# *Taenia solium* taeniosis and cysticercosis literature in Tanzania provides research evidence justification for control: A scoping review

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## SUMMARY

Research evidence to guide policy and research agenda for *Taenia solium* taeniosis and cysticercosis (TSTC) in Sub-Saharan Africa is lacking. A scoping review of all TSTC studies undertaken in Tanzania and published up to November 2018 was conducted. The literature were searched from PUBMED, Tanzania Veterinary Journal, Tanzania Journal of Health Research and Google, and extracted to provide evidence on disease burden and potential for control. Fifty (50) articles met the inclusion criteria and were reviewed. Prevalence of taeniosis of 2.3% - 5.2% was estimated based on copro-antigen ELISA while human cysticercosis of >16% was estimated based on serum antigen ELISA (Ag-ELISA) or IgG Western Blot. Neurocysticercosis contributed significantly to epilepsy in adults. Farm prevalence of porcine cysticercosis were 6.0% - 17.4% (lingual examination), 1.5% - 33.3% (Ag-ELISA) and incidence rates of 25/100 pig-years (lingual examination) and 69/100 pig-years (Ag-ELISA). Slaughter-slab prevalence were 0% - 18.2% (routine meat inspection). Lacking latrines, watering pigs with river or pond waters and feeding pigs with potato peels were associated with high porcine cysticercosis prevalence. Washing hands by dipping method instead of running water increased the risk of human cysticercosis. For the year 2012 the number of DALYs/1000 person-years for NCC-associated epilepsy was 0.7 (95% UI, 0.2–1.6), around 5 million USD (95% UI, 797,535–16,933,477) were spent due to NCC-associated epilepsy and nearly 3 million USD (95% UI, 1,095,960–5,366,038) were potentially lost due to porcine cysticercosis. Three rounds of annual treatment of school-age children with praziquantel significantly reduced prevalence of taeniosis and porcine cysticercosis. A health education intervention reduced porcine cysticercosis incidence by approximately 43% with no improvement in pig confinement or use of latrines. A single dose of oxfendazole 30 mg/kg body weight eliminated *T. solium* cysticerci in pig musculature but not in the brain. High prevalence of *T. solium* infections in humans and pigs have been reported in Tanzania while the parasite accounts for a considerable proportion of epilepsy in humans that could be prevented. A one-health approach is mandatory to elimination of TSTC. There is potential for integrating control of TSTC with schistosomiasis control.

**Key words:** Taeniosis, Cysticercosis, Slaughter-slab, Epilepsy, Public health

## INTRODUCTION

In 2010, the World Health Organisation added taeniosis/cysticercosis in its list of Neglected Tropical Diseases (NTD) requiring attention towards research, control and ultimately elimination (WHO 2010). In 2012, *T. solium* ranked first in the global scale of important food-borne parasites in terms of its impacts on public health and trade (FAO/WHO 2013). In 2013, the World Health Assembly passed the WHA66.12 resolution on neglected tropical diseases (NTDs), which promotes implementation of preventive and control strategies for taeniosis and cysticercosis in order to prevent epilepsy and other neurological and mental health problems (WHO 2013; Jarvis 2015). Member countries were urged to ensure continued country ownership of programmes for NTD prevention, control and elimination, and to further strengthening the disease surveillance systems especially on NTDs targeted for eradication. The World Organisation for Animal Health published a cysticercosis code in 2015 to guide international trade on pigs and pig products from countries endemic for *T. solium* (OIE 2018). In Tanzania, taeniosis/cysticercosis is identified as one of the country's important health research priorities, having been added in the list of the country's health research priorities for 2013-2018 and 2015-2020 (NIMR 2013; COSTECH 2016). It is urged that research should focus on establishing the magnitude and trends of the diseases and device mechanisms for control (COSTECH 2016).

Despite TSTC being a public health priority globally (WHO 2010; FAO/WHO 2013; NIMR 2013; WHO 2013; Jarvis 2015; COSTECH 2016; OIE 2018), there has been no control programme in place in most endemic countries, Tanzania inclusive. This could be attributed to lack of awareness by many stakeholders on the burden and impact of the diseases. This information is essential in guiding TSTC policies, practices and research agendas as well as encouraging cross-sectoral collaboration in endemic countries. National elimination of the parasite is the foundation for global eradication. This will require substantial country-level information be provided to all key stakeholders (Johansen *et al.,* 2017), which is currently lacking in most TSTC endemic countries. This study conducted a scoping review of literature to map out TSTC research evidence and highlight on the burden and potential for disease control in Tanzania. The

standard protocol used in this scoping review can be adapted to other countries to establish country-level research evidence for TSTC as well as other diseases.

