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PAHO/WHO Informal Consultation on the

Taeniosis/Cysticercosis Complex

August 23-25, 1995
Brasília, Brazil

Pan American Health Organization • World Health Organization

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PAHO/WHO INFORMAL CONSULTATION ON THE TAENIOSIS/CYSTICERCOSIS COMPLEX

23-25 August 1995, Brasília, Brazil

Pan American Health Organization
Division of Disease Prevention and Control

Communicable Diseases Program:
- Integrated Management of Childhood Illness (IMCI) Unit
- The Standardized Protocol for the Control of Intestinal Parasitic Disease in Children (PEPIN)

Veterinary Public Health Program
PAHO/HCP/HCV

World Health Organization
Schistosomiasis and Intestinal Parasites Unit
Division of Control of Tropical Diseases

Washington, D.C., August 1997.

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PRESENTATION

Parasitic infections are more common in the rural areas in the developing countries of Asia, Africa, Central and South America where access to safe water and basic sanitation are limited. They are often linked to poverty and associated with other social problems. Taeniosis and cysticercosis complexes have acquired importance because the larval stage (*cysticerco T. solium*) causes disabilities when they are located in the human central nervous system. New diagnostic imaging technology has revealed an increased number of human neurocysticercosis cases. They have also been a main concern in livestock producing areas because infected carcasses are condemned at slaughter based upon veterinary inspection.

In recent years demographic, economic and sociopolitical changes have caused a significant migration of rural populations to urban settlements and often they live in poverty and in unsanitary conditions. Some of these immigrants are carriers of gastrointestinal parasites, including the Taenia sp. Foecal contamination with transmission to many individuals via infested hands, water, or food is more likely to occur under these circumstances.

This is a complex epidemiological picture which requires a complex, but integrated solution. Intersectoral coordination and the community participation are fundamental.

Public health concern is growing and there is an increase of public and private initiatives for the surveillance and the control of the complex taeniosis/cysticercosis. However, many questions still remain. Further research and reporting should be done to address them.

In response to requests from member countries, the Pan American Health Organization convened a meeting of experts in Porto Alegre, Brazil, in October 1989. At this meeting, the biology, immunology, diagnosis, epidemiology and control strategies were reviewed and analyzed. Research groups from different countries exchanged information. Since then some countries in the Americas have developed control programs of taeniosis and cysticercosis and identified the steps necessary to diminish or eliminate the disease. The experiences gained by these countries could be used as models for future interventions.

As a follow-up to the above mentioned meeting, WHO and PAHO organized the informal consultation on the taeniosis/cysticercosis complex in Brasília, Brazil, in August 1995, as an effort to update the technical knowledge on this zoonosis and to discuss new approaches for its prevention and control. This document summarizes the discussion and recommendations of this meeting.

PAHO/WHO and the governments of affected countries are joining efforts to promote an improved healthy environment in the communities, recognizing that the prevention of taeniosis and cysticercosis as well as the control of the burden of all other parasitic disease, are a joint responsibility.

Dr. Stephen Corber
Director
Division of Disease Prevention and Control
Pan American Health Organization

BACKGROUND

Taeniosis/cysticercosis due to the pork tapeworm, *Taenia solium*, is a classical zoonosis, recognized since antiquity, which, as a result of a variety of demographic, technical, and political factors, is emerging as an increasingly important condition in both endemic and non-endemic regions. Neurocysticercosis (NCC) is infection of the central nervous system with the larval stages (cysticerci) of *T. solium*. The two-host life cycle of the tapeworm involves humans as definitive hosts and swine as intermediate hosts. Pigs are the source of human taeniosis, an intestinal tapeworm infection acquired by eating undercooked pork containing cysticerci, the larval or metacestode phase of *T. solium*. Human cysticercosis, however, is acquired by ingesting *Taenia* eggs shed in the feces of a human tapeworm carrier and thus may occur in humans who neither eat pork nor share environments with pigs. Although cysticerci may localize throughout the body, most clinical manifestations result from their presence in the central nervous system, where they can cause seizures, hydrocephalus, and other neurologic dysfunctions. Cysticercosis is widely endemic in rural areas of Latin America (most notably Mexico, Guatemala, El Salvador, Honduras, Colombia, Ecuador, Peru, Bolivia and Brazil), Asia and Africa. The World Health Organization estimated that 50,000 deaths due to neurocysticercosis occur every year; of course, many times that number of patients survive but are left permanently disabled by recurrent seizures or other neurologic damage.

