

A proposal to declare neurocysticercosis an international reportable disease

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Neurocysticercosis is an infection of the nervous system caused by *Taenia solium*. It is the most important human parasitic neurological disease and a common cause of epilepsy in Africa, Asia, and Latin America, representing enormous costs for anticonvulsants, medical resources and lost production. Neurocysticercosis is a human-to-human infection, acquired by the faecal–enteric route from carriers of intestinal *T. solium*, most often in areas with deficient sanitation. Intestinal tapeworms cause few symptoms, but adult taeniae carried by humans release large numbers of infective eggs and are extremely contagious. Ingestion of poorly cooked pig meat infested with *T. solium* larvae results in intestinal taeniosis but not neurocysticercosis.

With a view to hastening the control of taeniosis and neurocysticercosis we propose that neurocysticercosis be declared an international reportable disease. New cases of neurocysticercosis should be reported by physicians or hospital administrators to their health ministries. An epidemiological intervention could then be launched to interrupt the chain of transmission by: (1) searching for, treating and reporting the sources of contagion, i.e. human carriers of tapeworms; (2) identifying and treating other exposed contacts; (3) providing health education on parasite transmission and improvement of hygiene and sanitary conditions; and (4) enforcing meat inspection policies and limiting the animal reservoir by treatment of pigs. We believe that the first step required to solve the problem of neurocysticercosis is to implement appropriate surveillance mechanisms under the responsibility of ministries of health. Compulsory notification also has the major advantage of providing accurate quantification of the incidence and prevalence of neurocysticercosis at regional level, thus permitting the rational use of resources in eradication campaigns.

Keywords: epidemiological surveillance; international cooperation; neurocysticercosis, epidemiology.

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Introduction

Neurocysticercosis (NCC), defined as the infection of the central nervous system by the larval stage of the intestinal tapeworm *Taenia solium*, is the most

important parasitic disease of the human nervous system and constitutes a public health challenge for most of the developing world (1–5). Millions of persons are affected by *T. solium* taeniosis/cysticercosis (T/C) in Latin America (2–5), Asia (6, 7), and

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Africa (8–12), where the disease is a factor in the extremely high prevalence rates of epilepsy.

According to the Commission on Tropical Diseases of the International League Against Epilepsy (13, 14), the age-adjusted prevalence of active epilepsy in tropical countries ranges from 10 to 15 per 1000 inhabitants, almost twice the level in Western countries (15). Brain imaging has revealed that 50–70% of all patients with NCC present with seizures (12, 16–19). NCC is the leading cause of the onset of epileptic seizures in persons aged over 25 years in countries where *T. solium* infection is endemic (9–12, 20–24), and it is also an important cause of seizures in paediatric age groups (25–27). Epilepsy caused by NCC consequently represents an enormous expenditure for the developing world in terms of human suffering, lost production, the cost of anticonvulsants and the utilization of medical resources. NCC may also cause arachnoiditis, hydrocephalus, visual loss, stroke, dementia and numerous other neurological problems (1–5, 28–31).

NCC has been estimated to cause at least 50 000 deaths annually (32). The disease is endemic in the Andean area of South America, Brazil, China, the Indian subcontinent, Indonesia, Mexico and Central America, Papua New Guinea, South-East Asia, and sub-Saharan Africa (Fig.1). Cysticercosis is rare in Eastern and Central Europe, the Caribbean Islands (except Haiti), the Southern Cone of South America, and North America (except for the south-western states of the USA). NCC is uncommon in Australia, Japan, New Zealand, and the Pacific Islands, except among immigrants and tourists. NCC is absent from Israel and certain countries of North Africa, the Eastern Mediterranean Crescent and Central Asia where pork consumption is not allowed for religious reasons. The countries affected by T/C and NCC are listed in Table 1 (7).

Humans acquire NCC by ingesting eggs of *T. solium* shed in the faeces of human carriers of the parasite (1–5, 33). T/C is therefore a human-to-human infection acquired by the faecal–enteric route, usually in areas with deficient sanitation where there may be no facilities for hand-washing and proper stool disposal. Humans who ingest poorly cooked pig meat infected with larval forms of *T. solium* develop intestinal taeniosis, not NCC.

