14

Global Review of Human Taeniasis

AUTHORS DETAIL

Mughees Aizaz Alvi[1], Rana Muhammad Athar Ali[1*], Khurram Ashfaq[1], Imaad Rashid[1], Muhammad Imran[2], Muhammad Zaeem Abbas[3], Muhammad Saqib[1], Muhammad Shafeeq[1] and Faiq Ahmad[1]

[1]Department of Clinical Medicine and Surgery, University of Agriculture, Faisalabad, Pakistan
[2]Department of Pathology, University of Agriculture, Faisalabad, Pakistan
[3]Independent Researcher, Faisalabad, Pakistan
*Corresponding author: athar4545@gmail.com

Received: Sept 3, 2022 **Accepted: Oct 5, 2022**

INTRODUCTION

Human taeniasis is zoonotic cestodal infection caused by worms from the Taeniidae family. Although the disease has widespread distribution, communities in the developing nations bear the most of its burden. Taeniidae family possesses three species that may infect people; *Taenia (T.) asiatica* (also known as the "Asian tapeworm"), *Taenia (T.) solium* ("pork tapeworm") and *Taenia (T.) saginata* (sometimes called "beef tapeworm") (Ito et al. 2004).

The adult tapeworm of these three species is exclusively found in the small intestine of humans. For *T. saginata*, cattle serve as the intermediate host, whereas pigs are the larval hosts for Asian tapeworm and pork tapeworm. Humans develop disease by eating *T. solium* eggs from their environment and act as aberrant intermediate host. Although pain in abdomen and loss of weight have been observed, human taeniasis is mostly asymptomatic (Garcia et al. 2003; Flisser et al. 2011; Tembo and Craig 2015), though carriers may experience some discomfort when they see segments in their feces, particularly of motile *T. saginata* (Garcia et al. 2003). Perforation in gall bladder, swelling of appendix, and bowel blockage are infrequent complications of intestinal taeniasis (Hakeem et al. 2012; Kulkarni et al. 2014; Atef and Emna 2015; Li et al. 2015).

Human health burden is caused by larval infection of swine cestode (*T. solium*). Ingestion of fertile eggs of *T. solium* causes an abnormal cyst formation in numerous regions of the body of human. Cysts most commonly appear in the subcutaneous tissue, muscles, ocular system, and brain. The formation of a single or multiple cysts within the central nervous system - often the brain – are responsible for inducing nervous signs (Garcia et al. 2014).

According to a study conducted in various regions of world in 2010, disease in humans produced by swine tapeworm was culpable for 503,000 disability-adjusted life years (DALYs) lost per year (Murray et al. 2012). This is certainly an understatement of the total burden, considering that NCC may be responsible for thirty percent epilepsy occurrences in the prevalent regions (Rajshekhar et al. 2006; Ndimubanzi et al. 2010; Bruno et al. 2013). Swine tapeworm is also predicted to be the cause of 28,000 (95% CI 21,000-37,000) fatalities worldwide each year (Torgerson et al. 2015). Human taeniasis prevention and care are essential to control human cysticercosis, which will lead to decrease in epilepsy cases (Garcia et al. 2014).

Global Distribution

In the majority of North America, Australia, Europe, and New Zealand, *T. solium* has been successfully retained; although, disease transmission has been documented from some regions of Europe and North America (Sorvillo et al. 2011; Zammarchi et al. 2013; Devleesschauwer et al. 2017). Swine tapeworm is most prevalent in the developing nations, with the parasite endemic throughout African, and Asian countries, as well as in Latin America (Braae et al. 2015; Coral-Almeida et al. 2015). *T. saginata* is more widely distributed, including findings from Europe (Dorny and Praet 2007), New Zealand, Australia (Howell and Brown 2007), and other parts of the developing countries (Flisser et al. 2011).

Human taeniasis prevalence varies greatly across endemic countries, with a current meta-analysis indicating prevalence of 13.9% in Africa, 17.25% in Latin America, and 3% in Asia (Coral-Almeida et al., 2015). Prevalence of human taeniasis is low in USA, Canada and Australia, but the disease is re-emerging (Fig.1).

