



Short communication

Taenia solium from a community perspective: Preliminary costing data in the Katete and Sinda districts in Eastern Zambia



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ABSTRACT

The tapeworm *Taenia solium* is endemic in Zambia, however its socioeconomic cost is unknown. During a large-scale interventional study conducted in Zambia, baseline economic costs of human and porcine *T. solium* infections were measured.

Questionnaire surveys were conducted within three neighbourhoods in Zambia's Eastern province in 2015 and 2016. A human health questionnaire, capturing costs of clinical symptoms commonly attributable to human cysticercosis and taeniasis, was conducted in randomly selected households (n = 267). All pig-keeping households were administered a pig socioeconomic questionnaire (n = 271) that captured pig demographic data, costs of pig-keeping, and economic losses from porcine cysticercosis.

Of all respondents 62% had reportedly experienced at least one of the surveyed symptoms. Seizure-like episodes were reported by 12%, severe chronic headaches by 36%, and vision problems by 23% of respondents. These complaints resulted in 147 health care consultations and 17 hospitalizations in the five years preceding the study, and an estimated productivity loss of 608 working days per year.

Of all pigs 69% were bought within villages. Nearly all adult pigs were sold to local traders, and tongue palpation for detection of cysticerci was commonly performed. Reportedly, 95% of pig owners could not sell tongue-positive pigs, while infected pigs fetched only 45% of the normal sale value.

These preliminary costing data indicate that human and porcine *T. solium* infections substantially impact endemic areas of Eastern Zambia. A full socioeconomic burden assessment may enable improved *T. solium* management in sub-Saharan Africa.

1. Introduction

Taenia solium results in substantial public health and economic consequences globally. Endemic across much of sub-Saharan Africa, Asia and Latin America, it was ranked the most important parasite contributing to the global burden of food-borne diseases (WHO, 2015b).

Humans are the final host having the adult tapeworm (taeniasis,

TS). Scavenging pigs ingest infective eggs present in human faeces, and develop porcine cysticercosis (PCC). Humans also develop cysticerci following accidental ingestion of eggs (human cysticercosis, HCC). Neurocysticercosis (NCC) occurs when cysticerci develop in the host's central nervous system, and can cause neurological disorders (Carabin et al., 2011). NCC is the leading cause of preventable epilepsy in the developing world (WHO, 2015a). Studies in the Eastern Province of Zambia confirmed the region is hyper-endemic for *T. solium* (Mwape

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et al., 2015; Phiri et al., 2002).

Socioeconomic burden assessments of TS/CC remain largely lacking in literature. HCC costs include medical bills and loss of income and resources for affected families. Annual costs of inactivity in symptomatic HCC patients, unable to attend work or school, totalled over 8 million Euro in West Cameroon alone (Praet et al., 2009). Social stigmatisation of people with epilepsy (PWE) can markedly decrease quality of life. PCC may reduce the value of pigs and pork meat by up to 50% (Trevisan et al., 2015), reducing income for smallholder farmers, and further jeopardizing food safety and security in these communities.

This paper presents the first (preliminary) Zambian socioeconomic *T. solium* burden analysis.

2. Methods

2.1. Ethical considerations

Approval was granted by the Ethical Committees of the University of Zambia and the University of Antwerp, Belgium, the Zambian National Health Research Authority, local district health authorities, village headmen, the area chief, and participants.

2.2. Study site

The study was conducted in Nyembe neighbourhood in Katete district, and Chimvira and Herode neighbourhoods in Sinda district, in Zambia's Eastern Province (Fig. 1). Over half the national pig population is reared in this province, largely under free-ranging conditions by subsistence farmers. Pig slaughter occurs informally with little to no meat inspection, although tongue palpation for detection of PCC is increasing thanks to ongoing education campaigns.

Studies in the area determined prevalence of active TS as 6.3–11.9%, of active HCC as 5.8–14.5%, and of PCC up to 64% (Dorny et al., 2004; Mwape et al., 2012; Mwape et al., 2013). In Katete district, 57% of PWE had NCC, making it the single most important cause of acquired epilepsy in this area (Mwape et al., 2015).

2.3. Study design

The study at hand is part of the CYSTISTOP project consisting of three study arms: one human- and pig-based 'elimination' intervention arm, one pig-based 'control' intervention arm, and a 'negative control' arm.