Taenia carriers are extremely potent sources of NCC, endangering everyone coming into contact with them. It has been calculated that each tapeworm releases 1–5 proglottids per day and that each proglottid produces around 40 000 fertile eggs (34). *Taenia* eggs are fully embryonated, infective and highly resistant to adverse environmental conditions, and they may remain viable for up to eight months, particularly in warm and humid climates (35). These observations explain the extremely high infective potential of the tapeworms. Recently, García et al. (36) demonstrated that tapeworm carriers are at high risk of developing massive brain infection with viable *T. solium* cysticerci. The

commonly held view that tapeworms are harmless guests should be energetically discredited, given the magnitude of the T/C problem. However, it is true that adult tapeworms cause almost no symptoms in carriers and that medical advice is seldom sought because of the presence of proglottids in the stools; this makes it difficult to identify cases and provide treatment.

Available measures for eradication of endemic taeniosis/cysticercosis

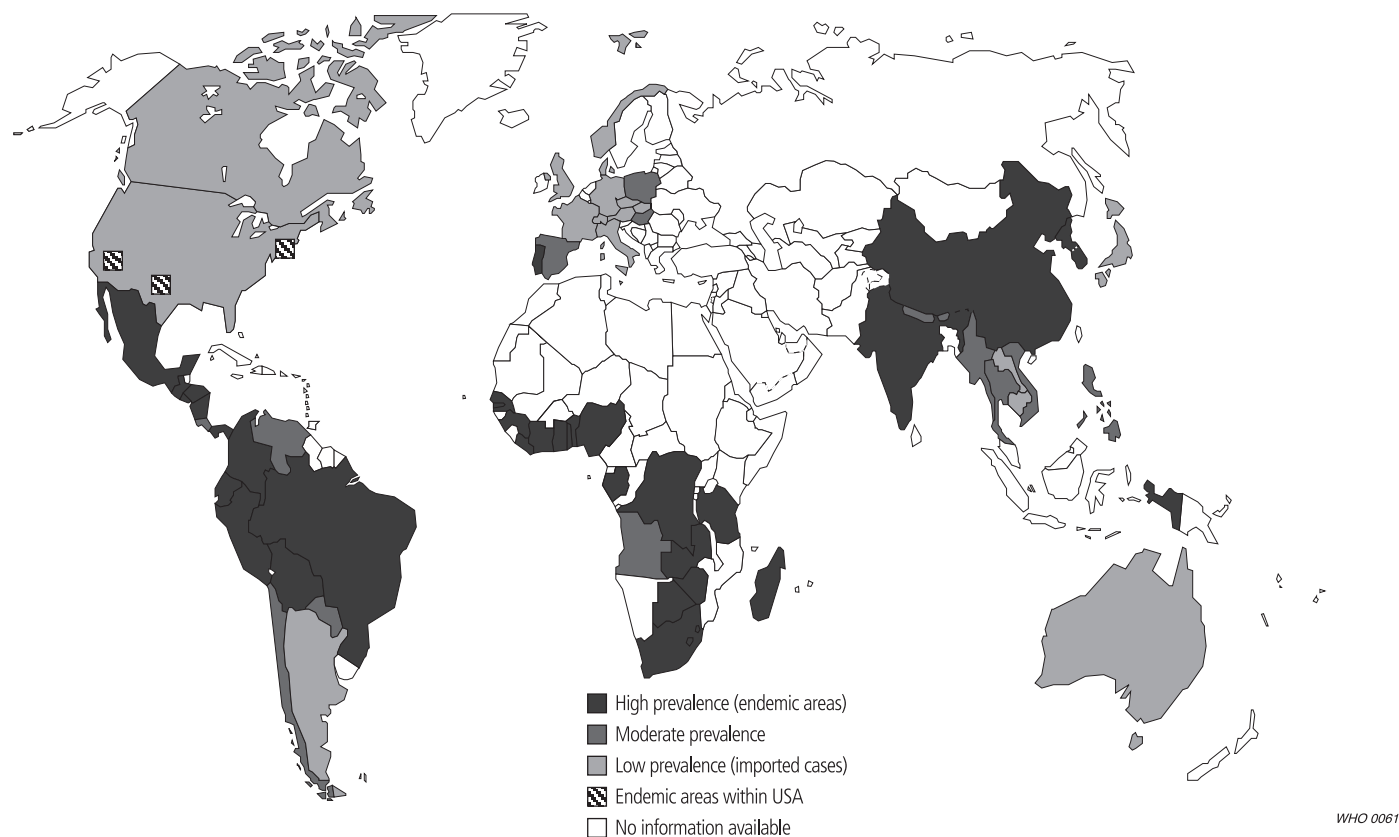
In 1993, cysticercosis was declared a potentially eradicable disease by the International Task Force for Disease Eradication (37). It has been demonstrated that public health control and eradication of endemic T/C can be achieved by eliminating the reservoirs of *T. solium* infection (32, 37–40). Cysticercosis virtually disappeared from Europe when the role of porcine cysticercosis became understood and meat inspection was strictly applied as the single most effective public health method of preventing and controlling it.