Diagnosis of Cases of Human Taeniasis

These estimates were made on the basis of a number of different diagnostic techniques. These have varying degrees of specificity (Sp) and sensitivity (Se) in the detection of taeniasis (Allan et al. 2003).

Adult *Taenia* carriers are traditionally diagnosed with the aid of microscope by observing ejected eggs in the feces. Despite the ease of this diagnostic procedure in resource-poor situations, a key disadvantage is the microscopy sensitivity, which is limited due to the irregular nature of released eggs. The reported sensitivity estimates vary from 3% (Allan et al. 1996) to 52% (Praet et al. 2013). Moreover, while microscopy has a high species specificity, speciation needs the examination of ejected proglottids, as *Taenia* eggs seem similar underneath the light microscope (Wilkins et al. 1999; Allan and Craig 2006).

Citation: Alvi MA, Ali RMA, Ashfaq K, Rashid I, Imran M, Abbas MZ, Saqib M, Shafeeq M and Ahmad F, 2023. Global review of human taeniasis. In: Aguilar-Marcelino L, Younus M, Khan A, Saeed NM and Abbas RZ (eds), One Health Triad, Unique Scientific Publishers, Faisalabad, Pakistan, Vol. 3, pp: 86-91. https://doi.org/10.47278/book.oht/2023.81

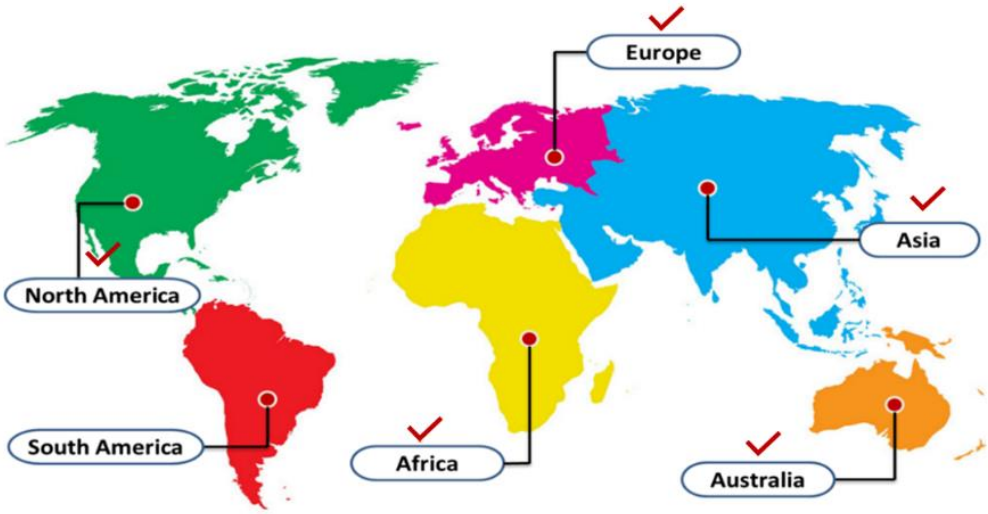

Fig. 1: Cosmopolitan distribution of human taeniasis

Fecal antigen (copro-Ag) detection is based on the identification of unique antigens in feces and, does not depend on active release of eggs or proglottids like microscopy to identify infection. It has now been effectively proved to diagnose *Taenia* spp. carriers in a range of settings. In a field experiment in Mexico, copro-Ag ELISA had a specificity/sensitivity (Sp/Se) of 99.0%/98.0%, whereas microscopy had a sensitivity of 38.0%, respectively (Allan et al. 1996).