**Key definitions**

As this review intends to provide a broad picture of TSTC research evidence available in Tanzania and highlight on the burden and potential for disease control, the following definition is provided.

**Disease burden**

Disease burden is the impact of a health problem as measured by financial cost, mortality, morbidity, or other indicators (Kay *et al.,* 2000). In human, it is often quantified in terms of quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs), both of which quantify the number of years lost due to disease (YLDs). One DALY can be thought of as one year of healthy life lost, and the overall disease burden can be thought of as a measure of the gap between current health status and the ideal health status (where the individual lives to old age free from disease and disability) (Kay *et al.,* 2000). Most zoonotic diseases pose dual impact as a results of infections in humans and animals. Cysticercosis provides one of best examples as it causes economic burden because of disability of people suffering neurocysticercosis and financial losses from condemnation of infected pork. In such cases, full societal burden due to the diseases must take into account the dual impact. This can then be assigned a DALY equivalent, termed animal loss equivalents (ALE), and added to the DALY associated with human ill health. The total burden for a zoonotic disease has been termed "zDALY" (Torgerson 2018). Nevertheless, previous TSTC studies in Tanzania have assessed disease burdens for humans and pigs separately as mapped in the present study.

**Objectives of the review**

The overall objective of this scoping review is to provide research evidence base for guiding country-level policies, practices and research agendas to the control of TSTC. The following are the specific objectives:

1. To determine the magnitudes, distribution and risk factors for TSTC in Tanzania based on previous studies conducted in the country;
2. To establish the public health and economic impacts of TSTC based on previous studies undertaken in Tanzania;
3. To explore tools available for control of TSTC in Tanzania;
4. To identify effective TSTC intervention strategies based on previous intervention trials conducted in Tanzania;
5. To determine cost-effectiveness of successful TSTC intervention strategies in Tanzania.

**METHODS**

**Inclusion criteria for studies**

**Types of participants**

This review included all studies on TSTC in humans and pigs, including reviews.

**Concept**

The review included any study conducted to measure any aspect of TSTC.

**Context/types of studies**

This review was intended to map the TSTC situation in Tanzania. Thus only studies undertaken in Tanzania addressing *T. solium* were included regardless of the setting (field or others), year of publication or study design. Both quantitative and qualitative studies were included. In addition, studies were included without considering their quality. Studies that utilised biological samples from Tanzania for diagnostic test evaluation or other scientific purposes undertaken by researchers abroad were excluded from the review.

**Searching strategy**

The literature searches were performed from April 22 to November 10 2018, and followed the standard three-steps as recommended elsewhere (Peters *et al.,* 2015) with an additional fourth step, to search for published studies. In the first step, a decision was made on which databases to be included. Based on initial searches, PUBMED was found to be the most common database that captured most of the literature in this research topic. In addition, we searched the Tanzania Veterinary Journal (TVJ) to capture possible additional publications being a local journal. Similarly, we searched from the Tanzania Journal of Health Research (TJHR), though no articles on *T. solium* were found in this particular journal. In searching the databases, we searched for key words "Tanzania AND *Taenia solium*" and looked at what other similar terms could have been used in the article titles, abstracts or journal article indexing. In the PUBMED, the MeSH terms for *Taenia solium* were "*Taenia soliums* OR *soliums*, *Taenia* OR Tapeworm, Pork OR Pork Tapeworm OR Pork Tapeworms OR Tapeworms, Pork". The MeSH terms for Tanzania were "United Republic of Tanzania OR Zanzibar OR Tanganyika". Thus we searched PUBMED for (*Taenia soliums* OR *soliums*, *Taenia* OR Tapeworm, Pork OR Pork Tapeworm OR Pork Tapeworms OR Tapeworms, Pork) [All fields] AND (United Republic of Tanzania OR Zanzibar OR Tanganyika) [All fields]. In the second step, we searched PUBMED followed by TVJ and TJHR using

our keywords. This was followed by a quick reading through all the retrieved articles, one-by-one and selecting those that were relevant to our research questions. In the third step, we searched all additional relevant articles cited in the list of references of each of the initially selected articles. These were also scanned through for additional references in their list of references. The fourth step involved an additional author-specific search in which persons known to have been involved in TSTC research in Tanzania were searched using Google, which was also able to capture potential grey literature. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for this study is presented in Figure 1.