Theoretically, T/C control may be achieved by mass treatment of human carriers of the tapeworm. However, in order to interrupt the biological cycle of the parasite and prevent human reinfection, concurrent treatment of the entire porcine population presumed to be infected with swine cysticercosis is essential because of the failure of official meat inspection systems in most countries affected by NCC. Recent progress in the prevention and treatment of pig cysticercosis includes the use of an effective, single-dose treatment with oxfendazole (41) or praziquantel (42), and efforts towards the development of a porcine vaccine. Following the successful molecular biology model of *T. ovis* (43), a vaccine for swine cysticercosis is currently under study by several groups (44–47).

Factors linked to socioeconomic development and education are also required for T/C control (1–5); these include appropriate means of stool disposal, treatment of residual waters, availability of clean water, educational campaigns promoting personal hygiene, proper hand-washing, improvement of traditional pig-rearing techniques, and effective inspection of pig meat. However, developing countries can hardly afford to wait until all the elements of socioeconomic development are present before they begin campaigns to eradicate T/C. The cost of eradication campaigns is certainly less than that of treatment, the loss of production and the human suffering caused by NCC.

Migration and tourism have resulted in NCC occurring with increasing frequency in Australia, Europe and North America (48–52). Frequent hand-washing and stool examination are strongly recommended for migrant workers who prepare or serve food, along with preventive anthelmintic treatment (37, 38). In areas of endemicity these measures should be adopted by all food handlers.

Fig. 1. Map showing areas where cysticercosis is endemic. Countries in black represent countries where cysticercosis is endemic; countries in grey represent those where cases have been reported



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Need for neurocysticercosis surveillance

Neurologists, neurosurgeons and physicians should realize that every newly diagnosed patient with NCC has probably been infected by someone harbouring a tapeworm in the patient's immediate environment. Epidemiological studies demonstrating clustering of cases of NCC around taeniasic individuals, strongly suggest a major role for direct contamination (36), and discredit previously held concepts that environmental dispersion of *T. solium* eggs by water or air was the major factor in infection. The realization that human cysticercosis is an infectious disease linked to contagion from an infective human source should lead to an investigation of the source, involving the same epidemiological approach as is customary for other contagious diseases. So far, T/C eradication campaigns have concentrated unsuccessfully on the role of the pig as an intermediary host and animal reservoir. We believe, however, that the first step in tackling endemic T/C should be to concentrate on NCC, its most important manifestation, by implementing appropriate surveillance mechanisms in order to define the scale of the problem. Epidemiological interventions should then be launched by the health ministries of the countries concerned so as to

interrupt the chain of transmission. Among other things, these interventions might include the following:

- searching for, treating and reporting the sources of contagion, i.e. the human carriers of adult tapeworms, at home, at work, in villages and in restaurants;
- identifying and treating other exposed individuals, i.e. humans in close contact with carriers of adult tapeworms;
- providing health education on parasite transmission and the improvement of hygienic behaviour and sanitary conditions through the provision of clean water and the treatment of residual waters;
- enforcing meat inspection in abattoirs and butcheries, and controlling the animal reservoir by treatment of pigs and improvement of pig husbandry.

The launching of the epidemiological process through case-reporting should be the responsibility of physicians treating patients with NCC and of hospital administrators. This approach would help to banish the apathy of clinicians and hospital administrators who deal with so many cases of seizures attributable to NCC, and would encourage an active preventive approach by health ministries.