One disadvantage of the presently offered fecal ELISAs is that they cannot distinguish between pork and beef tapeworms (Allan et al. 1996). Furthermore, cross-reactions with other gastrointestinal parasites such as, *Trichuris trichiura*, *Ascaris lumbricoides*, and some protozoa have been documented (Praet et al. 2013). DNA-based diagnostics have now been developed to provide species-specific diagnosis. A quick nested PCR test that used markers based on the reported *T. solium* oncospheral protein (Tso31) gene sequences exhibited 97%-100% sensitivity and 100% specificity, even under field settings (Mayta et al. 2008).

Given the fundamental challenges involved with diagnostic tests using faecal material, particularly in terms of health hazards and public acceptance, serological identification of mature *Taenia* carriers has a clear position. This was accomplished using an immunoblot technique for detecting antibodies against excretory and secretory antigens of swine tapeworm. When employed to test sera with confirmed infection status, including sera from beef tapeworm carriers and *Echinococcus* infected persons, the assay obtained a Se/Sp of 95%/100%, respectively (Wilkins et al. 1999).

However, use of local antigens limited the test's applicability outside the laboratory, and antigens have recently been generated in a baculo-virus system for application in different tests (Levine et al. 2004). rES33 and rES38 proteins are now being employed in an enzyme-linked immunoelectrotransfer blot (EITB) format in a current eradication programme against cysticercosis in Peru, with both demonstrating great sensitivity of 97.0% and 98.0% (rES33) and specificity of 100% and 91.0% (rES38), in field testing (Levine et al. 2007).

Treatment of Human Taeniasis

Adult *Taenia* spp. infections respond to the common anthelmintic medicines including tribendimidine (200 mg one per-oral dosage) (Steinmann et al. 2008), niclosamide (2 g/person), praziquantel (5-10 mg/kg, single per-oral dose) (Pearson and Guerrant 1983; Pearson and Hewlett 1985) and albendazole (3400 mg/person for three successive days) (Steinmann et al. 2011). Three times dose of albendazole can completely cure *Taenia* spp. cases, while praziquantel and niclosamide had effectivity rates of 95% and 85%, respectively (Pawlowski et al. 2005).

Praziquantel and niclosamide are the most effective antiparasitic medications against *Taenia* infection, and praziquantel seems to be an economical option @ $0.05-0.1 for a man/woman as a single dose (Engels et al. 2003). A few adverse outcomes of praziquantel have been reported, including stomach discomfort, laziness, and diarrhea (Raso et al. 2004); nevertheless, it is revealed that it may be due to potential of praziquantel to penetrate within brain, there may be nervous implication due to stimulation of undetected latent NCC (Flisser et al. 2003). In spite of the findings, no adverse outcomes were recorded in a research conducted in Tanzania in which school students were given the drug (praziquantel) in the region where schistosomiasis and cysticercosis were co-endemic (Braae et al. 2017). Albendazole therapy, which also crosses the blood brain barrier, may result in neurological adverse effects (Sotelo and Jung 1998); while niclosamide has low systemic penetration and hence has no impact on NCC (Pawlowski 2006).

Control Strategies of Human Taeniasis

Preventive chemotherapy refers to the taeniasis treatment to reduce the parasite load in a specified population and could be executed in three different ways. 1) Mass drug administration (MDA) is the treatment of entire population of a designated region at specified periods, regardless of physical state. 2) Targeted chemotherapy treats the specified risk group areas at specific intervals, whereas 3) selective chemotherapy examines persons and cures them based on their clinical state (Gabrielli et al. 2011). Many studies that have been conducted to examine the application of MDA for pork tapeworm (Keilbach et al. 1989; Diaz et al. 1991; Del Brutto et al. 1996; Allan et al. 1997; Sarti et al. 2000; Garcia et al. 2006; Wu et al. 2012; Ash et al. 2015). Most studies were found a decrease in taeniasis occurrence, while the impact on cysticercosis (human as well as porcine) were more diverse (Thomas 2015).

Data from modelling indicate that one-time MDA programmes rarely results in long-term suppression of *T. solium*, with fast reductions in frequency accompanied by a rapid recovery to earlier levels (Kyvsgaard et al. 2007). However, when MDA was used in conjunction with other techniques such as pig immunization and/or oxfendazole therapy, a persistent decline in porcine cysticercosis and human taeniasis was documented (Kyvsgaard et al. 2007; Assana et al. 2010; Okello et al. 2016).