In the past fifteen years, as a result of improvements in technology to diagnose and treat the disease and increasing migrations of persons from areas where *T. solium* is endemic, there has been a growing recognition as to how widespread and terrible the disease is in countries of Latin America, Africa and Asia and how frequently it results in severe disability and death. Recognizing the growing body of international literature on the disease and the need for synthesis of this information and development of recommendations for future research, surveillance and prevention of this disease, PAHO/WHO convened a meeting of international scientists to consider these questions.

PURPOSE

The Informal Consultation, jointly organized by the Division of Communicable Diseases, WHO, Geneva, and the Division of Disease Prevention and Control, PAHO, Washington, D.C., was held at PAHO Representation in Brasilia, Brazil, 23-25, August, 1995. The purpose was to review the scientific advances on prevention, control, diagnosis, and treatment of taeniosis and cysticercosis.

METHODOLOGY

The meeting was organized in several modules; in each, formal presentations of data were followed by discussion groups designed to identify needs for further research, recommendations, and intervention. The first module involved presentation of regional data on the medical, veterinary, and social significance of the disease in all major areas where the disease occurs. The second module consisted of presentations of new advances and "states of the arts" of diagnosis and treatment of the tissue and intestinal forms of the disease. The third module involved presentations of the principles, strategies and operational structure of intervention programs, including means of assessment.

PARTICIPANTS

In attendance were approximately 30 participants and observers, including scientists and administrators representing governmental and private medical and veterinary institutions from all major geographic regions where *Taenia soium* infection occurs as an endemic or imported disease. The list of participants is shown in Annex No. 1.

ACTIVITIES

At the Opening Ceremony, Dr. Miguel Angel Genovese, Acting Representative for Dr. Armando Lopez Scavino, Pan American Health Organization/World Health Organization Country Representative in Brazil officially welcomed the participants to the Informal Consultation. Dr. Lorenzo Savioli, Head of Intestinal Parasitic Infections, Division of Communicable Diseases, World Health Organization, Geneva, presented the terms of reference, objectives and desired outcome of the Informal Consultation, highlighting the PAHO/WHO collaborative efforts to solve the problems of intestinal parasites, and Dr. Edmundo Juares, President of the National Health Foundation, Ministry of Health of Brasil, officially opened the meeting, stressing the need of such Working Groups in the solution of some of the more neglected health problems. Each of the participants introduced her/himself, stating her/his origin, Institutional affiliation and actions and interests and activities in taeniasis and cysticercosis.

Dr. Marcelo Cruz was elected President of the Working Group, Dr. N. H. Wadía was elected Vice-President, and Dr. Peter Schantz, Centers for Disease Control and Prevention, Atlanta, Georgia, was elected Rapporteur.

DISTRIBUTION AND PREVALENCE

Representatives from Africa, Asia, and Central and South America America reviewed data on the regional incidence and public health importance of taeniosis and cysticercosis in those regions. It was noted that during the past ten years data collected on the disease have become considerably more comprehensive; formerly, the only data reported were clinic-based statistics on the frequency of Neurocysticercosis (NCC) among hospital patients or among autopsied cadavers. Neurocysticercosis has become officially reportable in some countries although serious under-diagnosis and under-reporting are widely acknowledged. Furthermore, differences in quality and availability of medical services and lack of comprehensive and consistent reporting in most countries make it difficult to compare incidence between countries and, within a country, between rural and urban areas. Improved diagnostic technology, new options for treatment, and greater awareness of cysticercosis by the medical and veterinary communities have resulted in increased numbers of cases diagnosed in traditional endemic areas and new disclosures of active transmission from regions where the disease was previously unrecognized or not reported. Clinical and population-based epidemiologic studies are further documenting the impact of the disease on affected communities. Neurocysticercosis is usually not specifically recognized by affected communities as the cause of seizures and other neurologic disorders; however, use of new, improved serologic and imaging diagnostic technology, has identified neurocysticercosis as the most important contributor to the high rates of epilepsy and migraine headaches in regions where *T. solium* is endemic. Analysis of the epidemiologic factors associated with these cases suggest a variety of potential risk factors including histories of taeniasis, owning pigs, and poor hygiene.