Table 1. Countries and territories with reported cases of human cysticercosis and neurocysticercosis

North Africa and Eastern Mediterranean Region^a	South America	Indian subcontinent
	Argentina	Bangladesh
	Bolivia	Bhutan
Sub-Saharan Africa	Brazil	India
Angola	Chile	Nepal
Benin	Colombia	Pakistan
Burkina Faso	Ecuador	Sikkim State
Burundi	French Guiana	Sri Lanka ^g
Cameroon	Guyana	
Congo	Paraguay	Central and Eastern Asia^g
Côte d'Ivoire	Peru	China
Ghana	Suriname	Democratic People's Republic of Korea
Madagascar	Uruguay ^d	Mongolia ^e
Malawi	Venezuela	Republic of Korea
Rwanda		
Senegal	Eastern Europe	South-East Asia Region
South Africa	Albania ^e	Cambodia
Togo	Bosnia and Herzegovina ^d	Indonesia
Zambia	Bulgaria	Lao People's Democratic Republic
Zimbabwe	Croatia	Malaysia
	Czech Republic ^d	Myanmar
North and Central America^b	Former Yugoslav Republic of Macedonia	Papua New Guinea
Belize	Greece	Philippines
Costa Rica	Poland	Thailand
El Salvador	Republic of Moldova	Viet Nam
Guatemala	Romania	
Honduras	Russian Federation	Western Pacific Region^h
Mexico	Slovakia ^d	
Nicaragua	Slovenia	
Panama	Yugoslavia ^d	
Caribbean Islands^c	Iberian Peninsula	
Haiti	Portugal ^f	
	Spain ^f	

^a No cases reported.

^b Only imported cases in Canada and the USA.

^c Cases in Guadeloupe and Martinique imported from Haiti.

^d Imported cases and infections acquired abroad.

^e No information available.

^f Endogenous and imported cases.

^g No data available. Probably no cases in Central Asian Republics of the former Soviet Union; only imported cases in Hong Kong (Special Administrative Region of China) and Japan.

^h Only imported cases in Australia and New Zealand.

Upgrading the status of human cysticercosis to that of an international reportable disease would have the major advantage of facilitating accurate quantification of the incidence and prevalence of NCC throughout the world. This is the first step necessary for the implementation of appropriate surveillance mechanisms. The Pan American Health Organization considers the absence of reliable epidemiological data on cysticercosis to be one of the main obstacles to satisfactory planning of eradication and prevention campaigns (53).

One of the first results of compulsory reporting of cysticercosis in the USA has been the provision of accurate data. Whereas only 497 patients with NCC were identified in the four largest hospitals in Los

Angeles County over an 11-year period (54), 134 cases were reported during the first 12 months of surveillance in 1989, when cysticercosis became a reportable disease (49). In the cysticercosis surveillance programme in Los Angeles County from 1988 to 1990, 138 cases were also reported, which represents an annual incidence of 0.6 per 100 000 population (55). Hispanics, mostly Mexican immigrants, had the highest rates (1.6 per 100 000). In 7% of the cases a tapeworm carrier was identified. Carriers were five times more likely to be found among contacts of patients with NCC who had been born in the USA than among contacts of patients who had been born outside the country.

In Mexico, human cysticercosis became a reportable disease in 1990. In 1993, 681 cases were notified, giving an incidence of 0.8 cases per 100 000 per year (56). The age groups most frequently affected were 25–44 years (286 cases), 45–64 years (139 cases), and 15–24 years (110 cases); there were 99 cases (15%) in children below 15 years of age. In contrast, 7550 cases of taeniosis were reported, giving an incidence of 8.5 per 100 000 per year. The large majority of cases were in Guanajuato, Jalisco, Mexico State and Morelos. On the basis of this information the Ministry of Health declared T/C a priority problem (57) and this led to special allocations of resources for taenicial treatments and educational campaigns in the most severely affected states.

Positive results from compulsory reporting of NCC have also been obtained in Brazil (58). In Ribeirão Preto, NCC became a reportable disease in October 1992 under a municipal pilot project for the

control of taeniosis and cysticercosis; 811 cases had been notified by the end of 1995, giving a prevalence rate of 54.5 per 100 000, one of the highest in the world. Clustering of NCC cases was noted in the north-west of the municipality (203 cases, 76.9%), making possible a rational distribution of resources to this area for eradication and education campaigns

Conclusion

The possibility now exists of eradicating human cysticercosis thanks to extensive knowledge about the natural history and biology of T/C, the development of accurate diagnostic methods and the availability of effective taenicial treatments. Progress towards eradication would be greatly enhanced if NCC were declared an international reportable disease. ■

Résumé

Faire de la neurocysticercose une maladie à déclaration obligatoire au niveau international

La neurocysticercose, infestation du cerveau par des larves de *Taenia solium*, est la principale complication de la ténia/cysticercose. La ténia/cysticercose représente un problème de santé publique important, surtout dans les pays où l'hygiène de l'environnement laisse à désirer, où la neurocysticercose est la principale cause de convulsions et d'épilepsie.