Selective chemotherapy is considered as an important part of pork tapeworm control (Montresor and Palmer 2006; Pawlowski 2008; Penrith 2009), particularly with more health coverage (Sarti and Rajshekhar 2003) and with modeling data indicating that this treatment results in significant decrease in disease frequency (Kyvsgaard et al. 2007). Two trials in the field have been conducted till now that involve selective chemotherapy. Both of these trials were undertaken in combination with targeted MDA in school. A significant reduction in neurocysticercosis was observed in research conducted during eight-year interval (Medina et al. 2011). Another survey in Tanzania revealed more than 77% decrease in occurrence of *Taenia* infection within 22 months (Braae et al. 2017).

Vaccination against *T. solium* larval invasion in the swine host have been developed now, and two of them including SP3VAC and TSOL18, displaying great effectiveness in swines from both natural and experimental threats (Lightowlers 1999; Plancarte et al. 1999; Huerta et al. 2001; Gonzalez et al. 2005; Sciutto et al. 2007a; Sciutto et al. 2007b; Morales et al. 2008; Silva and Costa-Cruz 2010; Lightowlers 2010; Morales et al. 2011; Jayashi et al. 2012). One disadvantage of available vaccine choices is that none kills preexisting cysts; consequently, it is advised that swine vaccination must be administered in combination with oxfendazole at a dosage of 30.0 mg/kg to influence porcine cysticercosis illnesses established pre-immunization.

When employed in a field study in Cameroon, this combo of TSOL18 immunization and high therapeutic dose of oxfendazole treatment provided full protection from infection (Assana et al. 2010). TSOL18 vaccine (Cysvax) has been marketed with cooperation from the University of Melbourne, GALVmed, Indian Immunologicals Limited, and commercial manufacturing has begun. Permission for its usage in India is now in process, with certification across Africa likely by 2020 (Thomas 2015). Cattle vaccination against *T. saginata* has some efficacy with the TSA9/TSA18 vaccine displaying excellent effectiveness in preventing cattle from infection (Rickard et al. 1981; Lightowlers et al. 1996; Lightowlers et al. 2000; Harrison et al. 2005). However, this vaccine is not presently explored on commercial scale since the existing clues do not reveal that it is financially feasible (Lightowlers 2006).

Anthelmintic therapy can be used to treat the larval form of *T. solium* and using oxfendazole (30 mg/kg) exhibits the highest effectiveness (Gonzales et al. 1996; Gonzalez et al. 1997; Gonzalez et al. 1998; Gonzalez et al. 2001; Sikasunge et al. 2008). Oxfendazole have no recorded negative effects (Gonzalez et al. 1998), and is now approved in several countries, and presently being manufactured particularly for pigs as Panthic 10% (Thomas 2015). Bovine cysticercosis responds to praziquantel (Thomas and Gönnert 1978; Pawlowski et al. 1978; Harrison et al. 1984), and protection over re-infection seems to extend at least 3 months. Despite its effectiveness in bovines, praziquantel has still not been prepared for large ruminants.

Multi Host Intervention as One Health Approach

There are several ways to combat both beef and pork tapeworm using approaches that address human as well as animal hosts (WHO 2015). Pig vaccination along with MDA result in rapid and consistent reduction in prevalence of *Taenia* infection in humans as well as in pigs (Kyvsgaard et al. 2007).

Pigs were followed employing EITB strip diagnostic tests for 18 months (US Centers for Disease Control, Atlanta, GA, USA). The findings showed that living in a treated area after the interventions was an important measure against porcine cysticercosis (Garcia et al. 2006). Recently, The Bill & Melinda Gates Foundation funded a wide-scale experiment to eradicate pork tapeworm from a vast region of remote Peru. Human MDA (2 g nicolsamide, three rounds per year) is provided in conjunction with pig vaccination (TSOL18) and antiparasitic therapy effectively removed swine tapeworm from the pig host in (105/107) experimental rural areas and parasitic elimination persisted for one year post-treatment (Garcia et al. 2016).