2.4. Data collection

Fifty percent of all consenting households (HHs) in the two intervention study arms were randomly selected for the human health questionnaire, conducted in March 2016. Respondents were asked about occurrence, frequency, duration and associated costs of tapeworm infections, and of three clinical symptoms commonly experienced by NCC-sufferers – seizure-like episodes, severe chronic headache (of two days' duration or longer), and vision problems – in the preceding five years.

All consenting pig-keeping HHs in the three study areas undertook the pig socioeconomic questionnaire in October 2015. Demographic pig herd data, pig-raising costs, and economic impacts of PCC were captured. A conversion rate of 10 Zambian kwacha to \$1.00 USD was used.

3. Results

Overall, 267 and 271 respondents completed the human health and pig socioeconomic questionnaires, respectively.

3.1. Economic characteristics of respondents

Most respondents (95%) were livestock and/or crop farmers, and 24% of HHs owned pigs. Many respondents (61%) received no regular monetary income, and depend on crop harvests or livestock sales for cash flow (personal observation). Wage earners reportedly received \$0.80–\$340.00 USD per month.

3.2. Clinical features

Over 60% (166/267) of surveyed individuals reportedly experienced symptoms in the past five years; 66%, 30% and 4% of respondents reported one, two or three of the surveyed symptoms, respectively.

NCC-associated symptoms (seizures, headaches, vision problems) were reported by 56% of surveyed respondents. Of the 31 reported seizure-like symptoms, eight had also caused falls and/or burns. Severe chronic headache and vision problems were reported by 36% and 23% of total respondents, respectively. Tapeworm segments in stool were reportedly observed by 40 individuals (Table 1).

3.3. Health services utilisation

Medical attention was sought by 64% of the 166 reportedly symptomatic individuals, generating 147 medical consultations. Over half the consultations (59%) were for severe chronic headaches. More than 40% of seizure sufferers and over 60% of vision-affected patients did not seek medical attention during the self-reporting period. Nurses were the most commonly visited medical provider. Only six visits (4%) were to traditional healers (Fig. 2).

3.4. Direct costs

In Zambia, patients receive free primary public health care, so reported medical costs were usually \$0 USD. One respondent reportedly spent \$100 USD on a doctor's visit for seizures (Table 2).

3.5. Indirect costs

'Sick days' (days unable to perform normal duties because of surveyed conditions) were reported by 71 respondents, representing 43% of the symptomatic group and 27% of total respondents. Almost half of chronic headache sufferers reported taking sick days (Tables 2 and 3). The median numbers of sick days per symptomatic person per year were between 0.5–1 day for the three NCC-associated conditions, however three seizure sufferers each reported taking between 170 and 360 total sick days in the five year self-reporting period.

Twelve symptomatic respondents reportedly lost their jobs because of their conditions. Median durations of unemployment were between one and three weeks for all three NCC-associated symptoms; one seizure patient reported 1260 days of unemployment.

In total, the 267 surveyed respondents lost 608 productive days per year due to the surveyed complaints (excluding hospitalisations). Seizure conditions caused the most losses.

Transport time to and from medical visits was generally under one hour, but ranged to 26 h for one return journey. Walking was the usual mode of transport.

3.6. Hospitalisations

Seventeen reportedly symptomatic respondents were hospitalised within the five-year self-reporting period, representing 10% of symptomatic and 6% of total survey respondents. Nine hospitalisations were seizure patients, representing 29% of this group. Chronic headaches and vision problems caused six and two hospitalisations respectively, representing 6.2% (6/97) and 3.3% (2/61) of those symptomatic