Les sujets contaminés après avoir consommé de la viande de porc mal cuite infestée par des cysticerques développent une ténia intestinale et deviennent porteurs définitifs de la maladie. Chaque ténia adulte libère quotidiennement dans les fèces du porteur un à cinq proglottis contenant chacun environ 40 000 œufs. L'homme contracte la neurocysticercose en ingérant des œufs de *T. solium* présents dans les matières fécales des porteurs. Les personnes infestées courent un risque élevé d'infestation cérébrale massive par des cysticerques viables de *T. solium*, par auto-infestation, et, comme l'ont montré des études épidémiologiques, constituent des grappes de cas de neurocysticercose. Tout porte à croire que l'infestation directe joue un rôle important dans la pathogénie de la maladie, alors qu'il est sans doute faux, par contre, que, comme on le croyait précédemment, les œufs de *T. solium* se transmettent par l'eau ou par l'air.

La neurocysticercose est par conséquent une infection transmise d'un individu à un autre qui se contracte par voie fécale-orale à partir des porteurs du ténia intestinal. Il faut combattre énergiquement l'idée très répandue selon laquelle le ténia, ou ver solitaire, est inoffensif et n'exige pas de traitement, compte tenu de l'ampleur du problème de la ténia/cysticercose et de ses complications. Les neurologues, neurochirurgiens et médecins généralistes doivent comprendre que, lorsqu'ils diagnostiquent un nouveau cas de neurocysticercose, c'est que le patient a probablement été contaminé

par quelqu'un de son entourage proche. Si l'on considère que la cysticercose humaine est une maladie infectieuse qui suppose une source de contagion humaine, il convient de rechercher et de traiter la source selon les mêmes principes épidémiologiques que pour la lutte contre d'autres maladies transmissibles.

En vue de lutter contre la ténia/cysticercose, et en particulier la neurocysticercose, nous proposons de considérer la ténia/neurocysticercose maladie à déclaration obligatoire au niveau international. Tout cas nouveau devra être notifié par le médecin traitant ou par l'administrateur de l'hôpital au ministère de la santé compétent. Une action épidémiologique sera alors entreprise afin d'interrompre la chaîne de transmission par les mesures suivantes : 1) rechercher, traiter et signaler les porteurs de ténia dans l'entourage du patient ; 2) rechercher et traiter les autres contacts possibles ; 3) informer la population des mécanismes de transmission du parasite, et améliorer les conditions d'hygiène et d'assainissement ; et 4) mettre en œuvre les politiques d'inspection des viandes, et circonscrire le réservoir animal par le traitement des porcs.

Nous considérons que la première mesure nécessaire pour résoudre le problème de la neurocysticercose consiste à appliquer les mécanismes de surveillance appropriés, sous la responsabilité du ministère de la santé. Faire de la neurocysticercose humaine une maladie à déclaration obligatoire aurait l'avantage non négligeable de faciliter la mesure de l'incidence et de la prévalence de la maladie dans le monde entier. La déclaration obligatoire permettrait en effet de mesurer précisément l'incidence et la prévalence de la ténia et de la neurocysticercose au niveau régional, ce qui faciliterait une utilisation plus rationnelle des ressources disponibles lors des campagnes d'éradication. Cette proposition a déjà été appliquée avec

succès au niveau national au Mexique, dans certains Etats des Etats-Unis d'Amérique et dans l'Etat de Ribeirão Preto, au Brésil.

L'éradication de la ténia/cysticercose paraît aujourd'hui réalisable grâce à nos connaissances étendues de l'histoire naturelle et de la biologie de

T. solium, à la mise au point de méthodes diagnostiques précises et à l'existence de traitements ténicides très efficaces. Le but de l'éradication paraît beaucoup plus accessible si l'on faisait figurer la ténia/neurocysticercose parmi les maladies à déclaration obligatoire au niveau international.

