons learned in Peru are as follows.

- Focus on detection, treatment and avoidance of new cases of human taeniasis and porcine cysticercosis.
- For mass treatment of tapeworm carriers, use niclosamide (2 g adult oral dose).
- For mass treatment of infected pigs, use oxendazole (30 mg/kg of body weight oral dose).
- Treat pigs initially with several doses of oxendazole to cure existing infections; then vaccinate to prevent new infections as the programme proceeds.
- Communicate clearly the impact of taeniasis/cysticercosis prevention and control on the health and economic well-being of the affected population, to ensure a high level of compliance.
- Complementary measures, such as improving sanitation, pig husbandry and meat hygiene, were not included in the programme in Peru, but are likely to be key to ensuring that efforts are sustainable.

The “best bet” options for sustainable prevention and control of taeniasis/cysticercosis are thus:

- Core “rapid impact” interventions:
  - treatment of human taeniasis;
  - mass treatment and vaccination of pigs.
- Relatively easy and inexpensive supporting measures:
  - community education;
  - improved sanitation – ending open defecation.
- Measures requiring more fundamental societal changes:
  - improved meat inspection, control and handling;
  - better pig management – no free-roaming.

3.2.1 Drugs

For humans

Praziquantel (10 mg/kg of body weight orally) and niclosamide (2 g orally) are the recognized effective drugs for treatment of human taeniasis. Praziquantel is no longer under patent and the price has decreased dramatically. Concern has been expressed about potential adverse effects from using praziquantel to treat taeniasis in people who may have asymptomatic cysticercosis, since the treatment could provoke the appearance of symptoms, such as epileptic seizures or other neurological complications. Praziquantel is already used to treat trematode infections in co-endemic areas, so its impact on taeniasis and possible adverse effects on patients with cysticercosis should be investigated. So far, reported adverse effects from widespread use of praziquantel for mass treatment of schistosomiasis in Africa in areas co-endemic for cysticercosis have been minimal. Niclosamide is considered a safer alternative for treatment of taeniasis. Results from the project in Peru suggest that the cure rate of the 2 g dose of niclosamide dose is only about 66%; it would therefore be useful to investigate the efficacy and safety of higher doses.

Whichever drug is used, consideration must be given to whether to employ mass treatment or targeted/selective treatment. This decision should be based on the local situation and the most appropriate, sustainable and cost-effective regimen. Targeted taeniasis treatment would be greatly facilitated if a cheap and simple method was available for rapid identification of tapeworm carriers.

The expert group drew the following conclusions.

- Local authorities should determine whether to employ mass or targeted treatment on the basis of cost-effectiveness, i.e. whether MDA is cheaper in the long run than detection and selective treatment.

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1 This section summarizes information compiled in a background document circulated before the meeting
Testing for and treatment of human tapeworm infections may ensure better acceptance and compliance in the communities.

The new *T. solium*-specific coproantigen test will probably not be ready for field use for several years.

The new serological test for detecting antibodies to *T. solium* taeniasis, based on synthetic recombinant antigens, is expected to be ready soon for field use for detecting cases and monitoring the success of interventions; it is expected to be inexpensive.

**Recommendation**

The group recommended that studies be carried out to determine the cost-effectiveness of MDA with a taeniacidal drug (praziquantel or niclosamide), with and without serological testing.

**Challenges and issues**

The group recognized a need for a method of confirming cure that does not require collection and handling of faeces.

**For pigs**

Oral administration of one dose of oxfendazole at 30 mg/kg of body weight is known to kill virtually all *T. solium* cysts in the muscles of pigs but not those in the brain. The drug is currently not approved for use in pigs and is not widely available; the withdrawal time\(^k\) of the drug in pork at the 30 mg/kg dose is unknown. The project in Peru relied on a 22% suspension of oxfendazole purchased from the USA for oral treatment of pigs; however, this concentration is no longer available, which means that large pigs require large volumes of the drug, leading to difficulties in administration. Attention should be given to optimizing the formulation of oxfendazole for mass treatment of pigs. The Global Alliance for Livestock Veterinary Medicines (GALVmed) is currently facilitating work to improve the formulation of oxfendazole for pigs.

**3.2.2 Vaccine**

A vaccine for porcine cysticercosis, based on an oncospheral antigen (TSOL18), is currently being field-tested. Currently, multiple doses of the TSOL18 vaccine are required to develop protective immunity to *T. solium* infection. Pigs need to be treated several times with oxfendazole to clear the parasite before they are vaccinated for long-term prevention. In the Peru project, adverse acute side-effects, such as fever, lethargy and lack of appetite, were observed in the vaccinated pigs; however, these effects were not observed in trials in Mexico. GALVmed is currently working with the University of Melbourne, Australia, and the private sector to optimize and manufacture the vaccine.

**3.2.3 Target population**

The most affected population groups are people in rural communities where pigs are raised, consumption of raw or undercooked pork is common, sanitation and pig husbandry practices are poor, and meat inspection and control lax or non-existent. In many endemic areas, pork is often sourced from pigs slaughtered outside the official meat inspection coverage. Mapping of pig populations, poverty levels, pork consumption habits and sanitation coverage, as well as an understanding of pig production systems, marketing and movements, can all assist in identifying communities at highest risk. National authorities need to establish national surveillance and reporting of cysticercosis/taeniasis cases as part of a routine system.

**3.2.4 Complementary measures**

Complementary measures that can help sustain the results of preventive chemotherapy and pig vaccination include community education, and improvement of sanitation, meat inspection and pig husbandry practices.

- Education is an essential component of any intervention package, as it creates demand for change; however, on its own it is not sufficient.
- Elimination of open defecation is a promising way of making control efforts sustainable, but its impact on cysticercosis/taeniasis prevention needs to be confirmed.

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\(^k\) Withdrawal time is the period after treatment before the animal is slaughtered and the meat consumed
Improving pork inspection and pig management are long-term measures that require fundamental societal change.

Recommendation
The group recommended that the impact of CLTS on transmission of *T. solium* should be investigated.

Challenges and issues
- There is a need to ensure that pigs do not have access to latrines.
- The possible negative impact of CLTS on smallholder pig production (e.g. there may not be enough food available for pigs if human waste is removed) should be investigated.

3.3 Community diagnosis

Epidemiological studies have demonstrated that neurocysticercosis cases tend to cluster around individuals infected with a *T. solium* tapeworm, who act as a focus of transmission. Public health follow-up of cysticercosis cases (patients with neurocysticercosis or subcutaneous nodules), including screening of household contacts, can identify tapeworm carriers, who can be treated, thus removing a potential source of further infection.

Surveillance of cysticercosis in pigs has been proposed as a practical, inexpensive and sensitive method for indirectly assessing human risk and monitoring and evaluating the effectiveness of community-based control programmes. However, some pigs may not go through the formal slaughterhouse system, especially if the farmers or pig traders suspect that they are infected. Thus, community-based surveys should be used to provide a more realistic assessment of infection. Detection of porcine cysticercosis cases is important, not only for determining whether cysticercosis/taeniasis is endemic but also for monitoring any interventions.

3.3.1 Rapid assessment and validation

Rapid epidemiological assessment
The appropriateness of and justification for interventions need to be verified through rapid epidemiological assessment of the targeted communities. Securing evidence for the public health and economic importance of cysticercosis will help ensure the commitment of local and national decision-makers to the proposed solutions. Engagement of stakeholders and other interested parties from the various relevant sectors, including veterinary, livestock and medical workers, should be promoted from the outset.

- There is a need to develop regional or national assessment procedures that can rapidly delimit endemic areas, in order to plan elimination programmes.
- There is currently no standard rapid assessment method, but such a method could be developed and validated.
- Data collection methods should be easy, convenient, non-invasive and acceptable to the communities.
- Some possible options are:
  - risk mapping, using information such as distribution of free-roaming pigs, sanitation coverage and pork consumption;
  - questionnaire surveys, key informant interviews, focus group discussions, and routine reporting from health facilities and pork inspections (slaughterhouses, butchers, pork sellers);
  - “trace back” from human or pig cysticercosis cases to the original community;
  - palpation for subcutaneous nodules in humans;
  - serological survey of blood donations.

Recommendation
Rapid assessment procedures should be developed for community diagnosis of taeniasis/cysticercosis. Pilot studies should be conducted to validate new procedures in communities at risk in different endemic regions

Challenges and issues
- New procedures will need to be tested in different regions and subregions, to determine whether they need to be adapted.

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1 This section summarizes information compiled in a background document circulated before the meeting
It would be useful to engage with the InDepth Network (International Network for the Demographic Evaluation of Populations and their Health in Developing countries), particularly its epilepsy programme in Africa.

Confirmation of infection
The expert group also considered that there was a need to confirm the presence of *T. solium* infections in order to provide evidence to justify intervention. The test used for confirmation should be inexpensive, and simple and quick to perform. Since there are likely to be relatively few taeniasis cases, detection of porcine and human cysticercosis cases will be needed. Pigs infected with cysticercosis can be used as “sentinels” of endemic transmission.

Recommendation
In communities at risk, the presence of cysticercosis in humans and pigs should be confirmed, using lingual examination or post-mortem inspection for pigs and antigen-ELISA and subcutaneous cyst biopsies for humans (see section 3.3.2).

Challenges and issues
The antigen-ELISA and the lingual examination may underestimate the true prevalence of infection. This may not be an issue if the aim is simply to show the presence of infection, but will be important if being used to monitor impact of intervention.

3.3.2 Tools for detection of infection

Tools for identifying target population groups or infected individuals can be based on questioning, parasitological examination, immunodiagnosis, molecular methods or imaging. Highly sensitive and specific tools are needed for individual diagnosis and clinical management of human cases. Test performance is less important for rapid assessment and epidemiological studies, for instance to identify “hot spots” of transmission. The tools currently available for detecting *T. solium* infection in humans and pigs are described below.