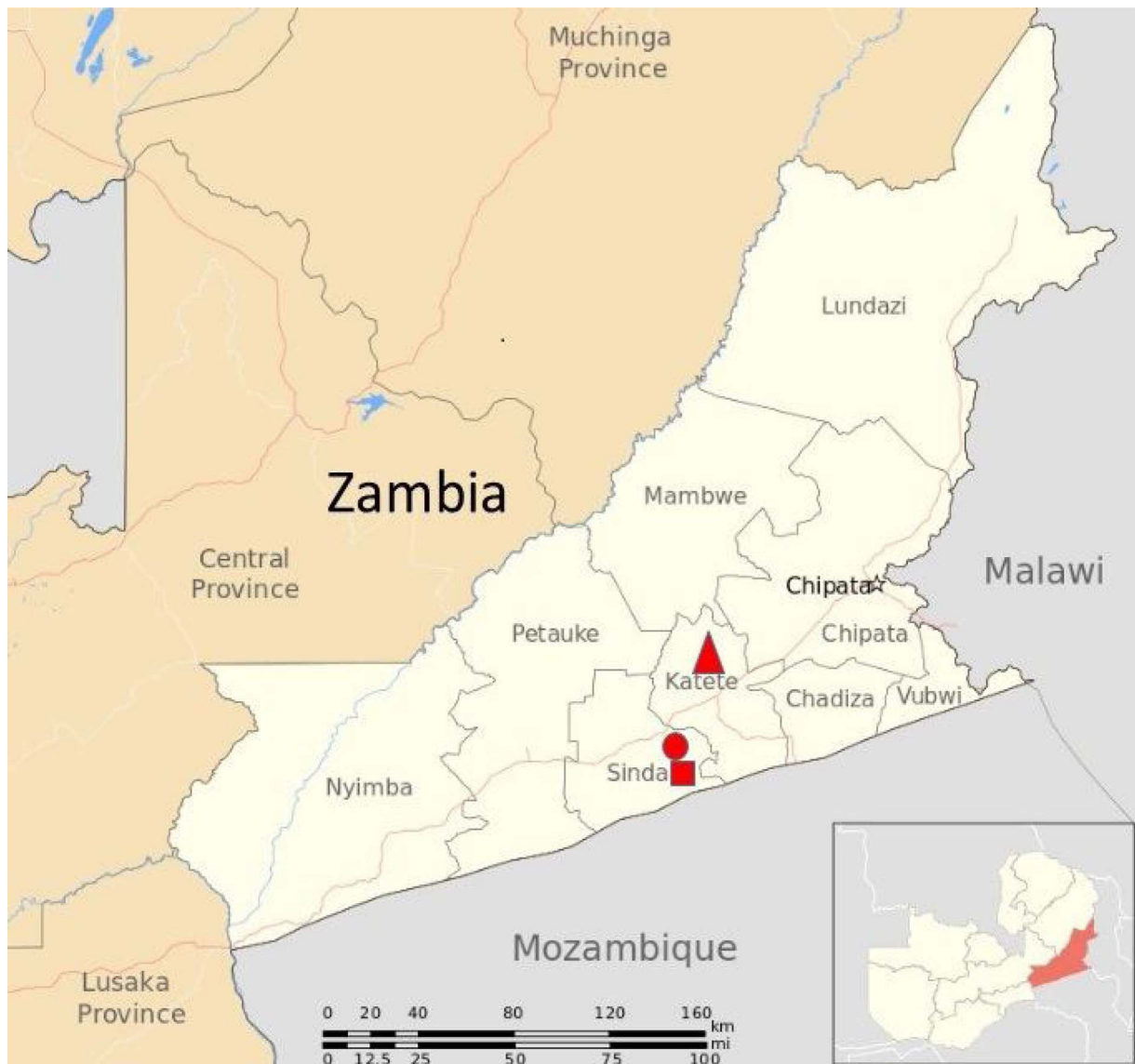


Fig. 1. Map of Zambia showing the study areas in the Eastern Province. ▲ = Nyembe neighbourhood ('elimination' study arm); ● = Herode neighbourhood ('negative control' study arm); ■ = Chimvira neighbourhood ('control' study arm).

Table 1

Clinical signs and symptoms reportedly experienced by survey respondents in the preceding five years. Some individuals reported more than one symptom.

Clinical signs and symptoms reported by survey respondents (N = 267)	n	% of total reported
NCC-associated conditions	189	71
Seizure-like symptoms	31	12
Loss of consciousness	15	5.6
Fainting	10	3.7
Uncontrollable shaking	6	2.2
Vision problems (one or both eyes)	61	23
Blurry vision	57	22
Blindness	4	1.5
Severe chronic headache	97	36
Tapeworm segments in stool	40	15

groups.