Porcine vaccine (TSOL18) and antiparasitic therapy were recently paired with MDA programme of humans (triple albendazole dose 400 mg in two rounds) in Lao PDR, where an earlier quick decrease in human *Taenia* infection was persisted during the two years of research (Ash et al. 2015; Okello et al. 2016).

Conclusion

There are numerous critical elements of human taeniasis treatment and control, exploring significant potential and problems of existing therapeutic and diagnostic techniques. There is a need for further scaling-out of successful pilot control programs in order to assess their long-term impact and cost-effectiveness in good way, primarily in Asian and African countries. There is a dire need of integrating research findings into government policy and community-level action, allowing vulnerable communities throughout the globe to address the effects of taeniasis in a better way.

REFERENCES

Allan JC and Craig PS, 2006. Coproantigens in taeniasis and echinococcosis. Parasitology International 55: 75–80.

Allan et al., 2003. Immunodiagnostic tools for taeniasis. Acta Tropica 87: 87-93.

Allan JC et al., 1996. Field trial of the coproantigen-based diagnosis of *Taenia solium* taeniasis by enzyme-linked immunosorbent assay. American Journal of Tropical Medicine and Hygiene 54: 352–356

Allan JC et al., 1997. Mass chemotherapy for intestinal *Taenia solium* infection: effect on prevalence in humans and pigs. Transactions of The Royal Society of Tropical Medicine and Hygiene 91: 595–598.

Ash A et al., 2015. Controlling *Taenia solium* and soil transmitted helminths in a northern Lao PDR village: impact of a triple dose albendazole regime. Acta Tropica 174: 171-178.

Assana E et al., 2010. Elimination of *Taenia solium* transmission to pigs in a field trial of the TSOL18 vaccine in Cameroon. International Journal of Parasitology 40: 515–519.

Atef M and Emna T, 2015. A rare cause of intestinal obstruction. Journal of Clinical Case Reports 5: 2.

Braae UC et al., 2015. *Taenia solium* taeniosis/cysticercosis and the co-distribution with schistosomiasis in Africa. Parasite and Vectors 8: 323.

Braae UC et al., 2017. Effect of repeated mass drug administration with praziquantel and track and treat of taeniosis cases on the prevalence of taeniosis in *Taenia solium* endemic rural communities of Tanzania. Acta Tropica 165: 246–251.

Bruno E et al., 2013. Epilepsy and neurocysticercosis in Latin America: a systematic review and meta-analysis. PLoS Neglected Tropical Diseases 7: 2480.

Coral-Almeida M et al., 2015. *Taenia solium* human cysticercosis: a systematic review of seroepidemiological data from endemic zones around the world. PLoS Neglected Tropical Diseases 9: 0003919.

Del Brutto O et al., 1996. Proposal of diagnostic criteria for human cysticercosis and neurocysticercosis. Journal of the Neurological Sciences 142: 1–6.

Devleesschauwer B et al., 2017. *Taenia solium* in Europe: still endemic? Acta Tropica 165: 96–99.

Diaz CSP et al., 1991. Epidemiologic study and control of *Taenia solium* infections with praziquantel in a rural village of Mexico. American Journal of Tropical Medicine and Hygiene 45: 522–531.

Dorny P and Praet N, 2007. *Taenia saginata* in Europe. Veterinary Parasitology 149: 22–24

Engels D et al., 2003. The control of human (neuro)cysticercosis: which way forward? Acta Tropica 87: 177–182.

Flisser A et al., 2003. Neurocysticercosis: regional status, epidemiology, impact and control measures in the Americas. Acta Tropica 87: 43–51.