**Human taeniasis**

Human tapeworm carriers are the source of cysticercosis infection for humans and pigs. Identification of *Taenia* species infecting humans is usually based on a combination of comparative morphology and immunological and molecular diagnostic approaches. The ideal test for taeniasis should be rapid and simple to perform, have high sensitivity and specificity, be performable on samples that can be easily collected and stored, and give negative results soon after treatment for taeniasis.

**Questioning and self-detection**

Spontaneous expulsion of proglottids is not common with *T. solium* tapeworms, so people may not be aware that they are infected. Thus this method is not very effective for detecting *T. solium* taeniasis. People may have trouble distinguishing *T. solium* proglottids from other parasites. In Mexico, awareness campaigns and distribution of preserved tapeworm segments were found to improve detection.

**Stool microscopy**

Routine stool microscopy is known to have poor specificity and sensitivity for *T. solium* taeniasis, because *T. solium* eggs are excreted only intermittently and are morphologically indistinguishable from those of *T. saginata* and *T. asiatica*. The test’s sensitivity can be improved if it is repeated on different days; however this is not usually very practical.

**Peri-anal egg detection**

In Graham’s test, adhesive tape is used to collect *Taenia* spp. eggs from the skin around the anus. The tape is then examined with a microscope. The sensitivity of this test for *T. solium* is unknown and there are concerns that those administering the test (who may be poorly trained health workers or family members) may be exposed to *T. solium* eggs.

**Coproantigen detection by ELISA**

This test detects *Taenia* tapeworm-specific antigens in human faeces by a polyclonal antibody-based sandwich ELISA. Its specificity is greater than 99% and sensitivity is about 95%, which is much greater than that of routine coprology. Tapeworm antigens, which are very stable and can be kept fresh, frozen or chemically fixed, are detectable prior to patency and usually cease being excreted within a week of treatment. The test is not species-specific, so may also detect *T. saginata* and *T. asiatica*; the worms themselves will need to be collected to distinguish the species morphologically. Recent incorporation of anti-adult somatic and anti-adult excretory/secretory antibodies has led to greater specificity.
Morphological examination of tapeworm
Following treatment for taeniasis, tapeworms can be collected using purgatives and then differentiated morphologically. However, the scolex may not be expelled and the worms can decompose quickly. Morphological differences are not always clear (e.g. overlapping of number of uterine branches). Faecal material must be handled very carefully because of the risk of infection with *Taenia* eggs.

Molecular methods/copro-DNA assays
Molecular tools (PCR, PCR-restriction fragment length polymorphism (RFLP), multiplex-PCR) can be used to detect DNA of *T. solium* in faeces and can also be used on parasite samples (worms, proglottids, eggs) to determine the species and genotype. These molecular tools are highly sensitive and specific, but are also expensive, requiring special equipment and expertise, and are thus not appropriate for routine field use.

Serology
Detection of species-specific circulating antibodies against *T. solium* tapeworms in serum samples indicates a history of tapeworm infection, but does not necessarily reflect current, active infection. The original test was based on native excretory/secretory *T. solium* antigens, which made it labour-intensive, time-consuming and expensive. The most recent test is based on recombinant proteins, resulting in a much more practical and affordable test for taeniasis.

Conclusions
- Copro-antigen ELISA has long been the best option for detection of taeniasis, but it is not species-specific or commercially available. The new more specific test should be further field-tested.
- The new rapid tests for use on serum have great potential and should be further field-tested. Commercialization needs to be considered.

Human cysticercosis
The diagnosis of neurocysticercosis can be difficult because of the high proportion of cases that are asymptomatic, the non-specific signs and symptoms of the disease, and the fact that clinical manifestations develop many years after first infection. Consistent and accurate diagnostic criteria for cysticercosis should be based on a combination of exposure history, clinical presentation, subcutaneous nodule biopsy (if present), neuroimaging studies and serological tests. The ideal test for human cysticercosis should be rapid and simple to perform, have high sensitivity and specificity, be performable on samples that can be easily collected and stored, and differentiate between active, degenerated and past infection.

Parasitological methods
Cysticercosis can be detected in cadavers at autopsy. Subcutaneous cysticercosis is a common manifestation in Asia and parts of Africa, and can be detected by physical examination and biopsy of subcutaneous nodules. This is particularly useful in remote areas, where more sophisticated techniques may not be available. Brain biopsies (especially for single enhancing lesions), cysts recovered from ventricles by neuroendoscopy, and cysts recovered from open surgery can also be used to identify cysticercosis cases.

Imaging
Imaging techniques (CT and MRI) provide a safe and precise, but rather expensive, way of diagnosing cysticercosis. The equipment is not usually available in poor endemic areas of the world. Imaging can confirm the etiology of the disease, while also providing information on the intensity of infection, location of cysts and the stage of lesions. CT is more sensitive for detecting calcified cysts while MRI is more accurate for assessing the intensity of infection and the location and stage of the cysts.

Serological methods
Immunodiagnosis of cysticercosis is useful for surveillance, epidemiological surveys and community-based studies, as well as for monitoring individual treatment and community-based prevention and control programmes. Methods to detect specific antibodies – which indicate prior exposure to infection and not necessarily current active infection with viable parasites – include EITB and ELISA. The EITB is highly specific (nearly 100%) and highly sensitive (98%) for cases of neurocysticercosis with two or more viable cysts. However, it relies on acquisition and purification of native cyst material, making it labour-intensive and costly. Synthetic and recombinant antigens, e.g. rT24, have recently been developed, which give similar sensitivity and specificity. The US Centers for Disease Control and Prevention (CDC) has developed an ELISA using rT24, which is easy to perform and requires minimal equipment; this is now being developed as a lateral flow test. An antibody-detecting ELISA test developed in Japan also uses recombinant antigens with high specificity (100%) and sensitivity (90%). The possible overestimation of active infection, because of transient antibody responses or persistence of antibodies after elimination of the parasite, must be considered when community-based epidemiological studies are conducted. A highly sensitive and species-specific ELISA test for detecting circulating parasite antigens in serum and
cerebrospinal fluid has been found useful for monitoring the success of anti-parasitic treatment: it is correlated with cyst intensity and usually becomes negative within 3 months of effective treatment. However, it has limitations as a confirmatory serological test as it does not detect degenerating calcified *T. solium* cysts.

**Questioning**

A questionnaire approach, based on symptomatology (especially epilepsy) and risk factors, has been proposed for detection of probable symptomatic NCC cases and potential transmission “hot spots” in rural areas where immunodiagnosis and neuroimaging are not available. Studies are under way to validate the utility of such a questionnaire in comparison with serological testing and CT scanning.

**Conclusions**

- Action should be targeted to areas where there is high exposure, as indicated by a high seroprevalence of *Taenia* antibodies. The new rT24 ELISA, based on recombinant antigens, shows great promise as a diagnostic tool. All new tests need to be evaluated in the field.
- Reliable diagnosis of neurocysticercosis requires a combination of tools, one of which should be neuroimaging.
- Diagnostic tests suitable for clinical management of neurocysticercosis are neuroimaging and detection of cysticercosis antigen.

**Porcine cysticercosis**

Identifying infected pigs can assist in eliminating infected animals from the community, and is also useful as a measure of the exposure of pigs to *T. solium* and of the effect of intervention, i.e. the pigs serving as sentinels. An ideal test for porcine cysticercosis would be highly sensitive and specific, simple and rapid to perform, and able to differentiate between active and dead cysts. The diagnostic tests described below are available for detecting porcine cysticercosis.

**Tongue palpation**

Visual inspection and palpation of the ventral surface of the tongue is a simple and specific test for detecting cysticerci. It is used by farmers and pig traders in endemic countries as an inexpensive and quick way of identifying animals with *T. solium* cysticercosis. However, its sensitivity varies greatly, depending on the intensity of infection, from <30% at low intensity to >70% at high intensity. It is a useful tool for rapid assessment of sites to identify and monitor “hot spots”.

**Pig carcass inspection**

Inspection (and incision) of predilection sites in the pig carcass at slaughter is a simple and specific tool for determining infection status. However, it generally underestimates the prevalence of cysticercosis in the pig population, both because of its low sensitivity and because farmers and pig traders may avoid taking pigs to official slaughter establishments if they suspect that the animals are infected. When conducted properly, meat inspection provides a useful tool for rapid assessment of “hot spots”, as well as for validating diagnostic methods and intervention strategies. It also allows “trace back” of infection to farms or homes in which a *T. solium* tapeworm carrier may be present, thus pinpointing a site for targeted treatment.

**Serological diagnosis**

Immunodiagnostic tests developed for detecting human cysticercosis (e.g. EITB, antibody-ELISA and antigen-ELISA) have been adapted for testing pigs. Serological tests are more sensitive than lingual examination, and are appropriate for use in prevalence and community-based surveys and intervention studies. Tests that detect antibodies may overestimate the prevalence of infection, because of the long-term persistence of maternal antibodies in piglets born to *T. solium*-infected sows and because pigs may develop a transient antibody response without a patent infection becoming established. The antigen-ELISA is a very sensitive test for porcine cysticercosis, but its current lack of species specificity does not allow differentiation of larval *T. solium* infections from larval infections with other *Taenia* species (i.e. *T. hydatigena* and *T. asiatica*); this is a problem in areas where these parasites co-exist (e.g. South-East Asia).