Resumen

Propuesta para que la neurocisticercosis sea declarada internacionalmente enfermedad de notificación obligatoria

La neurocisticercosis (NCC), definida como la infección del cerebro por formas larvarias de *Tenia solium*, constituye la complicación más importante de la teniosis/cisticercosis (T/C). La T/C es un importante problema de salud pública, especialmente en los países donde el saneamiento ambiental es deficiente, en los cuales la NCC es la causa más frecuente de convulsiones y epilepsia.

Las personas que ingieren carne insuficientemente cocida de cerdo infectado con cisticercos desarrollan una teniosis intestinal y se convierten en huéspedes definitivos. Cada tenia adulta libera diariamente en las heces fecales del portador 1-5 proglótides, que contienen unos 40 000 huevos fértiles cada una. Los humanos adquieren la NCC por ingestión de huevos de *T. solium* presentes en la materia fecal de los portadores. Las personas infectadas corren grave riesgo de sufrir una infección cerebral masiva por cisticercos viables de *T. solium*, por autoinfección, y, según se ha demostrado en estudios epidemiológicos, constituyen centros de agrupación de casos de NCC. Esto sugiere poderosamente que la infección directa desempeña un importante papel en la patogénesis de la NCC, mientras que probablemente sea incorrecta la antigua creencia de que los huevos de *T. solium* se transmiten por el agua o el aire.

La NCC es, por consiguiente, una infección que se transmite de persona a persona y se adquiere por vía fecal-oral a partir de portadores de la tenia intestinal. Hay que combatir enérgicamente la idea común de que la tenia, o solitaria, es inofensiva y no necesita tratamiento, máxime habida cuenta de la magnitud del problema de la T/C y de sus complicaciones. Los neurólogos, neurocirujanos y médicos generalistas tienen que percatarse de que cuando diagnostican un nuevo caso de NCC, el paciente probablemente ha contraído la infección de alguien de su entorno cercano. Una vez admitido que la cisticercosis humana es una enfermedad infecciosa que tiene una fuente de contagio humana, habría que investigar y tratar la fuente con los mismos principios epidemiológicos que se utilizan habitualmente en el control de otras enfermedades transmisibles.

Con miras a controlar la T/C, y en particular la NCC, proponemos que la teniosis/NCC sea declarada internacionalmente enfermedad de notificación obligatoria. Todo caso nuevo tendría que ser notificado por el médico tratante o por el administrador hospitalario al correspondiente ministerio de Salud del país. Se lanzaría entonces una intervención epidemiológica para interrumpir la cadena de transmisión aplicando las medidas siguientes: 1) búsqueda, tratamiento y notificación de portadores de tenia en el entorno del paciente; 2) búsqueda y tratamiento de otros posibles contactos; 3) educación de la población en los mecanismos de transmisión del parásito, y mejoramiento de las condiciones de higiene y saneamiento; y 4) aplicación de las políticas de inspección de carnes, y limitación del reservorio animal mediante el tratamiento de los cerdos.

Consideramos que la primera medida necesaria para resolver el problema de la NCC es que se apliquen los mecanismos de vigilancia apropiados, bajo la responsabilidad de los ministerios de Salud. Elevar la categoría de la neurocisticercosis humana declarándola internacionalmente enfermedad de notificación obligatoria tendría la importante ventaja de facilitar la cuantificación de la incidencia y la prevalencia de la NCC en todo el mundo. La notificación obligatoria permite una cuantificación precisa de la incidencia y la prevalencia de la teniosis y la neurocisticercosis a nivel regional, lo que facilita una utilización más racional de los recursos disponibles en las campañas de erradicación. Ya se ha aplicado con éxito esta propuesta a nivel nacional en México, en algunos estados de los Estados Unidos de América y en el Estado de Ribeirão Preto (Brasil).

La erradicación de la T/C parece hoy factible gracias a que disponemos de amplios conocimientos sobre la historia natural y la biología de *T. solium*, de métodos de diagnóstico precisos y de tratamientos ténicidas muy eficaces. La meta de la erradicación estará mucho más cerca cuando se aplique internacionalmente la propuesta de declarar la T/NCC enfermedad de notificación obligatoria.

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