Available data from countries of the Americas was summarized by several participants (Agapejev, Allan, Beltran, Camargo, Gilman, Sarti Gutierrez, Schantz, Tsang). Published reports document the occurrence of clinical neurocysticercosis in most of the countries of the Americas. Although hospital-based studies are difficult to interpret quantitatively, active surveys and epidemiological studies, using state-of-the-art diagnostic methods, have been conducted in selected populations. Community-based surveys of rural populations in selected areas where *T. solium* is endemic indicate that seroprevalence varys from 4%-25%. Neurocysticercosis is the primary cause of epilepsy and migraine-type headaches in regions where it has been studied. Serologic and/or computer tomographic examinations of persons with seizure histories document that cysticercosis is the cause of 25%-70% of cases. Extrapolation from the limited reported data on infection suggests that 30-50 million persons in Latin American countries have been exposed. Among countries of the Americas, only Canada, the United States and, possibly, Argentina and Uruguay appear to be free of transmission in the pig-human cycle; however, those latter countries are observing an increase in imported and introduced infections related to immigration of persons from

countries where *T. solium*is endemic. Imported cases, noted in many non-endemic industrialized countries, include persons with latent neurocysticercosis and carriers of intestinal-stage *T. solium* infection; the latter, through food-handling and other modes of direct and indirect contact, have been identified as sources of locally-acquired cases of NCC.

Professor N.H. Wadi summarized data on the disease in Asia. Almost all available data are from hospital and clinic-based populations and are biased in terms of the true geographic origin and other factors actually associated with transmission. No systematically collected surveillance data are available and the disease is not "officially-recognized" in most countries. In India, for example, the disease is believed to be widely distributed but most common in the northern regions, however, the lack of uniform reporting systems confound interpretation of the limited data. Perhaps, the most widely-recognized information from this area is derived from the classic clinical studies of NCC in British soldiers stationed in India in the first half of this century. In India, *Taenia* infections occur mainly in pork-eating populations particularly in rural populations and lower classes. Current information, mainly anecdotal, suggests that vegetarian populations are exposed through direct contact and environmental contamination from *Taenia* carriers among persons of social and ethnic groups who consume pork. The vast majority of clinical cases reported in India are of the single-lesion variety with relatively mild symptoms and benign outcome; these are believed to be associated with exposure to eggs in contaminated foodstuffs or other indirect exposure to tapeworm carriers. Interestingly, the greatest number of cases of the rare, massive, disseminated form of the disease have also been reported from India; the explanation for these extremes are unexplained. Transmission in Asia is strongly influenced by prevailing cultural practices and socioeconomic conditions. There are no reports from the strictly Muslim countries of Iran, Pakistan and Bangladesh. It is also reported widely from China and parts of Korea. It is known to occur although, few published data are available in southeastern countries of Burma, Cambodia, Laos, Vietnam and parts of Indonesia (Bali) and the Philippines. Improvements in socioeconomic conditions were associated with reduction or disappearance of the conditions in Japan, Taiwan, Hong Kong, Singapore and, less so, in Thailand.

Prof. M. Dumas reviewed knowledge of taeniosis/cysticercosis in Africa. *T. solium* is apparently transmitted in most of the continent with the exception of the strictly Muslim areas of North and Sub-Saharan Africa. In South Africa where medical services are relatively sophisticated, NCC has long been a subject of scientific reports; however, elsewhere, there are very limited data because of the lack of diagnostic facilities, especially the sohisticated and expensive imaging technology which is so useful for characterization of intracerebral lesions. It was noted anecdotally that the first report of NCC in a country often follows the training of the first neurologist in the country. The general lack of sanitary services, including disposal of human excrement, and widespread occurrence of pigs, mainly running loose, where they can ingest

human feces permits transmission of *T. solium* in most of the regions. Controlled slaughter of swine is rarely practiced and consequently cysticerci-infected pork is generally consumed by humans who either ignore or are ignorant of its significance. Neurocysticercosis is a common clinical entity in many countries of West (Senegal, Benin, Ivory Coast, Togo, Ghana), Central (Zaire, Cameroun, Burundi and Rwanda), and Southern (Madagascar, South Africa, Zimbabwe). Few reports of NCC in humans in East Africa have been documented, however, a recent report of *Taenia solium* cysticercosis in 13% of pigs slaughtered in three abattoirs in Tanzania suggest it may be widespread. NCC is an important cause of neurological disability: studies in patients with epilepsy in several countries have documented that 30%-51% of cases are due to *Taenia solium* infection. In Africa, as in Asia, subcutaneous localization of cysticerci, concomitant with intracerebral infection, is common; this is in contrast to the infection in American countries where subcutaneous localization in patients with NCC is relatively rare. No progress in control of the disease in African countries has been reported.