Efforts are currently under way to improve detection of porcine cysticercosis, by:
- improving the specificity of antigen-ELISA through the use of camelid-derived single-domain antibody fragments (nanobodies);
- simplifying and lowering the cost of detection of antibodies, through the use of recombinant antigens;
- developing tests that can be carried out where the pigs are kept (pen-side tests).
3.4 The way forward

3.4.1 Pilot interventions

The participants in the Consultation agreed that there are not yet sufficient appropriate tools for pilot interventions for control or elimination of *T. solium* taeniasis/cysticercosis. A number of operational research issues will need to be dealt with and improved tools developed over the next 2–3 years, as outlined below. In the interim, however, there may be opportunities to assess the collateral benefits of control programmes for other relevant neglected tropical diseases on transmission of taeniasis/cysticercosis, such as the integrated NTD control programmes in Africa and elsewhere, and the planned pilot projects for control of FBTs in Bolivia, China, the Philippines, and the border of the Lao People’s Democratic Republic and Cambodia (see section 2.4.1).

3.4.2 Operational research

A number of important operational constraints to efforts to control or eliminate taeniasis/cysticercosis were identified during the Consultation. A research plan to address these operational issues was formulated, with the aim of being “tool ready” for pilot control projects within 2–3 years. The priority operational issues and tools needed are listed below.

- **Rapid assessment methods for community diagnosis of taeniasis/cysticercosis should be developed and validated in different endemic regions.**
  - An agreed standardized method is needed, which is easy and convenient to use, non-invasive and acceptable to the affected communities.
  - An interagency working group on taeniasis/cysticercosis should be established to facilitate risk mapping.
  - WHO should coordinate the collaboration of the multiple stakeholders.

- **A strategy for identifying, treating and monitoring *T. solium* taeniasis should be developed and validated.**
  - The efficacy and safety of praziquantel (10 mg/kg of body weight) and niclosamide (at doses greater than the current 2 g) for taeniasis treatment should be compared.
  - An agreed standardized protocol is needed for detection, treatment and monitoring of *T. solium* taeniasis, which should then be validated in the field.
  - These efforts should be led by the Cysticercosis Working Group in Peru, with financial and technical support from WHO.

- **Rapid, specific, field-applicable tools for detecting human and porcine *T. solium* infections should be developed.**
  - Rapid tests for detecting porcine cysticercosis and human taeniasis/cysticercosis that can be used at the penside or point of care need to be developed, evaluated and made available.
  - A species-specific antigen-ELISA is needed for detecting *T. solium* cysticercosis in pigs.
  - These efforts should be led by the US Centers for Disease Control and Prevention and the Institute of Tropical Medicine, Antwerp, Belgium.

- **The vaccine and specific treatment for porcine cysticercosis should be improved.**
  - Field tests of the vaccine should be completed, refined and scaled up.
  - Oxendazole should be registered for use in pigs.
  - The withdrawal time following a 30 mg/kg of body weight dose of oxendazole should be determined.
  - Oxendazole needs to be made readily available in an acceptable format.
  - Consensus is needed on a strategy for prevention and control of porcine cysticercosis, based on treatment with or without vaccination.
  - These efforts should be led by GALVmed.

- **The impact of CLTS on transmission of taeniasis/cysticercosis should be investigated.**
  - Studies should be conducted in pilot sites (e.g. Bolivia, Lao People’s Democratic Republic and Zambia) to compare the impact of preventive chemotherapy, with and without CLTS, on transmission of taeniasis/cysticercosis.
  - These efforts should be led by WHO.

Better documentation of the socioeconomic impact of cysticercosis and a better understanding of the transmission dynamics of taeniasis/cysticercosis in the different endemic regions are also urgently needed. The public health and economic relevance of cysticercosis, its impact on marginalized populations and its link with poverty need to be better documented, in order to raise awareness among affected communities, decision-makers and potential investors in efforts to combat the problem. Political will is a key factor for sustainability of control efforts, and depends on decision-makers understanding the burden of cysticercosis and its impact on health, agricultural systems and overall development, as well as on the affected populations demanding action.
Part B.
Recommendations from the Meeting
4. Recommendations

4.1 On disease control

4.1.1 General recommendations

1. Policies and recommendations for control of foodborne trematode infections and taeniasis/cysticercosis should be developed and adopted by the governments of endemic countries and all implementing agencies or institutions; human and financial resources should be mobilized and allocated by the governments concerned.

2. The following three areas should be specifically addressed:
   a. Awareness of the diseases should be raised in the affected communities, including recognition of their symptoms and signs, and knowledge of available control measures and prevention, through improved cooperation between the primary health care, sanitation and general education sectors.
   b. Individual case management should be strengthened.
   c. Capacity and expertise for control of neglected tropical diseases in general, and FBT infections and taeniasis/cysticercosis in particular, should be strengthened at all levels. Particular attention should be given to:
      ▪ laboratory testing and equipment (e.g. diagnosis, technology transfer, referral centres, quality control, commercialization of simple tests);
      ▪ integrated management (e.g. control programme management, forecasting and monitoring, and supply of drugs and reagents);
      ▪ information system and data reporting.

3. Intersectoral task forces should be established to ensure coordination, especially in the fields of human and animal public health, education, and optimal use of available facilities and information.

4. The optimal use and sharing of resources should be encouraged, as well as an increased synergy with other ongoing communicable disease public health interventions (e.g. Global Fund to Fight AIDS, Tuberculosis and Malaria, International League Against Epilepsy, International Bureau for Epilepsy, Neurocysticercosis and Epilepsy Research Network)

4.1.2 Technical recommendations

1. All epidemiological information available at country level should be compiled and reviewed in order to complete risk mapping of the diseases. Small interagency (intersectoral) working groups should be established to further this work.

2. Rapid assessment tools should be developed and validated, with the aim of identifying areas at risk. International research groups focussing on human and animal health, such as the Regional Network for Asian Schistosomiasis and other Helminth Zoonoses (RNAS+) should be involved in these activities.

3. Preventive chemotherapy is the core intervention in control of opisthorchiasis, clonorchiasis and taeniasis, and is an option in control of fascioliasis. Its role in control of paragonimiasis still needs to be elucidated.

4. Monitoring and evaluation are essential components of any control intervention against foodborne trematode infections and taeniasis/cysticercosis

5. Disease control activities against foodborne trematode infections and taeniasis/cysticercosis should involve a wide range of sectors, such as human health, veterinary public health, livestock production, food industry, water supply, sanitation, education, environmental management and socioeconomic development.
6. Disease-specific guidelines on disease control should be developed and included as part of the report of the present meeting\(^\text{\textsuperscript{6}}\). The guidelines should include recommendations to control programme managers, covering the following aspects:

   a. identification of communities at risk;
   b. intervention strategy;
   c. monitoring and evaluation;
   d. improvement of case management by existing medical services.

4.2 On research

4.2.1 General recommendations

1. The potential impact of novel approaches to sanitation, such as community-led total sanitation, on transmission of helminth infections, and specifically on foodborne trematode infections and taeniasis/cysticercosis, should be explored.

2. Mapping of the distribution of snail, fish and crustacean intermediate hosts should be promoted and encouraged.

3. The development of molecular tools for characterization of snail intermediate hosts should be promoted and encouraged.

4. Assessment of the risk of foodborne trematode infections, through monitoring of animal health, should be promoted and encouraged.

5. The economic benefits of integrated and intersectoral control of foodborne trematode infections and taeniasis/cysticercosis should be promoted and encouraged.

6. Drug use in animal health should be monitored in order to better identify signals of potential resistance.

4.2.2 Technical recommendations

**Clonorchiasis and opisthorchiasis**

a. Two rapid assessment methodologies for identifying areas at risk should be compared:
   - the classical method, i.e. sampling a representative number of individuals in a defined number of schools or villages in the suspected area;
   - the lot-quality assurance sampling (LQAS) method: developed and used in the manufacturing sector for product quality control, this method allows a smaller number of individuals to be sampled in a larger number of sites.

b. Two intervention strategies for areas at low risk of clonorchiasis and opisthorchiasis should be compared:
   - universal treatment (mass drug administration) once every 24 months;
   - targeted treatment, once every 12 months, of individuals who report habitually eating raw fish.

c. Molecular biology tools that can differentiate between *O. viverrini*, *C. sinensis* and MIF should be developed and validated.

d. The role of animal reservoir hosts in transmission should be investigated.

e. The impact of CLTS on transmission of opisthorchiasis and clonorchiasis should be investigated.

**Fascioliasis**

a. The efficacy of triclabendazole in both humans and animals should be monitored, in order to mitigate the risk of development of resistance.

b. New drugs and screening tests for human fascioliasis should be developed.

\(^{6}\) The guidelines are given in Sections 5 and 6.
Paragonimiasis
a. The performance and limits of individual case management in addressing the public health control of paragonimiasis should be investigated.
b. The usefulness of preventive chemotherapy in the control of paragonimiasis should also be investigated.

Taeniasis/cysticercosis
a. Rapid assessment methods for community diagnosis of taeniasis/cysticercosis should be developed and validated in different endemic regions.
b. Rapid, specific, field-applicable diagnostic tools for detecting and monitoring human and porcine *T. solium* infections should be developed. In particular:
   - the specificity of antigen-ELISA for testing pigs should be improved;
   - a simple and cheap test to detect human taeniasis should be further elaborated.
c. A strategy for identifying, treating and monitoring *T. solium* taeniasis should be developed and validated. In this context, the efficacy and safety of praziquantel (10mg/kg of body weight) and niclosamide (>2g single dose) for taeniasis treatment should be compared.
d. The vaccine and specific treatment for porcine cysticercosis should be improved.
e. The impact of CLTS on transmission of taeniasis/cysticercosis should be investigated.
Part C.
Disease Prevention and Control
5. Prevention and control of foodborne trematode infections

5.1 Clonorchiasis and opisthorchiasis

5.1.1 Identification of endemic areas

Morbidity and mortality reporting system
In areas where clonorchiasis and/or opisthorchiasis are known or suspected to occur, both diseases, together with their clinical manifestations (such as ascites) and associated pathology (such as cholangiocarcinoma (CCA)), should be included in the routine morbidity and mortality reporting system. This will allow endemic areas to be identified and stratified through detection of clustered cases.