Median reported hospitalisation costs per visit for seizures were \$126 USD (range \$0.70–567.00 USD), \$3 USD (range \$1.00–3.00 USD) for chronic headaches and \$1 USD (range \$0.00–3.00 USD) for vision problems.

The median duration of each hospitalisation was 14 days (range 3–30 days) for seizure conditions, 2.5 days (range 2–14 days) for vision problems and 2.5 days for severe headache (range 2–4 days).

3.7. Socioeconomics of pig-keeping

Pig herd size ranged from one to twenty-one, with a median of three pigs. Most owners (92%) kept only indigenous pigs. All pigs were at least partially free roaming.

Most respondents (75%) provided some housing for their pigs, constructed mainly from logs (41%) or mud bricks (30%). Median total housing costs of labour and materials were each \$0 USD but reportedly ranged up to \$40 USD and \$110 USD, respectively.

All respondents provided maize bran as supplemental feed for pigs, and many also provided seasonal produce including watermelons and pumpkins (90%) and/or kitchen leftovers (53%). Median monthly price of feed was \$0.50 USD (range \$0–8 USD.)

Most owners (69%) bought young pigs from within the village, generally at 6 months of age for \$5–10 USD, kept them until 24 months of age, and then sold them for approximately \$24 USD (median values). Most adult pigs were sold to traders (95%), and sometimes to

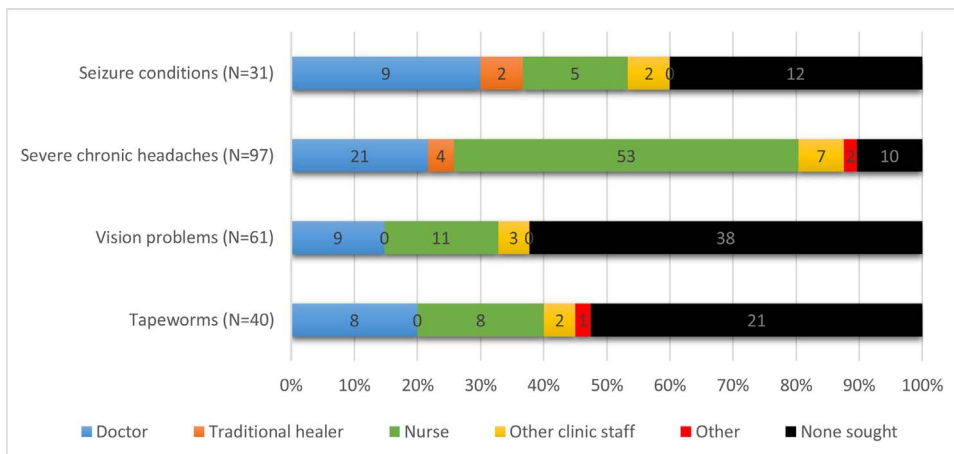


Fig. 2. Self-reported treatment-seeking behaviours and utilization of medical facilities by symptomatic survey respondents (number and proportions of medical visits).

neighbours (28%) or nearby villages (25%) [Percentages exceed 100% as multiple selections were permitted].

Of the 30% of respondents who reported treating sick pigs, most spent less than \$0.10 USD (range \$0–120 USD) per year, and administered the treatments themselves. Others (46%) slaughtered sick pigs for sale, burial or personal consumption, while 44% left sick pigs to die. Sick pigs were most commonly sold to traders (32%) but also to neighbours or nearby villages.

Many pig owners (76%) reported that their pigs’ tongues were examined for cysts at the point of sale, and most (95%) were unable to sell tongue-positive pigs. If an infected pig was sold it reportedly fetched a median price of \$10 USD, representing a value loss of 45% of a healthy pig.

4. Discussion

This is the first study describing community baseline socio-economics of human and porcine *T. solium* infections in Zambia, and demonstrates that the parasite imposes a substantial economic and health burden on endemic rural communities.

Most surveyed respondents were subsistence farmers, growing crops and/or raising livestock for personal consumption. Salaried employment was uncommon. Approximately one-quarter of HHs kept pigs, and costs of feeding, housing and medicating pigs were usually minimal. Although meat inspection in the villages is rare, identification of PCC via tongue palpation often results in infected pigs being unsaleable, or fetching much-reduced prices. This seriously affects pig-keeping HHs relying on livestock sales to provide cash for household expenses like school fees and health care.