In all countries where *Taenia solium* is endemic, there is a need for provision of diagnostic and therapeutic resources at the community level, improved reporting and surveillance systems and surveys to determine the prevalence of infection and rates of associated morbidity. One effective approach to quantification of neurological disorders at the community level is the "WHO protocol for epidemiological evaluation of neurological disorders in developing countries"; this provides a standardized procedure for estimating the prevalence of major neurological illnesses: epilepsy, migraine headaches, stroke, extra-pyramidal disorders and peripheral neuropathies. The protocol is applied in 3 phases: in the first phase a screening questionnaire is given by paramedical personnel door-to-door to all inhabitants. Those found suspect of harboring a neurological disorder are then examined by neurologists in the second stage. Those with a confirmed neurological illness (specifically epilepsy and migraine) are then offered the possibility of receiving further laboratory evaluation by means of immunological testing and, where available, computed tomography scans of the head.

DIAGNOSIS AND TREATMENT

Presentations in the second module concerned recent advances and the current states of the art of diagnosis, including both intestinal and tissue-stage forms of infection and immunity, and treatment. Criteria for classification of clinical forms were proposed with special reference to their use for staging and prognostic evaluation.

It was noted that advances in diagnosis of neurocysticercosis largely accounts for the "epidemic emergence" of the disease in all countries where the disease is seen whether as an endemic or imported disease. The demonstration that certain anthelmintic drugs, namely praziquantel and albendazole, are effective against cys-

ticerci provided physicians strong incentives to pursue a correct diagnosis of patients with neurological symptoms compatible with cysticercosis. The development of sensitive intracerebral imaging technologies had the greatest impact. Computed tomography (CT) and magnetic resonance imaging (MRI) of the brain have revolutionized the diagnosis of NCC by improving the discernment of intracerebral lesions. Although in many patients adequate information for specific diagnosis is available from either CT or MRI, most studies comparing the two imaging procedures have concluded that MRI is more sensitive and specific for identifying most forms of NCC, the exception being microcalcifications for which CT is more sensitive. Unfortunately, these imaging technologies are relatively expensive, not available to most populations severely affected by this disease, and the equipment is not readily applied in field studies.

Resolution of differential diagnosis in cases of questionable imaging findings can often be achieved by serologic tests. Historically, many tests and antigen preparations have been used: most of these, when critically evaluated, were found to be both insensitive and nonspecific. It is now known, however, that *T. solium* has specific antigens which are recognized by antibodies produced by infected hosts; these can be discriminated in enzyme-linked immunosorbent transfer blot (EITB) assays. The preferred serodiagnostic test is the EITB assay, developed at CDC, based on identification of antibody binding to one of at least seven specific glycoprotein bands. Tests using uncharacterized antigens are not highly sensitive nor specific and cannot be recommended. The immunoblot test is available in the U.S. at the CDC (Atlanta, Georgia), and several commercial sources, and is now performed in research laboratories in several countries in Latin America. After extensive evaluation it has proven to be 100% specific and has a sensitivity superior to that of other tests with which it has been compared. Comparison of the immunoblot assay with an ELISA for screening open populations confirmed the superiority of the former and showed that use of a test with less than optimum operating characteristics (sensitivity and specificity) may provide very misleading epidemiological data. The absolute specificity of the immunoblot assay produces high positive predictive values and thus is useful for serosurveys and epidemiologic studies, the results of which are beginning to document the previously underestimated public health problem in many countries. The test is also sensitive and specific for detecting exposure in pigs and has been proposed as applicable for epidemiologic studies and monitoring progress of control programs. Research in progress includes purification and recombinant production of specific antigens and development of more economic and field-applicable diagnostic assays.

A major factor previously limiting clinical and epidemiologic studies of *T. solium* had been the lack of sensitive methods for diagnosis of intestinal-stage tapeworm infections. Detection of taeniid antigens in infected host feces has significantly improved the sensitivity of diagnosis of taeniasis. Until recently, the diagnosis of intestinal taeniosis had been based on detection of proglottids or eggs in feces; these approaches lack sensitivity, however, because the parasite in these forms are often absent from the feces.