Rapid assessment
While the morbidity and mortality reporting system is being put in place, it is recommended that available information on the occurrence of the diseases should be collected from local or referral hospitals and treatment centres, or by reviewing the available published and unpublished literature for epidemiological surveys. In the absence of any written documentation, local health officers may be able to provide reliable information for the identification of foci of transmission.

If no information is available on the diseases, a rapid screening of suspected areas can be conducted by compiling the available information on the habit of eating raw or undercooked freshwater fish, or by carrying out a questionnaire survey on the topic in a sample of the population living in the suspected area. Information on detection of C. sinensis or O. viverrini metacercariae in fish can be obtained from fisheries institutions and can help in the identification of suspected areas.

The available information should be stratified by district, allowing a first classification of districts as endemic or non-endemic. Attention should be given to the district of origin of each patient, so as to better determine the site where the infection took place, and rule out imported cases.

Epidemiological surveys
In endemic districts, the epidemiology of the diseases under study should be investigated with the aim of classifying each district according to level of risk, based on prevalence of infection. Should such information be readily available, there is no need to conduct further surveys.

If a survey is needed, the Kato-Katz thick smear test should be used. It is recommended that individuals from all age groups should be included in the sample. Children may be easier to survey, but in some communities they do not eat raw fish, even though the practice is common among adults. Exclusively surveying children might therefore lead to the erroneous conclusion that clonorchiasis and opisthorchiasis are not transmitted in the community. A sampling approach based on age stratification will also provide information on the groups at highest risk.

Survey methodology
Classical sampling remains the recommended methodology for classifying endemic districts according to level of risk. Lot quality assurance sampling (LQAS) has been suggested as a valid alternative, but its use in FBT infections still needs to be validated.

- Classical sampling. This methodology is based on the one used to assess the significance of soil-transmitted helminth infections at district level.
  - In each district, select a number of sample villages, with a proportion of 1:25 000 inhabitants (that is, 4 villages for every 100 000 inhabitants). Examples: if the district has a population of 50 000, select 2 villages; if a district has a population of 150 000, select 6 villages.
  - In each village, sample between 50 and 100 individuals: 50% should be schoolchildren aged 5–14 years, and 50% adults (>15 years). Make sure that the proportions of males and females reflect the proportions in the population.
  - Collect stool samples from each individual and screen them for C. sinensis and O. viverrini eggs using the Kato-Katz technique.
  - Calculate the prevalence of infection. Also note the intensity of infection (the same sites could also be used as sentinel sites for monitoring and evaluation; see below).

- LQAS. This methodology was originally used in the manufacturing sector for product quality control. A sample of “lots” of goods is inspected; those lots with fewer than a predetermined number of defective pieces are considered of acceptable quality, and those with more are rejected. LQAS is not designed to estimate the proportion of defective pieces in a given lot, but only to classify the proportion as above or below a given threshold.
LQAS has also been applied in public health contexts. For example, to assess whether a given area can be considered as high risk or low risk for a given disease, the resident population is divided into “lots”. The target survey unit is defined (e.g. “an individual infected with clonorchiasis or opisthorchiasis”), an operational threshold of prevalence of infection is set as defining high risk, and a corresponding sampling plan is calculated, i.e. the number of individuals to be sampled in each lot (n) and the maximum allowable number of infected individuals (d). Those lots with fewer than the threshold number of infected individuals are considered as low risk, and those with more are considered high risk.

LQAS has been applied in Madagascar for rapid, low-cost identification of communities that were hyperendemic for *Schistosoma mansoni* infection. The school was adopted as the lot, schoolchildren aged 5–14 years were selected as the target survey unit and a prevalence of 60% was chosen as the threshold of high risk. Various sampling plans were selected and tested (n=14 and d=5; n=12 and d=4; n=10 and d=3; n=8 and d=2; n=6 and d=1; n=4 and d=0). The sensitivity of LQAS was in most cases 100%, while specificity was between 15% and 55%. LQAS has also been employed for rapid stratification of high- and low-risk communities in *S. mansoni*-endemic areas in Uganda. Research is under way to assess its applicability to other helminth infections (S. Brooker, unpublished data) and its use in the evaluation of malaria outcome indicators.

Quality control

It is recommended that a subsample of faecal specimens be cross-checked using the formol ethyl acetate concentration technique (FECT), in order to differentiate between *C. sinensis*, *O. viverrini* and MIF eggs. The pathogenicity of MIF infections has not yet been clearly demonstrated.


5.1.2 Intervention strategy

Preventive chemotherapy, the large-scale distribution of anthelminthic drugs to populations at-risk, is the main intervention strategy against clonorchiasis and opisthorchiasis. Table 5.1 summarizes the recommended action according to level of prevalence of infection. A few key recommendations regarding implementation are given here.

- Take the district as the implementation unit (a sub-district is acceptable if the population in the district is large).
- Implement the same strategy in all communities in the district, based on the information collected in the sampled villages.
- Use the WHO recommended drug and dosage for large-scale interventions, i.e. praziquantel (PZQ), 40 mg/kg of body weight, in a single administration.
- Use weighing scales for calculating the dose. Alternatively, for school-age children, the WHO tablet dose-pole for PZQ can be used.
- For low-risk districts, both option 1 and option 2 in Table 5.1 are acceptable. However, an appropriate, standardized methodology for option 2 still needs to be identified and validated.
- Try to keep the interval of retreatment as regular as possible (e.g. always give treatment during the same month).

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Table 5.1 Recommended treatment schedules for control of clonorchiasis and opisthorchiasis through preventive chemotherapy

<table>
<thead>
<tr>
<th>District</th>
<th>Prevalence of infection in the sample population</th>
<th>Action to be taken</th>
<th>Type of intervention and target population</th>
<th>Interval of re-treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High risk</td>
<td>20%</td>
<td>Universal treatment (MDA)</td>
<td>Treat all the individuals in the district</td>
<td>12 months</td>
</tr>
<tr>
<td>Low risk</td>
<td>&lt; 20%</td>
<td>Option 1: Universal treatment (MDA)</td>
<td>Treat all the individuals in the district</td>
<td>24 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Option 2: Targeted treatment</td>
<td>Treat all the individuals in the district who report habitually eating raw fish</td>
<td>12 months</td>
</tr>
</tbody>
</table>

\[ Use PZQ, 40 mg per kg of body weight, in a single dose. \]

In addition to being used for preventive chemotherapy, PZQ should be made available in peripheral health centres in all suspected districts for individual case management of infected individuals. The diagnostic protocol should be adapted to the diagnostic tools available in peripheral health settings.

Severely ill individuals and children below 4 years of age should be excluded from preventive chemotherapy interventions. They may, however, be treated in an individual case-management context, if the physician judges it acceptable and under medical supervision. Pregnant and lactating women can be given PZQ both for individual case-management and as preventive chemotherapy.

**Adverse events following treatment**
PZQ has been shown to be a safe drug for both individual case management and preventive chemotherapy. However, especially when large numbers of people are treated, it is likely that some will experience adverse events (AEs) following treatment. AEs are mainly systemic and are linked to biological substances released by the dying worms. They include headache, abdominal pain, dizziness and urticaria, and are usually mild and transient. The occurrence of mechanical AEs, linked to the expulsion of dead worms from the hepatobiliary system, is rare. AEs are in all cases more frequent and/or severe in patients with a heavy worm burden, and therefore occur mainly in populations that have not previously been treated. They will therefore be more common during the first round of preventive chemotherapy, and their frequency will decrease in subsequent rounds.

Serious adverse events (SAEs), i.e. an AE that results in death, a life-threatening condition, admission to hospital or prolongation of a hospital stay, or persistent or significant disability or incapacity, are extremely rare. A system for detecting and reporting AEs and SAEs should be in place in conjunction with any treatment intervention. SAEs should be reported to the relevant authority, using definitions and forms given elsewhere.

**5.1.3 Monitoring and evaluation**
The purpose of monitoring and evaluation is to assess the impact of the implemented activities on the target population. This is done by following up a given set of indicators, which evolve and change as a consequence of the activities.

**Morbidity and mortality indicators**
- Annual trends in the number of cases of clonorchiasis or opisthorchiasis, or of their manifestations (ascites and CCA), diagnosed at local or referral hospitals or reported from the district under study offer a useful indication of the progress made.
- Summary statistics from different hospitals and districts allow comparison between different implementation units. Trends in one particular hospital or district can be followed over time.
- Data can be stratified at subdistrict, village or community level, to obtain a more detailed picture of the epidemiological situation.
- It is important to advocate with the relevant health authority for registration of cases and their inclusion in the routine morbidity and mortality reporting system.