Flisser A et al., 2011. Cysticercosis and taeniosis: *Taenia solium*, *Taenia saginata* and *Taenia asiatica*. In: Palmer SR, Soulsby L, Torgerson P, Brown DWG, editors. Oxford Textbook of Zoonoses: Biology, Clinical Practice, and Public Health Control: Oxford University Press; pp: 625–642.

Gabrielli AF et al., 2011. Preventive chemotherapy in human helminthiasis: theoretical and operational aspects. Transactions of The Royal Society of Tropical Medicine and Hygiene 105: 683–693.

Garcia HH et al., 2003. *Taenia solium* cysticercosis. Lancet 362: 547–556.

Garcia HH et al., 2006. Combined human and porcine mass chemotherapy for the control of *T. solium*. American Journal of Tropical Medicine and Hygiene 74: 850–855.

Garcia et al., 2014. Clinical symptoms, diagnosis, and treatment of neurocysstic ercosis. Lancet Neurology 13: 1202-1215.

Garcia HH et al., 2016. Elimination of *Taenia solium* transmission in Northern Peru. The New England Journal of Medicine 374: 2335–2344

Gonzales AE et al., 1996. Effective, single-dose treatment or porcine cysticercosis with oxfendazole. American Journal of Tropical Medicine and Hygiene 54: 391–394.

Gonzalez AE et al., 1997. Treatment of porcine cysticercosis with oxfendazole: a dose-response trial. The Veterinary Record 141: 420–422.

Gonzalez AE et al., 1998. Time-response curve of oxfendazole in the treatment of swine cysticercosis. American Journal of Tropical Medicine and Hygiene 59: 832.

Gonzalez AE et al., 2001. Protection of pigs with cysticercosis from further infections after treatment with oxfendazole. American Journal of Tropical Medicine and Hygiene 65: 15–18.

Gonzalez AE et al., 2005. Vaccination of pigs to control human neurocysticercosis. American Journal Tropical Medicine and Hygiene 72: 837.

Hakeem SY et al., 2012. *Taenia saginata*: a rare cause of gall bladder perforation. Case Reports in Surgery 2012: 572484.

Harrison L et al., 1984. Absorption of cysticerci in cattle after treatment of *Taenia saginata* cysticercosis with praziquantel. Research in Veterinary Science 37: 378–380.

Harrison L et al., 2005. Ag-ELISA and PCR for monitoring the vaccination of cattle against *Taenia saginata* cysticercosis using an oncospheral adhesion protein (HP6) with surface and secreted localization. Tropical Animal Health and Production 37: 103–120.

Howell J and Brown G, 2008. Gastrointestinal: beef tapeworm (*Taenia saginata*). Journal of Gastroenterology and Hepatology 23: 1769–1769.

Huerta M et al., 2001. Synthetic peptide vaccine against *Taenia solium* pig cysticercosis: successful vaccination in a controlled field trial in rural Mexico. Vaccine 20: 262–266.

Ito A et al., 2004. Cysticercosis/taeniasis in Asia and the Pacific. Vector Borne Zoonotic Diseases 4: 95–107.

Jayashi CM et al., 2012. Successful immunization of naturally reared pigs against porcine cysticercosis with a recombinant oncosphere antigen vaccine. Veterinary Parasitology 188: 261–267.

Keilbach NM et al., 1989. A programme to control taeniasis-cysticercosis (*T. solium*): experiences in a Mexican village. Acta Leidensia 57: 181–189.

Kulkarni AS et al., 2014. Appendicular taeniasis presenting as acute appendicitis a report of two cases with review of literature. International Journal of Health Science and Research 4: 194–197.

Kyvsgaard NC et al., 2007. Simulating transmission and control of *Taenia solium* infections using a Reed-Frost stochastic model. International Journal of Parasitology 37: 547–558.

Levine MZ et al., 2004. Characterization, cloning, and expression of two diagnostic antigens for *Taenia solium* tapeworm infection. Journal of Parasitology 90: 631–638.

Levine MZ et al., 2007. Development of an enzyme-linked immunoelectrotransfer blot (EITB) assay using two baculovirus expressed recombinant antigens for diagnosis of *Taenia solium* taeniasis. Journal of Parasitology 93: 409–417.