Taenia sp. antigens can be detected in feces in the absence of eggs; antigen is present before egg production begins, is independent of the number of eggs in the feces, and disappears from feces within a few days of successful treatment. Coproantigen (CoAg) assays are based on capture-type ELISAs with polyclonal antisera raised against either worm somatic or excretory-secretory products, These assays are simple to perform, highly reproducible, and need little in terms of expensive equipment or reagents; no other parasites cause cross reactions. Sensitivity of the assays is also very high, although some false negative results occur. Both microplate & dipstick dot ELISA's have been standardized and tested in field studies. Use of the tests have nearly trebled the numbers of *T. solium* cases diagnosed in field studies compared to the use of microscopy. These features mean that the diagnosis of intestinal taeniid infection by coproantigen has now become a practical solution to many problems previously encountered in this field. They may be particularly useful in their current format for baseline epidemiological & surveillance studies. They are easy to develop and relatively cheap. One rabbit antisera has been shown to be capable of being used as the basis of around 20,000 - 50,000 individual tests.

It was noted that, in spite of all the benefits in knowledge that have resulted from improvements in diagnosis and treatment, there is a need for standardized criteria for classification of the disease in terms of viability and "activity" so as to permit correct diagnosis, clinical staging and prediction of outcome of therapy; such criteria were proposed by this working group. Reliance on nonspecific clinical, radiological, or immunologic criteria alone is insufficient for accurate diagnosis. Although the disease has a known etiologic agent, it is not possible to demonstrate it in every patient. The proposed diagnostic criteria combine clinical, neuroimaging, immunological, and epidemiologic criteria to categorize three degrees of diagnostic certainty: definitive, probable, and possible. Definitive diagnosis requires histological demonstration of the parasite or the combination of suggestive neuroimaging findings with postiive serodiagnostic test results. A probable diagnosis should be made in patients with suggestive neuroimaging findings but negative serodiagnostic results and in those with positive serodiagnostic studies without other evidence of the disease. A possible diagnosis could be entertained in patients who, living in endemic areas, present with less specific neuroimaging findings without other strong evidence of infection. It was proposed that adoption of this classification scheme will be useful for both clinical and epidemiological studies.

Neurocysticercosis is a pleomorphic disease that causes complex pathology and severe neurologic syndromes; therefore, a single therapeutic approach cannot be expected to be effective in every patient. Consequently, precise characterization of the disease in terms of viability of cysticerci, location of the parasite within the central nervous system, and the degree of the host's inflammatory response are of great importance before planning a rational therapy. The therapeutic approach to most patients with NCC include the use of both symptomatic drugs (anticonvulsants and corticos-

teroids) and specific anthelmintic therapy. In addition, surgical procedures are necessary in some patients with the disease. Anthelmintic drugs are highly effective against living intra-parenchymal and subarachnoidal cysticerci. In these cases, the drugs induce disappearance of cysts (as evidenced by neuroimaging) and also result in clinical improvement of the patients. Anthelmintic drugs should be used with caution in patients with masive infection because the inflammatory reaction that occurs as the result of the therapy may induce clinical deterioration of the patient. Similarly, the drugs should not be used in patients with hydrocephalus and in those with cysticercosic encephalitis. Anticysticercal drugs are of no value in patients with calcifications alone since these lesions represent dead larval parasites. It was noted that the indications for and value of anthelmintic drugs in NCC remains controversial. Anticysticercal drugs are commonly used in management of NCC by physicians in endemic countries, however, there are others who believe they rarely benefit the patient. There is a need for controlled clinical trials to define the conditions under which anthelmintic treatment is required and/or can truly benefit the patient.

Symptomatic therapy with antiepiletic drugs is advised in patients with seizures, and corticosteroids are recommended in patients with cysticercotic encephalitis and arachnoiditis. Surgical procedures sometimes indicated for patients with NCC include shunt placement in cases of hydrocephalus, and, occasionally, resection of large subrachnoid or intraventricular cysts.