Parasitological indicators
- Before preventive chemotherapy interventions are implemented, the baseline prevalence and intensity of infection of clonorchiasis and opisthorchiasis should be assessed by conducting parasitological investigations on a sample of the target population in selected sentinel sites. Such sentinel sites should also be followed up over time (ideally once a year; otherwise once every two years) with the aim of assessing the public health impact of the activities implemented. If epidemiological surveys were carried out earlier to classify the endemic areas, the sentinel sites can be selected from those already surveyed.
- Surveys should make use of the Kato-Katz thick smear technique to identify worms’ eggs in fresh stool samples. One sample per person and one slide per sample are sufficient. The indicators to be followed up are prevalence and intensity of infection with *C. sinensis* or *O. viverrini*, calculated on the basis of finding eggs of either parasite in the stool samples. Intensity of infection should be given as eggs per gram of faeces (epg). Quality control should be carried out on a subsample of slides to distinguish between eggs of *C. sinensis*, *O. viverrini* and MIF.
- Logistically, schoolchildren are easier to sample than any other population group. In the identified sentinel sites, baseline and follow-up surveys can therefore take place at schools, targeting children aged 5–14 years where this population group is known to be at risk of infection. In areas where only adults consume raw or undercooked fish, the adult population in the village should be sampled. The age and sex distribution of the habit of eating raw fish can be assessed through a questionnaire survey. If appropriate and feasible, both children and adults should be sampled in the same sentinel site.
- Programme managers should use judgement in selecting the number of sentinel sites, depending on the epidemiology of the disease or the scale of the control interventions. Monitoring and evaluation are important components of any disease control intervention, but should not overburden the programme; common sense should be applied. As a general rule, where the number of individuals targeted is below 2 million, one or two sentinel sites per 200 000 individuals appear to offer an adequate representation. If larger numbers are targeted, a lower number of sentinel sites (e.g. 1 per 500 000 target individuals) can be sampled. Between 50 and 100 children per school or adults per village appear adequate in all cases. In high-risk districts, follow-up should take place at annual or biannual intervals, immediately before the following round of treatment is implemented. More spaced intervals are acceptable in low-risk districts, and in areas where the logistic arrangements are challenging.

Other indicators
Additional indicators can be monitored and evaluated in a subsample of the units, where this is justified by the epidemiology of the disease, the availability of resources or a specific interest.
- Monitoring and evaluation of morbidity using ultrasound. A portable ultrasound machine can be used to obtain images of the liver for screening suspected individuals. Indicators associated with clonorchiasis and opisthorchiasis include increased periductal echogenicity (IPDE), diffuse dilatation of the intrahepatic bile ducts (DDIHD), and especially floating echogenic foci in the gallbladder (FEFGB).
- Infection rates in intermediate and reservoir hosts can also be monitored and evaluated using PCR.
- The proportion of fish or crustacean farms that have received a quality certificate from the national agriculture or aquaculture authorities can also be monitored and evaluated.

Quality control
Differentiation between eggs of *C. sinensis*, *O. viverrini* and MIF should be carried out using the formol ethyl acetate concentration technique (FECT) on a subsample of the slides.

5.1.4 Complementary public health interventions
Implementation of treatment activities against clonorchiasis and opisthorchiasis should be complemented, where feasible, by the following measures:

Rapid-impact interventions
- Measures to decrease human faecal contamination of aquaculture systems and cultured fish ponds (sanitation).

Long-term measures
- Improved food-safety measures on aquatic products in the premarketing stage, including the development of a system for certification of fish farms by the national agriculture or aquaculture authorities.
- Information, education and communication on safe food practices.
- Improvement of sanitation, aimed at decreasing contamination of freshwater streams with human faeces.
- Control or containment of the snail intermediate hosts.
5.2 Fascioliasis

5.2.1 Identification of endemic areas

Morbidity and mortality reporting system
Human fascioliasis should be included in the routine morbidity and mortality reporting systems of all countries. This will allow the epidemiological situation in each country to be assessed, and endemic areas to be identified and stratified through detection of clustered cases.

Rapid assessment
While the morbidity and mortality reporting system is being put in place, it is recommended that information on the occurrence of cases of human fascioliasis should be collected from local or referral hospitals and treatment centres, or by reviewing the available published and unpublished literature for epidemiological surveys. In the absence of any written documentation, local health officers may be able to provide reliable information for the identification of foci of transmission.

The available information should be stratified by district, allowing a first classification of districts as endemic or non-endemic. Attention should be given to the district of origin of each patient, so as to better determine the site where the infection took place, and rule out imported cases.

If cases of animal fascioliasis are known to occur in a given country or area, there is a risk of transmission to humans; the epidemiological situation of fascioliasis in humans should therefore be assessed further.

Epidemiological surveys
Epidemiological surveys should be implemented in those areas where it is suspected that there are a high number of cases. The aim is to detect clustering of cases or high-risk areas where implementation of preventive chemotherapy would be an option.

Survey methodology
The survey should take place in primary schools. In each target district, 3–5 schools (depending on district size and population) should be selected; in each school, between 50 and 100 children should be sampled.

Since fascioliasis has a hypo-endemic pattern in most settings, a first screening of stool samples should be carried out using a copro-antigen test. A direct parasitological test (Kato-Katz thick smear) can then be carried out on the copro-antigen-positive samples. One sample of faeces should be taken from every child; a single Kato-Katz thick smear should be prepared from each copro-antigen-positive sample.

Where fascioliasis is known to occur exclusively or mainly in adults, the survey should be implemented in this population group.

Indicators to be assessed are:
(1) prevalence of infection with *Fasciola* spp., as assessed by the copro-antigen test;
(2) prevalence of infection with *Fasciola* spp., as assessed by the Kato-Katz thick smear; and
(3) intensity of infection with *Fasciola* spp., as assessed by the Kato-Katz thick smear, expressed as epg.

5.2.2 Intervention strategy

In all endemic districts (i.e. those with cases of human fascioliasis), triclabendazole should be made available in central and peripheral health centres for case management of infected individuals. The diagnostic protocol adopted should reflect the availability of diagnostic tools in each setting. The example below shows one possible way of organizing control of fascioliasis, based on individual case management. The diagnostic criteria and case definition are progressively simplified from central to peripheral level, to avoid unnecessary referral of patients to a higher level and ensure that treatment is offered to the highest possible number of individuals in need. Each country should decide on the most appropriate combination of diagnostic tests, depending on the availability of resources and technical facilities.
Suggested diagnostic criteria for administration of treatment against fascioliasis in endemic districts

Central-level hospitals
Treatment is administered on the basis of a combination of the following criteria and diagnostic tests, according to the physician’s judgement:
- history of consumption of raw aquatic vegetables;
- a clinical picture suggestive of fascioliasis, such as abdominal pain in the epigastric or right-upper quadrant region, lasting at least a week;
- eosinophilia;
- ultrasound or CT scan suggestive of fascioliasis;
- detection of Fasciola spp. eggs in stool samples (by Kato-Katz thick smear or sedimentation technique);
- positive immunodiagnostic test (on serum, stool or urine specimen).

Intermediate-level hospitals
Treatment is administered when both the conditions mentioned under (1) are met and one of the conditions mentioned under (2):
1. Both these should be present:
   - history of consumption of raw aquatic vegetables;
   - a clinical picture suggestive of fascioliasis, such as abdominal pain in the epigastric or right-upper quadrant region, lasting at least a week.
2. Plus, one of the following:
   - eosinophilia;
   - ultrasound scan suggestive of fascioliasis;
   - detection of Fasciola spp. eggs in stool samples (by Kato-Katz thick smear or sedimentation technique);
   - positive immunodiagnostic test (on serum, stool or urine specimen)

Peripheral-level hospitals, dispensaries, health centres
Treatment is administered when both the following conditions are met:
- history of consumption of raw aquatic vegetables; and
- abdominal pain in the epigastric or right-upper quadrant region, lasting at least a week.
If possible, diagnosis should be confirmed, either by detection of Fasciola spp. eggs in stool samples (by Kato-Katz thick smear or sedimentation technique) or using an immunodiagnostic test (on serum, stool or urine specimen).

In districts where there appears to be a clustering of cases of human fascioliasis, as shown by epidemiological surveys or other methods, the possibility of administering preventive chemotherapy in the subdistricts, villages or communities where the cluster has been found should be considered. Preventive chemotherapy in foci of transmission can be implemented as targeted treatment of school-age children (5–14 years), as they usually have the highest prevalence and intensity of infection, or as universal treatment (MDA) of the entire resident population.

The recommended drug in all cases is triclabendazole (TCZ), 10 mg/kg of body weight, given in a single administration. In management of individual cases, a double dose (20 mg/kg of body weight) can be administered in case of treatment failure or if the physician judges it necessary.

Severely ill individuals should not be treated. Children below 4 years of age and pregnant and lactating women should not be given preventive chemotherapy, but can be treated individually under medical supervision.

In individual case-management, as well as for monitoring and evaluation purposes, the intensity of infection at individual level, based on the Kato-Katz thick smear, can be classified as follows: 1–99 epg: light infection; 100–399 epg: moderate infection; 400 epg: heavy infection.

Adverse events following treatment
TCZ has been shown to be safe for the treatment of fascioliasis, both in individual case management and in the context of preventive chemotherapy. However, especially when large numbers of individuals are treated, it is likely that some of them will experience adverse events (AEs) following treatment. AEs are of two types: systemic and mechanical.
- Systemic events are mainly linked to biological substances released by the dying worms. They include: sweating, weakness, abdominal pain, dizziness, headache, nausea, urticaria, and cough, and are usually mild and transient.
Mechanical events are generally linked to the expulsion of dead worms from the hepatobiliary system, and include biliary colic, possibly associated with jaundice. While the occurrence of systemic AEs is approximately the same in all age groups, mechanical AEs occur more frequently in children, because of the smaller size of the bile ducts, which therefore offer a higher resistance to the expulsion of the worms. Both systemic and mechanical AEs are more frequent and severe in patients with a heavy worm burden, and therefore occur mainly in populations that have not previously been treated. They will therefore be common during the first treatment intervention or round of preventive chemotherapy, and their frequency will subsequently decrease. Serious adverse events (SAEs), i.e. an AE that results in death, a life-threatening condition, admission to hospital or prolongation of a hospital stay, or persistent or significant disability or incapacity, are extremely rare. A system for detecting and reporting AEs and SAEs should be in place in conjunction with any treatment intervention. SAEs should be reported to the relevant authority using the definitions and forms given elsewhere.