Li P et al., 2015. Taeniasis related frequent intestinal obstruction: case report and mini-review. Journal of Gastroenterology and Hepatology Research 4: 1455–1458.

Lightowlers M et al., 2000. Vaccination against cysticercosis and hydatid disease. Parasitology Today 16: 191–196.

Lightowlers M, 2006. Cestode vaccines: origins, current status and future prospects. Parasitology 133: 27–42.

Lightowlers MW et al., 1996. *Taenia saginata*: vaccination against cysticercosis in cattle with recombinant oncosphere antigens. Experimental Parasitology 84: 330–338.

Lightowlers MW, 1999. Eradication of *Taenia solium* cysticercosis: a role for vaccination of pigs. International Journal of Parasitology 29: 811–817.

Lightowlers MW, 2010. Eradication of *Taenia solium* cysticercosis: a role for vaccination of pigs. International Journal of Parasitology 40: 1183–1192.

Mayta H et al., 2008. Nested PCR for specific diagnosis of *Taenia solium* taeniasis. Journal of Clinical Microbiology 46: 286–289

Medina MT et al., 2011. Reduction in rate of epilepsy from neurocysticercosis by community interventions: the Salamá, Honduras study. Epilepsia 52: 1177–1185.

Montresor A and Palmer K, 2006. Taeniasis/cysticercosis trend worldwide and rationale for control. Parasitology International 55: 301–303.

Morales J et al., 2008. Inexpensive anticysticercosis vaccine: S3Pvac expressed in heat inactivated M13 filamentous phage proves effective against naturally acquired *Taenia solium* porcine cysticercosis. Vaccine 26: 2899–2905.

Morales J et al., 2011. Recombinant S3Pvac-phage anticysticercosis vaccine: simultaneous protection against cysticercosis and hydatid disease in rural pigs. Veterinary Parasitology 176: 53–58.

Murray CJL et al., 2012. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet 380: 2197–2223

Ndimubanzi PC et al., 2010. A systematic review of the frequency of neurocysticercosis with a focus on people with epilepsy. PLoS Neglected Tropical Diseases 4: 870.

Okello AL et al., 2016. Assessing the impact of a joint human-porcine intervention package for *Taenia solium* control: results of a pilot study from northern Lao PDR. Acta Tropica 159: 185–191.

Pawlowski Z et al., 1978. The efficacy of mebendazole and praziquantel against *Taenia saginata* cysticercosis in cattle. Veterinary Science Communications 2: 137–139.

Pawlowski Z et al., 2005. Control of *Taenia solium* taeniasis/cysticercosis: from research towards implementation. International Journal of Parasitolology 35: 1221–1232

Pawlowski ZS, 2006. Role of chemotherapy of taeniasis in prevention of neurocysticercosis. Parasitology International 55: 105–109.

Pawlowski ZS, 2008. Control of neurocysticercosis by routine medical and veterinary services. Transactions of The Royal Society of Tropical Medicine and Hygiene 102: 228–232.

Pearson RD and Guerrant RL, 1983. Praziquantel: a major advance in anthelminthic therapy. Annals of Internal Medicine 99: 195–198.

Pearson RD and Hewlett EL, 1985. Niclosamide therapy for tapeworm infections. Annals of Internal Medicine 102: 550–551.

Penrith ML, 2009. Cysticercosis Working Group in Eastern and Southern Africa – 6th General Assembly. Journal of the South African Veterinary Association 80: 206–207.

Plancarte A et al., 1999. Vaccination against *Taenia solium* cysticercosis in pigs using native and recombinant oncosphere antigens. International Journal of Parasitology 29: 643–647.

Praet N et al., 2013. Bayesian modelling to estimate the test characteristics of coprology, coproantigen ELISA and a novel real-time PCR for the diagnosis of taeniasis. Tropical Medicine and International Health 18: 608–614.