Over half of surveyed respondents had experienced one of the neurological disorders commonly associated with NCC. It was of course not proven that NCC was the causative factor in each of these participants; there was insufficient budget for determination of respondents’ infection status. However, studies conducted in Katete district determined active HCC prevalence between 12.2–14.5% (Mwape et al., 2013), and confirmed NCC lesions in 57% of PWE (Mwape et al., 2015).

Table 2

Direct and indirect median (and range) medical costs associated with the surveyed complaints.

	Seizures	Severe chronic headache	Vision problems	Tapeworms
Cost of consultation (\$ USD)	0 (0–100.0)	0 (0–0.5)	0 (0–6.0)	0 (0–1.0)
Cost of treatment (\$ USD)	0 (0–0.10)	0 (0.0–5.0)	0 (0–9.5)	0 (0–1.0)
Medical costs per medical visit (\$ USD)	0 (0–10.0)	0 (0–1.0)	0 (0–9.5)	0 (0–2.0)
N° of medical visits per year	0.8 (0.2–12)	0.2 (2–20)	0 (0–2)	0 (0–1)
Medical costs per year (\$ USD)	0 (0–26.0)	0 (0–4.0)	0 (0–15.2)	0 (0–1.2)
Travel time per medical visit (hours)	3 (0.5–6)	1 (0–4)	0 (0–26)	0.25 (0–6)
Travel time per year (hours)	0.4 (0–24)	0.4 (0–24)	0 (0–15.6)	0 (0–3.6)

It may therefore be reasonable to assume that the high occurrence of the reported neurological conditions among the surveyed respondents, and the high prevalence of active NCC in the population, are at least partly linked.

Medical care had been sought by most of the reported chronic headache sufferers (96%) and symptomatic seizure patients (61%), compared to only 38% of those with vision problems. Delaying treatment can exacerbate disease severity and duration, and increase total healthcare-related costs in future. Although primary health care is free in Zambia, rural health centres are often undersupplied, which may contribute to the treatment gap.

Sickness and unemployment arising from the NCC-associated conditions cost the 267 surveyed respondents 608 productive days per year. These losses directly impact household incomes, particularly when the breadwinner is affected, and can cause longer-term financial damage for those unable to retain or regain employment. Relatives must often stay home to care for affected patients, thereby adding to or even doubling the inactivity burden.

Economic impacts currently ascribed to NCC-associated epilepsy are considerable: nearly \$6 million USD in Tanzania alone, according to a 2012 study (Trevisan et al., 2015). PWE receive fewer educational and employment opportunities, are less likely to marry, and are at higher risk of both sexual abuse and premature death than non-epileptics (Birbeck et al., 2007; Riasi et al., 2014). However, the social burden of epilepsy is highly variable and difficult to quantify. Many NCC sequelae, including visual deficits, gait abnormalities, hydrocephalus and stroke (Winkler and Richter, 2015), are currently not being captured in field studies, leading to probable underestimations of burden calculations.

Our study has limitations. While primary healthcare is free for patients in Zambia, the actual costs are being borne by the Zambian government, and must be captured in future burden assessments. NCC may have caused fatalities in the study communities during the five-year self-reporting period, which would affect the economic burden reported here. Ethical restraints prevented the examination of hospital records for this purpose.

Table 3

Sickness and unemployment (excluding hospitalizations) among symptomatic survey respondents (n = 166) per year, in the preceding five years.

	Seizure conditions	Severe chronic headaches	Vision problems	Combined totals
Sickness				
Respondents who take 'sick days' due to condition (% of N)	12/31 (39%)	47/97 (49%)	12/61 (20%)	71/166 (43%)
Median number of sick days per person per year (range)	0.5 (0–72)	0.6 (0.2–6.2)	0.9 (0–6.0)	–
Total days lost to sickness per year	235	53	23	311
Unemployment				
Respondents who lost job due to condition (% of N)	2/31 (7%)	7/97 (7%)	3/61 (5%)	12/166 (7%)
Median days unemployed per person per year (range)	2.8 (0–252)	1.4 (1.4–9.8)	5.6 (4.2–5.6)	–
Total days lost to unemployment per year	258	24	15	297
Total (combined) working days lost per year	493	77	38	608

A recent outbreak of African swine fever meant fewer pig-keeping households were available for surveying than expected, which may have affected pig demographics and management behaviours. However, as such outbreaks occur quite commonly in this region, it would be reasonable to expect that data obtained during this study are within normal limits.