5.2.3 Monitoring and evaluation

The purpose of monitoring and evaluation is to assess the impact of the implemented activities on the target population. This is done by following up a given set of indicators, which evolve and change as a consequence of the activities.

Morbidity and mortality indicators
- Annual trends in the number of cases of fascioliasis diagnosed at local or referral hospitals or reported from the district under study offer a useful indication of the progress made.
- Summary statistics from different hospitals and districts allow comparison between different implementation units. Trends in one hospital or district can be followed over time.
- Data can be stratified at subdistrict, village or community level, to obtain a more detailed picture of the epidemiological situation.
- It is important to advocate for registration of cases with the relevant health authority.

Parasitological indicators
- Before any disease control activities are implemented, the baseline prevalence and intensity of infection of fascioliasis should be assessed by conducting field surveys on a sample of the population in selected sentinel sites. This is especially important if preventive chemotherapy is being considered. The sentinel sites should also be followed up over time (ideally once a year; otherwise, once every two years), with the aim of assessing the public health impact of the activities implemented or simply the natural evolution of the disease epidemiology (individual case management would not be expected to change transmission rates). If epidemiological surveys were carried out earlier to identify the endemic areas, the sentinel sites for monitoring and evaluation purposes can be selected from those already surveyed.
- Monitoring and evaluation surveys should make use of the Kato-Katz thick smear technique for the identification of the worms’ eggs in fresh stool samples. If sufficient resources are available, the collected faecal samples should be screened beforehand using a coproantigen-detection test (since the prevalence of infection with fascioliasis is frequently moderate or low). Combined use of the Kato-Katz and coproantigen tests would allow both key indicators to be assessed: prevalence (both tests) and intensity of infection (Kato-Katz). Intensity of infection should be given as eggs per gram of faeces (epg). In sentinel sites, baseline and follow-up surveys should take place at schools and target school-age children (5–14 years).
- Programme managers should use judgement in selecting the number of sentinel sites, depending on the epidemiology of the disease or the scale of the control interventions. As a general rule, where the number of individuals targeted is below 2 million, one or two schools per 200,000 individuals appear to offer an adequate representation. If larger numbers are targeted, a lower number of schools (e.g. 1 per 500,000 target individuals) can be sampled. Between 50 and 100 children per school appear adequate in all cases. Follow-up should take place at intervals of two years, before the following round of treatment is implemented. More spaced intervals are also acceptable if resources are limited.

Other indicators
Additional indicators can be monitored and evaluated in a subsample of the units, where this is justified by the epidemiology of the disease, the availability of resources or a specific interest.
- Haemoglobin concentration/anaemia. Low haemoglobin levels have been shown to be associated with fascioliasis, and to be related to the number of worms infecting an individual and the number of eggs per gram of faeces. When intensive control interventions, such as preventive chemotherapy, are

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implemented in areas where prevalence and intensity of fascioliasis are significant, an increase in haemoglobin concentration and a decrease in the prevalence of anaemia can be observed in the medium term.

- Imaging. A portable ultrasound machine can be used to obtain images of the liver for screening suspected individuals. Indicators associated with fascioliasis include hypo-echogenic areas within the liver parenchyma (in the acute phase), and the distension and thickening of the wall of the gallbladder, dilatation and wall-thickening of the common bile duct, dilatation of the intrahepatic bile duct, and hyper-echogenic structures or masses in the gallbladder, either floating or attached to the wall (in the chronic phase).

5.2.4 Complementary public health interventions

Implementation of treatment activities against fascioliasis should be complemented, where feasible, by the following measures:

Rapid-impact interventions
- Veterinary public health measures, including treatment of domestic animals with fasciolicides other than TCZ in areas where the disease is common in humans, in order to minimize the risk of resistance), and fencing off of suspected grazing lands.

Long-term measures
- Information, education and communication promoting: separation between animal grazing lands and human living and cultivation areas; cultivation of vegetables in water free from faecal pollution; and thorough cooking of vegetables before consumption
- Control or containment of the snail intermediate hosts.
- Drainage of grazing lands.

5.3 Paragonimiasis

5.3.1 Identification of endemic areas

Morbidity and mortality reporting system
Paragonimiasis should be included in the routine morbidity and mortality reporting system of all areas where it is suspected to occur. This will allow endemic areas to be identified and stratified through detection of clustered cases.

Rapid assessment
While the morbidity and mortality reporting system is being put in place, it is recommended that information on the occurrence of the disease be collected from local or referral hospitals and treatment centres, or by reviewing the available published and unpublished literature for epidemiological surveys. In the absence of any written documentation, local health officers may be able to provide reliable information.

If there is no information available on the disease, suspected areas can be rapidly screened by compiling available information, or carrying out a questionnaire survey, on the habit of eating raw crabs or other crustaceans. Suspected areas can also be identified by looking for clusters of individuals who respond poorly to tuberculosis treatment.

The available information should be stratified by district, allowing a first classification of districts as endemic or non-endemic. Attention should be given to the district of origin of each patient, so as to better determine the site where the infection took place, and rule out imported cases.
Detection of cases and identification of foci of transmission

In all endemic districts, screening for *Paragonimus* spp. eggs should be included in the sputum screening of individuals with suspected tuberculosis.

**Sputum screening**

*Paragonimus* spp. eggs can be observed directly in a small amount of sputum under the microscope. The eggs are more than ten times bigger than red blood cells and can be seen even under low power. Since the eggs are destroyed by Ziehl-Neelsen stain, which is used to detect *Mycobacterium tuberculosis*, separate sputum examinations for paragonimiasis and tuberculosis are recommended. If this is not feasible, sputum should be examined first for *Paragonimus* spp. eggs and immediately after for acid-fast bacilli by the Ziehl-Neelsen method.\(^5\)

Foci in endemic districts can also be identified using questionnaire surveys of food habits, as mentioned above, or of symptoms such as chronic cough and bloody or rusty sputum.

5.3.2 Intervention strategy

In all endemic districts, triclabendazole (TCZ) or, if this drug is not available, praziquantel (PZQ) should be available in peripheral health centres for case management of infected or suspected individuals.

- Infected individuals are all those with a confirmed diagnosis of paragonimiasis, whether detected through the tuberculosis sputum screening activities or through any other diagnostic process as mentioned in section 2.3 above. The diagnostic protocol should be adapted to the tools available in peripheral health settings. In all cases, in view of the poor sensitivity of the diagnostic tests available, the protocol should be as inclusive as possible, to minimize the risk of leaving infected individuals untreated.

In areas where cases appear to be clustered, treatment should be offered to people suspected of having paragonimiasis, as well as those with a confirmed diagnosis.

- Suspected infected individuals are those coming from an endemic district, who have a history of consumption of raw crabs or other raw crustaceans, and who present any one of the following characteristics:
  - cough lasting for more than 3 weeks;
  - bloody or rusty sputum;
  - clinically or radiologically diagnosed tuberculosis with a negative sputum smear (smear-negative tuberculosis);
  - poor or no response to tuberculosis treatment.

For both confirmed and suspected cases, the recommended treatment regimen is: TCZ, 20 mg/kg of body weight, in two divided doses of 10 mg/kg of body weight, to be administered on the same day. Alternatively, PZQ may be given, at a dose of 25 mg/kg of body weight, 3 times a day for 3 days (this regimen should be adopted only if the patient can be expected to comply with the treatment).

In communities and villages where cases of paragonimiasis appear to be significantly clustered, universal treatment (MDA) should also be considered. In this case, the recommended treatment regimen would be TCZ, 20 mg/kg of body weight in a single administration.

With both drugs, some population groups need special consideration.

- **TCZ:** severely ill individuals, children below 4 years of age and pregnant women should be excluded from preventive chemotherapy interventions. They may, however, be treated in an individual case-management context, if the physician judges it acceptable and under medical supervision.

- **If PZQ is used:** severely ill individuals and children below 4 years of age should be excluded from preventive chemotherapy interventions. They may, however, be treated in an individual case-management context, if the physician judges it acceptable and under medical supervision. Pregnant and lactating women can be given PZQ both for individual case-management and as preventive chemotherapy.

Adverse events following treatment
Both PZQ and TCZ have been shown to be safe drugs for treatment of paragonimiasis. However, especially when large numbers of individuals are treated, it is likely that some will experience adverse events (AEs) following treatment. AEs are mainly systemic and are linked to biological substances released by the dying worms. They include: headache, abdominal pain, nausea, dizziness, urticaria and cough, and are usually mild and transient. AEs are more frequent and severe in patients with a heavy worm burden, and therefore occur mainly in populations that have not previously been treated. They will therefore be more common during the first treatment intervention, and their frequency will subsequently decrease.

Serious adverse events (SAEs), i.e. an AE that results in death, a life-threatening condition, admission to hospital or prolongation of a hospital stay, or persistent or significant disability or incapacity) are extremely rare. A system for detecting and reporting AEs and SAEs should be in place in conjunction with any treatment intervention. SAEs should be reported to the relevant authority, using the definitions and forms given elsewhere 5.

5.3.3 Monitoring and evaluation
The purpose of monitoring and evaluation is to assess the impact of the implemented activities on the target population. This is done by following up a given set of indicators, which evolve and change as a consequence of the activities.

Morbidity and mortality indicators
- Annual trends in the number of cases of paragonimiasis diagnosed at local or referral hospitals or reported from the district under study offer a useful indication of the progress made.
- Active surveillance can be implemented, using rapid questionnaire screening to detect cases, on the basis of symptoms such as chronic cough and bloody or rusty sputum.
- Passive surveillance can be implemented, by integrating detection of paragonimiasis into tuberculosis screening based on sputum samples.
- Summary statistics from different hospitals or districts, or generated by surveillance exercises, allow comparison between different implementation units. Trends in one particular hospital or district can be followed over time.
- Data can be stratified at subdistrict, village or community level, to obtain a more detailed picture of the epidemiological situation.
- It is important to advocate for registration of cases with the relevant health authority.