PREVENTION AND CONTROL

A discussion of administrative and technical problems limiting progress with this disease was lead by representatives from WHO/PAHO (Beltran, Ruiz, Savioli). This was followed by presentations of experiences in research on epidemiology and control in a variety of countries represented (Sarti, Cruz, Gilman). It was argued that *Taenia solium* is a potentially eradicable infectious disease (Schantz) and this was followed by presentations on administrative, social, and technical issues that must be dealt with and overcome in order to achieve the goals. Group discussions on suggested control strategies were lead by representatives of PAHO/WHO.

In 1993, the International Task Force For Disease Eradication declared *Taenia solium* a potentially eradicable infection, however, there are still no documented examples in which eradication has been achieved through active intervention. There were several characteristics of the parasite which appear to make it vulnerable to eradication: 1) the life cycle requires humans as definitive hosts, 2) tapeworm infections in humans are the only source of infection for pigs, the natural intermediate hosts, 3) swineherds can be managed, 4) no reservoirs for infection exist in wildlife. *T. solium* appears to be a possible candidate for eradication because it gradually disappeared from most European countries even without control measures targeted specifically at it.

Factors credited with the elimination of *T. solium* include improvements in general sanitation and economic status, the introduction of indoor pig husbandry, and rigorous meat inspection.

Under the conditions that exist currently in countries where *T. solium* is endemic, and given available resources, we do not yet know what is required to reduce and ultimately eliminate transmission. Although no intervention program specifically targeted against T. solium at the national or regional level has been implemented in recent times with proven success, several strategies for control have been proposed; these include

Comprehensive programs of long-term intervention: This involves appropriate enabling legislation, health education, modernization of swine husbandry practices, improvement of efficiency and coverage of meat inspection, provision of adequate sanitary facilities, and measures to detect and treat human tapeworm carriers. Such comprehensive improvements, although not targeted at T. solium, are what incidentally reduced transmission in many European countries. Such programs are extremely desirable and represent the long-term goal of health development because they yield broad benefits at many levels of society. They are very expensive and require advanced levels of infrastructure development. Political and economic realities in many communities where T. solium is endemic today, however, provide little hope that all of these measures can be implemented in the near future. For example, the investment in water, sanitation, and health services needed to eliminate the risk of cholera throughout Latin America has been estimated to exceed $200 billion over the next 12 years. It remains to be seen if resources of that magnitude can be mobilized even for a disease like cholera that is regarded as terrifying and life-threatening.

Short-term, targeted intervention programs: To achieve more rapid progress toward eradication and substantial reduction of sickness and death caused by neurocysticercosis, short-term intervention measures have been proposed and, in some cases, partially evaluated. These include:

Mass or selected taeniacidal treatment of humans

This strategy is based on the identification of foci and treatment of everyone or of all diagnosed or suspected cases of taeniosis in humans, with the goal of immediate interruption of transmission from humans to pigs and other humans. The feasibility of this strategy was shown in a trials in Ecuador and Mexico in which approximately 15,000 persons in several communities were administered praziquantel (5-10 mg/kg body weight); this intervention achieved at least temporary reduction in prevalence of cysticercosis in pigs. Even such low doses, however, were noted to have possibly re-activated symptoms of neurocysticercosis in at least one case of previ-

ously undiagnosed NCC, thus revealing a potentially harmful adverse reaction to this intervention. Because rates of taeniosis are similar in both sexes and all age groups, this intervention strategy requires (mass) treatment of all individuals in order to maximize chances for effect. Although, the cost of this medication in Ecuador was estimated as low as US$ 0.20 per person, it is important to note that praziquantel is not widely available in rural clinics. Further research on the costs, safety, and effectiveness of various taeniacidal drugs, and strategies of their administration, are necessary.

Cysticercidal treatment of pigs

Modern anthelmintic drugs, e.g., praziquantel and albendazole, are known to be effective for treating larval stage infection in humans and pigs, however, the requirement for multiple doses, or the frequency of adverse reactions, or both, limit the possibilities for their use in pigs. However, the recent demonstation of the 100% efficacy of the benzimidazole compound, oxfendazole, given as a single dose, for destroying cysticerci, while not damaging the animal nor the meat product, introduces the possibility of treatment of pigs as a possible intervention. It was noted that the pig is a good target for surveillance and intervention for many reasons including their value to the owner, the local awareness and easy recognition that cysticercosis reduces their value, and the current availability of effective means of diagnosis and treatment. Intervention measures focused on pigs have not yet been evaluated on any scale and the cost, sustainability, and long-term effectivess of these approaches need to be evaluated.