5. Conclusion

These preliminary costing data indicate that *T. solium* cysticercosis imposes a substantial socioeconomic burden on rural Eastern Zambian communities. A full socioeconomic burden assessment may allow calculations of cost-effectiveness measures of control and elimination, allowing determination of optimal *T. solium* policies in sub-Saharan Africa.

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References

- Birbeck, G., Chomba, E., Atadzhonov, M., Mbewe, E., Haworth, A., 2007. The social and economic impact of epilepsy in Zambia: a cross-sectional study. *Lancet Neurol.* 6, 39–44.
- Carabin, H., Ndimubanzi, P.C., Budke, C.M., Nguyen, H., Qian, Y.J., Cowan, L.D., Stoner, J.A., Rainwater, E., Dickey, M., 2011. Clinical manifestations associated with neurocysticercosis: a systematic review. *PLoS Negl. Trop. Dis.* 5.
- Dorny, P., Phiri, I.K., Vercauteren, J., Gabriël, S., Willingham III, A.L., Brandt, J., Victor, B., Speybroeck, N., Berkvens, D., 2004. A bayesian approach for estimating values for prevalence and diagnostic test characteristics of porcine cysticercosis. *Int. J. Parasitol.* 34, 569–576.
- Mwape, K.E., Phiri, I.K., Praet, N., Muma, J.B., Zulu, G., Van den Bossche, P., de Deken, R., Speybroeck, N., Dorny, P., Gabriel, S., 2012. *Taenia solium* infections in a rural area of Eastern Zambia—a community based study. *PLoS Negl. Trop. Dis.* 6, e1594.
- Mwape, K.E., Phiri, I.K., Praet, N., Speybroeck, N., Muma, J.B., Dorny, P., Gabriel, S., 2013. The incidence of human cysticercosis in a rural community of Eastern Zambia. *PLoS Negl. Trop. Dis.* 7, e2142.
- Mwape, K.E., Blocher, J., Wiefek, J., Schmidt, K., Dorny, P., Praet, N., Chiluba, C., Schmidt, H., Phiri, I.K., Winkler, A.S., Gabriel, S., 2015. Prevalence of neurocysticercosis in people with epilepsy in the eastern province of Zambia. *PLoS Negl. Trop. Dis.* 9.
- Phiri, I.K., Dorny, P., Gabriel, S., Willingham III, A.L., Speybroeck, N., Vercauteren, J., 2002. The prevalence of porcine cysticercosis in Eastern and Southern provinces of Zambia. *Vet. Parasitol.* 108, 31–39.
- Praet, N., Speybroeck, N., Manzanedo, R., Berkvens, D., Nsame Nforinwe, D., Zoli, A., Quet, F., Preux, P.M., Carabin, H., Geerts, S., 2009. The disease burden of *Taenia solium* cysticercosis in Cameroon. *PLoS Negl. Trop. Dis.* 3, e406.
- Riasi, H., Sanati, A.R., Kazem, G., 2014. The stigma of epilepsy and its effects on marital status. *Springerplus* 3, 762.
- Trevisan, C., Devleeschauwer, B., Schmidt, V., Winkler, A.S., Harrison, W., Johansen, M.V., 2015. The societal cost of *Taenia solium* cysticercosis in Tanzania. *Acta Trop.* 2015.
- WHO, 2015a. Investing to Overcome the Global Impact of Neglected Tropical Diseases: Third WHO Report on Neglected Tropical Diseases. World Health Organization, Geneva, Switzerland, pp. 211.
- WHO, 2015b. WHO Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007–2015. World Health Organization, pp. 268.
- Winkler, A.S., Richter, H., 2015. Landscape Analysis: Management of Neurocysticercosis with an Emphasis on Low- and Middle-income Countries. World Health Organization (WHO), Geneva, Switzerland, pp. 65.