Parasitological indicators
Because of the low sensitivity of the diagnostic techniques based on sputum and stool samples in the general population, monitoring and evaluation of parasitological indicators is not recommended.

Other indicators
Because of the low specificity of the findings, as well as the low applicability of the necessary techniques (chest X-ray and CT scan) in field conditions, monitoring and evaluation of morbidity indicators is not recommended.

5.3.4 Complementary public health interventions
Implementation of treatment activities against paragonimiasis should be complemented, where feasible, by the following measures.

Rapid-impact interventions
- Measures to decrease human faecal contamination of aquaculture systems and cultured crustacean ponds (sanitation).

Long-term measures
- Information, education and communication on safe food practices.
- Sanitation to decrease contamination of freshwater streams with human faeces and sputum.
- Control or containment of the snail intermediate hosts

- Improved food safety measures for aquatic products in the premarketing stage, including the development of a certification system for crustacean farms by the national agriculture or aquaculture authorities.
- Veterinary public health measures, such as treating dogs with PZQ.
6. Prevention and control of *Taenia solium* taeniasis/cysticercosis

6.1 Identification of endemic communities

**Health and agriculture reporting systems**

Human taeniasis and cysticercosis should be included in the routine health and agriculture reporting systems of all countries with a high potential for cases to occur. This will allow the epidemiological situation in humans and pigs in each country to be assessed, and suspect areas to be identified and stratified through detection of clustered cases.

**Rapid assessment**

While the health and agriculture reporting systems are being established, it is recommended that information should be collected on the occurrence of cases of human and porcine *T. solium* infection. For human cases, information can be obtained from local or referral hospitals and treatment centres. In particular, information should be sought on detection of subcutaneous cysticercosis nodules and results of imaging (CT and MRI scans) and serological testing of people with epilepsy. For information on porcine cases of cysticercosis, meat inspection records can be consulted. The available published and unpublished literature should be reviewed for relevant epidemiological surveys. In the absence of any written documentation, key informants, such as local health and livestock officers, meat inspectors, pork butchers, pig traders and farmers, can provide reliable information, which can be collected through questionnaire surveys, key informant interviews or focus group discussions.

The available information should be stratified by district, allowing a first classification of districts as endemic or non-endemic. Attention should be given to the district of origin of each patient or infected pig, so as to better determine the site where the infection took place, and rule out imported cases. Mapping of pig distribution and pig husbandry systems by district can also provide helpful information. Disease transmission would be expected primarily in areas where pigs are kept, so these would be the priority areas for initial attention. Rapid assessment of pig-keeping areas could include lingual examination of pigs and thorough examination of pig carcasses at official slaughterhouses and other sites where pigs are killed (e.g. homes, livestock markets, bars and food establishments).

Cases of porcine cysticercosis in a country or area should be regarded as sentinels of sites of transmission, and an indication that further assessment of the epidemiological situation of taeniasis/cysticercosis in humans is necessary. Tracing back of human taeniasis/cysticercosis cases to the original community may lead to other human and porcine cases.

**Epidemiological surveys**

The epidemiology of taeniasis/cysticercosis in endemic districts should be further investigated, with the aim of classifying each district according to the prevalence of infection. If this information is already available, there is no need to conduct further surveys.

Classification of districts endemic for *T. solium* infections should be based on detection of the disease in humans or pigs. The rT24 ELISA and rES33 EITB, performed on fingerprick blood samples collected on filter-paper, should be used to detect human taeniasis/cysticercosis. The copro-antigen ELISA and Kato-Katz thick smear test may be conducted on faecal samples, as additional tests for non-specific taeniasis where appropriate (e.g. in conjunction with surveillance programmes for soil-transmitted helminths, schistosomiasis and other neglected tropical diseases). It is recommended that individuals of all ages should be included in the sample. People included in the survey who have epilepsy or other neurological problems (or a subset of them), whether testing positive or negative, may be further tested with neuroimaging (CT or MRI scan) to confirm the findings. People who test positive in the survey but have no neurological problems should not automatically be scanned, for ethical reasons. However, scanning may be needed to determine whether and what treatment to prescribe as this is determined based on the location and type of cyst(s).

Pigs should be tested for disease by lingual examination, carcass inspection and antigen-ELISA or rT24-ELISA, as appropriate. Porcine cysticercosis surveys should always be undertaken in the communities rather than in slaughterhouses, as farmers and pig traders may avoid taking their pigs to official slaughtering establishments if they suspect that the animals have cysticercosis. Surveys of pork preparation and consumption habits would provide additional information on the potential for disease transmission.

A standardized methodology for conducting surveys for *T. solium* infections has not yet been adopted. The classical sampling methodology developed for assessing the significance of soil-transmitted helminth
infections at the district level (see section 5.1), modified to remove the focus on schoolchildren and to include sampling of pigs (i.e. community-based surveys), may be appropriate.

6.2 Intervention strategy

An appropriate, standard methodology for intervention remains to be developed and validated in endemic communities. The scope and content of each control programme must be decided in relation to the situation in the area and population concerned. *T. solium* taeniasis/cysticercosis is not a global problem, but a regional or even local one. The focal nature of human and porcine cysticercosis has important consequences for the selection of prevention and control strategies (see box). The choice of strategy has to be based on the collection of objective data to answer the following questions: Why? Where? Is it a priority? Who is responsible? What will be the cost? And what support is needed? The available data suggest that implementing only a single approach to *T. solium* control is not sufficient; this was shown clearly in Peru. For sustainable prevention and control, and eventual elimination, a combination of approaches is needed, including the following.

- Preventive chemotherapy of human taeniasis:
  - mass or targeted treatment of humans with praziquantel (10 mg/kg of body weight) or niclosamide (2 g);
  - in areas where integrated control of neglected tropical diseases, including schistosomiasis or fishborne trematodes, is being undertaken, praziquantel may be administered at higher doses.
- Mass treatment and vaccination of pigs:
  - frequent administration of oral oxfendazole (30 mg/kg of body weight);
  - possible vaccination of pigs with TSOL18, after the parasites have been eliminated by chemotherapy.
- Community education in:
  - health (hygiene, food preparation, etc.);
  - pig husbandry.
- Improved sanitation to end open defecation.
- Improved meat inspection, control and handling, including strengthening and enforcement of pork inspection and control guidelines.
- Better pig management; no free-roaming pigs.

Once the priority operational research issues identified by the expert consultation (see section 5.2.2) have been resolved, the “best bet” elimination strategy can be finalized and validated through pilot projects in key endemic sites.

### Focus-oriented treatment

Chapter 6 of the 2005 revised version of the WHO/FAO/OIE *Guidelines for the surveillance, prevention and control of taeniasis/cysticercosis* recommends that focus-oriented treatment of taeniasis/cysticercosis should be conducted wherever possible. Control foci would be communities where cases of porcine cysticercosis or human taeniasis have been detected.

- In endemic rural pig-breeding areas, a control focus is defined as:
  - a locality with cysticercotic pigs; or
  - a farm supplying cysticercotic pigs.
- In rural and urban areas outside cysticercosis-endemic areas, a control focus may be:
  - a patient with late epilepsy (and other family members);
  - any case of confirmed or suspected taeniasis.

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Adverse events following treatment

Of the three drugs proposed for inclusion in *T. solium* taeniasis/cysticercosis control efforts, niclosamide appears to be very safe. However, there are some issues regarding the safety of oxfendazole and, especially, praziquantel that need to be addressed. Niclosamide is considered to be very safe, as it is not absorbed from the intestinal tract. However, there have been reports of a number of side-effects and adverse reactions, most of which are usually transitory and mild; they include slight abdominal pain, loss of appetite, nausea, vomiting and diarrhoea. Other side-effects, such as dizziness, drowsiness, pruritus and skin rash, have also been reported infrequently. Side-effects of praziquantel administration can also be mild, e.g. lethargy, headache and dizziness; drowsiness, abdominal pain, fever, sweating, fatigue, pruritus and skin rash have also been reported occasionally. More serious side-effects are rare. An anaphylactic reaction (generalized urticaria, dyspnoea, palpitations and dizziness) has been observed following praziquantel treatment of a person infected with clonorchiasis. In areas of Africa, Asia and Latin America, people being treated with praziquantel at 10 mg/kg of body weight for taeniasis control may be co-infected with trematodes that are also susceptible to the drug (e.g. *schistosomes*, *C. sinensis*, *O. viverrini*). While the dose (10 mg/kg of body weight) of praziquantel being administered is quite low and is unlikely to kill adult flukes, it could possibly affect fluke eggs trapped in tissues (e.g. of the liver or intestinal wall). This may cause them to hatch in situ, producing an immune reaction and related side-effects, such as fever and sweating. Also, a considerable percentage of people with taeniasis may be co-infected with cysticercosis or neurocysticercosis. Treatment of such people with 10 mg/kg of body weight of praziquantel may affect the cysticerci in a way that provokes a host immune reaction; this may lead to symptoms such as seizures, if the cysticerci are located in the brain. There have been reports of praziquantel treatment precipitating seizures, severe headache and other neurological symptoms in patients with asymptomatic neurocysticercosis. These serious neurological side-effects have occurred in individuals with viable brain cysts, particularly those with multiple viable cysticerci; in field conditions, they may be only a small minority of the population.