Vaccination of pigs and/or humans

Although the technology is not yet developed for *T. solium*, there is sound theoretical possibility that an effective vaccine to protect swine and human intermediate hosts could be developed. Such has already been demonstrated in the cases of the related taeniids T. ovis and Echinococcus granulous for which cloned recombinant antigen vaccines have been produced. Although their production may be feasible, how vaccines would fit into the overall intervention strategy, their cost, effectiveness and sustainability remain to be demonstrated.

Health education: Experience with other zoonotic rural health problems, such as echinococcosis in New Zealand and Tasmania (Australia), indicated that educational interventions in the form of posters and pamphlets had no effect, by themselves, on transmission of the infection. They were believed, however, to have sensitized the pop-

ulation to accept the introduction of other interventions such as restrictions on home slaughter of livestock and diagnostic dosing of dogs; these latter actions have nearly eradicated infection from those island regions. The results of a recent field trial in Mexico of educational intervention against *T. solium*, in which the educational strategy was based on careful ethnographic study and involved extensive community participation, suggested that education may suceed in changing knowledge and practices related to the infection; within 6 months of completion of the educational intervention rates of transmission had declined significantly as measured by infection prevalence in young pigs. Continued educational intervention, supported by legislation and active enforcement, may suceed in reducing and perhaps, ultimately eliminating, transmission of the cestode; however, further studies of the effectiveness of health education, with long-term followup, are needed. .

It was noted that health education, whether part of short-term or long-term programs, is a fundamental requirement to obtain local cooperation and sustainability of the intervention strategy. Experiences with other diseases indicate that, to be maximally effective, health education must be based on local perceptions, knowledge, and practices related to the disease and must involve participation of the community.

Maintenance Activities: Fundamental to any strategy of intervention against *T. solium* is the sustainability of the measures. Once substantial progress in reducing transmission of taeniosis/cysticercosis through targeted intervention has been achieved, means must be developed to sustain progress. One approach may be to integrate control activities into primary health care systems. Maintenance activities might include identification of new foci of transmission followed by targeted application of measures to eliminate infection. To be effective in the long term, control measures based on these short-term approaches have to be supported by aggressive educational campaigns and by significant improvements in personal hygiene and general sanitation within the disease-endemic area.

Developing an Action Plan: As a first step toward achieving prevention and control of taeniasis and cysticercosis, it is necessary to implement national plans aimed at controlling this disease; it was noted that a number of countries already have national action plans, however, few activities have been implemented. As a first step, it is necessary to identify regions where *T. solium* is endemic, to measure prevalence of taeniosis and cysticercosis in pigs and humans, and to evaluate the economic and social costs of the disease. There is a need for operational research aimed at verifying the effectiveness, costs, and benefits of alternative intervention strategies against *T. solium* in a variety of geographic and socioeconomic setting.

Obstacles To Overcome: *T. solium* is widely endemic in rural areas of developing countries where political, socioeconomic, and environmental conditions permit

the tapeworm's life cycle in pigs and humans to be completed. Active intervention for control of *T. solium* infection is still at its infancy and there are severe economic and social problems existing in most endemic areas that hinder implementation of programs.

Even though special studies reveal that morbidity caused by NCC is measurable and severe in endemic populations, the nature of the disease and the lack of locally-available diagnostic facilities make NCC an essentially silent and un-recognized disease of humans within most affected communities; these realities complicate efforts to motivate and empower the community to initiate efforts to control the disease. Pig owners, however, easily recognize the infection in their animals; the fact that cysticercosis reduces the value of infected pigs suggests a focus for education and prevention measures. In contrast, people rarely understand the relationship between cysticercosis in pigs and taeniosis or cysticercosis in humans and thus lack knowledge and incentive to change behavior that fosters transmission. In many if not most communities where *T. solium* is endemic there is an absence of piped water, sanitary infrastructure, waste disposal, and other basic services; consequently, to be effective in the short term intervention measures must be designed to circumvent these deficiencies to the extent possible. Primary health care facilities are also often lacking or inadequate. Since the disease is generally related to poverty and all its associated manifestations, all strategies to control the disease must consider costs and locally-available resources. Nevertheless, the many recent advances in diagnosis and treatment of the disease, and the new knowledge of the impact of the zoonotic disease on local health and economy, provide incentive and improved means to undertake the tasks.

ANNEX 1 LIST OF PARTICIPANTS

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