Rajshekhar V et al., 2006. Active epilepsy as an index of burden of neurocysticercosis in Vellore district, India. Neurology 67: 2135–2139.

Raso G et al., 2004. Efficacy and side effects of praziquantel against *Schistosoma mansoni* in a community of western Côte d'Ivoire. Transactions of The Royal Society of Tropical Medicine and Hygiene 98: 18–27

Rickard M et al., 1981. A preliminary field trial to evaluate the use of immunisation for the control of naturally acquired *Taenia saginata* infection in cattle. Research in Veterinary Science 30: 104–108.

Sarti E and Rajshekhar V, 2003. Measures for the prevention and control of *Taenia solium* taeniosis and cysticercosis. Acta Tropica 87: 137–143.

Sarti E et al., 2000. Mass treatment against human taeniasis for the control of cysticercosis: a population-based intervention study. Transactions of The Royal Society of Tropical Medicine and Hygiene 94: 85–89.

Sciutto E et al., 2007a. Further evaluation of the synthetic peptide vaccine S3Pvac against *Taenia solium* cysticercosis in pigs in an endemic town of Mexico. Parasitology 134: 129–133.

Sciutto E et al., 2007b. Improvement of the synthetic tri-peptide vaccine (S3Pvac) against porcine *Taenia solium* cysticercosis in search of a more effective, inexpensive and manageable vaccine. Vaccine 25: 1368–1378.

Sikasunge CS et al., 2008. *Taenia solium* porcine cysticercosis: viability of cysticerci and persistency of antibodies and cysticercal antigens after treatment with oxfendazole. Veterinary Parasitology 158: 57–66.

Silva CV and Costa-Cruz JM, 2010. A glance at *Taenia saginata* infection, diagnosis, vaccine, biological control and treatment. Infectious Disorders- Drug Targets 10: 313–321.

Sorvillo F et al., 2011. Public health implications of cysticercosis acquired in the United States. Emerging Infectious Diseases 17: 1.

Sotelo J and Jung H, 1998. Pharmacokinetic optimisation of the treatment of neurocysticercosis. Clinical Pharmacokinetics 34: 503–515.

Steinmann P et al., 2008. Tribendimidine and albendazole for treating soil-transmitted helminths, Strongyloides stercoralis and *Taenia* spp.: open-label randomized trial. PLoS Neglected Tropical Diseases 2: 322.

Steinmann P et al., 2011. Efficacy of single-dose and triple-dose albendazole and mebendazole against soil-transmitted helminths and *Taenia* spp.: a randomized controlled trial. PLoS One 6: 25003.

Tembo A and Craig P, 2015. *Taenia saginata* taeniosis: copro-antigen time-course in a voluntary self-infection. Journal of Helminthology 89: 612–619.

Thomas H and Gönnert R, 1978. The efficacy of praziquantel against experimental cysticercosis and hydatidosis. Zeitschrift fur Parasitenkunde 55: 165–179.

Thomas LF, 2015. World Health Organization, Landscape Analysis: Control of *Taenia solium*. Geneva, Switzerland.

Torgerson PR et al., 2015. World Health Organization estimates of the global and regional disease burden of 11 foodborne parasitic diseases, 2010: a data synthesis. PLoS Medicine 12: 1001920.

WHO, 2015. The Control of Neglected Zoonotic Diseases: From Advocacy to Action: Report of the Fourth International Meeting Held at WHO Headquarters 19–20 November 2014. Geneva, Switzerland.

Wilkins PP et al., 1999. Development of a serologic assay to detect *Taenia solium* taeniasis. American Journal of Tropical Medicine and Hygiene 60: 199.

Wu W et al., 2012. A review of the control of clonorchiasis sinensis and *Taenia solium* taeniasis/cysticercosis in China. Parasitology Ressearch 111: 1879–1884.

Zammarchi L et al., 2013. Epidemiology and management of cysticercosis and *Taenia solium* taeniasis in Europe, systematic review 1990–2011. PLoS One 8: 69537.