In controlled studies to investigate *T. solium* cyst death following administration of oxfendazole to pigs at 30 mg/kg of body weight, no visible adverse reactions were noted following treatment; all pigs fed normally and demonstrated no signs of illness. However, the possibility of effects at a dose of 30 mg/kg of body weight, on both pig/piglet health and production, as well as the minimum withdrawal time to eliminate potential effects on the health of pork consumers deserve further attention before the drug can be included in intervention programmes for taeniasis/cysticercosis. No adverse reactions to the porcine cysticercosis vaccine have been described in published controlled studies. However, in field tests of the vaccine conducted under the Cysticercosis Elimination Project in Peru, adverse acute side-effects, such as fever, lethargy and lack of appetite, were observed in vaccinated pigs. As with any vaccination, some pigs may be expected to develop a local reaction at the site of injection within a few hours, manifested as pain, swelling, erythema, etc., especially since the vaccine contains an adjuvant. Systemic reactions to the vaccine, such as fever, anorexia and lethargy, would be expected to occur infrequently.

Serious adverse events (i.e. an adverse event that results in death, a life-threatening condition, admission to hospital or prolongation of a hospital stay, or persistent or significant disability or incapacity) are extremely rare. Any adverse reactions should be recorded and addressed quickly; the safety of the treatment protocol being followed should be reassessed and the targeted community informed as soon as possible about the results and any changes needed. A system for detecting and reporting adverse events should be in place in conjunction with any treatment intervention. Serious adverse events should be reported to the relevant authority, using the definitions and forms given elsewhere.

6.3 Monitoring and evaluation

The purpose of monitoring and evaluation is to assess the progress of implementation and the impact of the activities on the target population. This is done by following up a set of indicators, which evolve and change as a consequence of the activities.

**Health and agriculture systems indicators**

- Annual trends in the number of cases of human taeniasis/cysticercosis (in particular subcutaneous nodules and neurocysticercosis) and porcine cysticercosis diagnosed at local or referral hospitals and slaughterhouses, respectively, or reported from the district under study, offer a useful indication of the progress made.
• Summary statistics from different hospitals, districts and pork inspection records allow comparison between implementation units. Trends in one particular hospital, district or pork inspection site can be followed over time.
• Data can be stratified at subdistrict, village or community level to obtain a more detailed picture of the epidemiological situation.
• It is important to advocate for registration of cases with the relevant health and agriculture or livestock authorities. However, if there are no incentives for poor people to register cases (e.g. porcine cysticercosis cases not seen in official slaughterhouses), the results may be strongly biased and even counterproductive.

Parasitological indicators
• Before any interventions are implemented, the baseline distribution and prevalence of taeniasis/cysticercosis in humans and pigs should be assessed by conducting parasitological investigations on samples of the target human and pig populations in selected sentinel sites. Such sentinel sites should also be followed up over time (ideally once a year; otherwise, once every two years) to assess the public health and agricultural impact of the activities implemented. If epidemiological surveys were carried out earlier, the sentinel sites for monitoring and evaluation purposes can be selected from among those already surveyed; in this case, the data generated by the original epidemiological survey would serve as baseline.
• A standardized methodology for conducting surveys for *T. solium* infections has not yet been adopted. Surveys for monitoring the impact of interventions on the transmission of taeniasis/cysticercosis should focus in the short term on the incidence of human taeniasis (using copro-antigen and copro-DNA testing) and porcine cysticercosis (using serological tests and carcass inspection, “slicing” where possible and examining predilection sites). In the long term, the incidence of human cysticercosis and NCC should be the focus of attention (using serological tests, detection of subcutaneous nodules and number of hospital admissions for symptomatic NCC).
• “Sentinel” cysticercosis-negative pigs can be brought into communities where interventions have been undertaken to monitor whether transmission of taeniasis/cysticercosis has been interrupted (i.e. determine whether they become infected using serological tests or carcass slicing).
• Community-based surveys at the village level should be conducted among children and adults. Pigs should be surveyed at the household level and pig carcasses examined at all local sites and in other places where pigs from the surveyed community are slaughtered.
• Programme managers should use judgement in selecting the number of sentinel sites, depending on the epidemiology of the disease or the scale of the control interventions. Monitoring and evaluation are important components of any disease control intervention but should not overburden the programme; common sense should be applied.

Other indicators
Additional indicators can be monitored and evaluated in a subsample of the implementation units, where this is justified by the epidemiology of the disease, the availability of resources or a specific interest.
• Monitoring and evaluation of epilepsy incidence in the human population could be used as a long-term indicator of NCC in endemic areas.
• The economic situation of pig farmers can be monitored; improvements may indicate that pork has become safer and pig production and marketing have improved.
• Knowledge and behaviour change after educational interventions can be evaluated through:
  - questioning of community members before and after the interventions to measure increase in and retention of knowledge about taeniasis/cysticercosis and their transmission;
  - observation of households and communities before, during and after intervention to assess changes in behaviour (e.g. pork preparation habits, pig management practices, sanitation and hygiene).
• Improvements in human waste management would be indicated by:
  - increased number and use of latrines;
  - absence of human faeces in open areas of the community;
  - enforcement of community sanctions against open defecation; and
  - validation and certification of communities as “open-defecation-free”.

Quality control
Neither the currently available coproantigen ELISA nor the routine Kato-Katz thick smear can differentiate between the various *Taenia* species that infect humans as adult tapeworms (*T. solium*, *T. saginata*, *T. asiatica*). Worms, proglottids or eggs would need to be collected to allow differentiation on the basis of morphological assessment or molecular testing, in order to confirm the impact of interventions specifically aimed at *T. solium*.
Annex 1.
List of participants

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Dr Fidel Villegas, Veterinary Public Health Officer, Office of the PAHO/WHO Representative, La Paz, Bolivia
### Annex 2. Agenda

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<td>09.00-10.00</td>
<td>Inauguration</td>
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<td>10.00-10.15</td>
<td>Objectives of the meeting</td>
<td>D. Engels</td>
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<td>10.15-10.30</td>
<td>Current situation of FBT infections and taeniasis/cysticercosis:</td>
<td>J. Ehrenberg</td>
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<td>10.30-10.45</td>
<td>In WPR</td>
<td>J. Waikagul</td>
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<td>10.45-11.00</td>
<td>In SEAR</td>
<td>F. Villegas</td>
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<td>Tea/Coffee Break</td>
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<td>11.30-12.00</td>
<td>Where do we start from? Lessons from previous meetings (20' presentation, 10' Q&amp;A):</td>
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<td>12.00-12.30</td>
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<td>A.L. Willingham</td>
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<td>Where do we start from? Lessons from country and pilot initiatives (20' presentation, 10' Q&amp;A):</td>
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<td>Control of opisthorchiasis in Thailand</td>
<td>F. Villegas</td>
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<td>15.00-15.30</td>
<td>Control of fascioliasis in Peru and Bolivia</td>
<td>H. Le Quang</td>
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<td>Control of fascioliasis infections in Vietnam</td>
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<td>16.00-16.30</td>
<td>Control of opisthorchiasis in Lao PDR</td>
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<td>Elimination of taeniasis/cysticercosis in Peru</td>
<td>H. Garcia</td>
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<td>17.30-18.00</td>
<td>Community-led total sanitation (CLTS)</td>
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<td>18.00-18.30</td>
<td>General discussion</td>
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<td>Core intervention packages for FBT infections (presentation to be based on the background document)</td>
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<td>Aquaculture and control of fishborne trematode infections</td>
<td>H. Madsen</td>
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<td>11.00-12.30</td>
<td>Discussion, conclusions and recommendations for pilot interventions and further operational research / tool improvement</td>
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<td>MORNING SESSION - Chair: X.-N. Zhou</td>
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<td>Monitoring and Evaluation of interventions against taeniasis/cysticercosis (presentation to be based on the background document)</td>
<td>A.L. Willingham</td>
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<td>Discussion, conclusions and recommendations for pilot interventions and further operational research / tool improvement (continues)</td>
<td>All Participants</td>
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<tr>
<td></td>
<td>12.30-14.00</td>
<td>Lunch</td>
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<tr>
<td>Day 4</td>
<td>15 October</td>
<td>AFTERNOON SESSION - Chair: J. Utzinger</td>
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<tr>
<td>M &amp; E</td>
<td>14.00-15.00</td>
<td>Monitoring and Evaluation of interventions against FBT infections (presentation to be based on the background)</td>
<td>P. Odermatt</td>
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<tr>
<td></td>
<td>15.00-17.30</td>
<td>Discussion, conclusions and recommendations for pilot interventions and further operational research / tool improvement</td>
<td>All Participants</td>
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<td>16.00-16.30</td>
<td>Tea/Coffee break</td>
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<tr>
<td></td>
<td>16.30-17.30</td>
<td>Discussion, conclusions and recommendations for pilot interventions and further operational research / tool improvement (continues)</td>
<td>All Participants</td>
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<tr>
<td>DAY</td>
<td>TIME</td>
<td>SESSION/PRESENTATIONS</td>
<td>SPEAKER</td>
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<td><strong>MORNING SESSION</strong></td>
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<tr>
<td><strong>Day 5</strong></td>
<td><strong>16 October</strong></td>
<td><strong>The way forward</strong></td>
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<tr>
<td></td>
<td>09.00-10.00</td>
<td>Introduction: assessment of state of readiness to support pilot interventions, or the need for further preliminary work (operational research / tool improvement)</td>
<td>D. Engels</td>
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<td></td>
<td>10.00-12.30</td>
<td>Development of protocols for pilot, field-based control interventions or setting further agenda</td>
<td>Working Groups (FBTs, taeniasis/cysticercosis)</td>
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<td>10.30-11.00</td>
<td>Tea/Coffee break</td>
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<td>16.00-16.30</td>
<td>Tea/Coffee break</td>
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<tr>
<td><strong>Closure</strong></td>
<td>16.30-17.30</td>
<td>Wrap-up and closing ceremony</td>
<td>J. Ehrenberg, D. Engels</td>
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