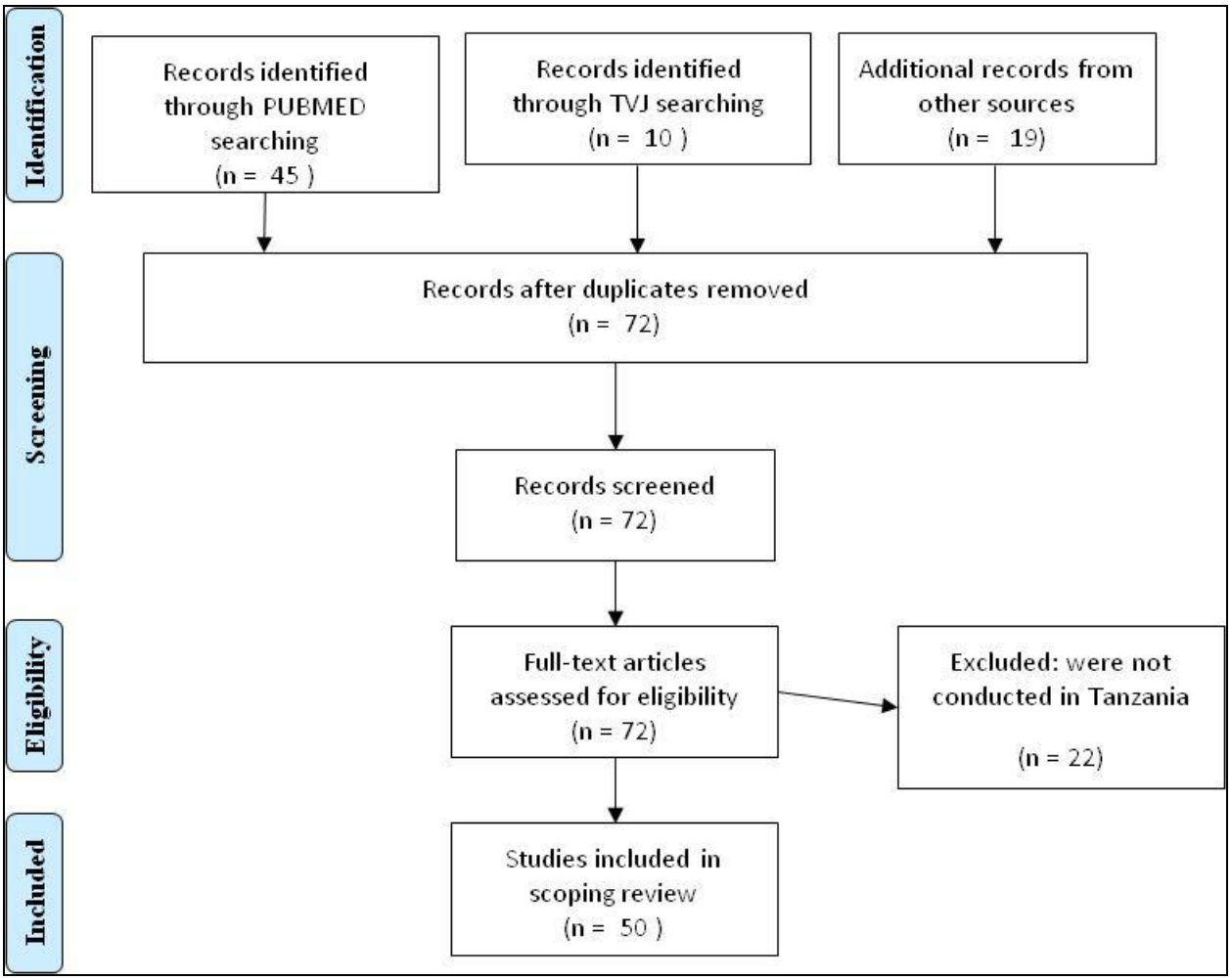


**Figure 1.** PRISMA diagram for a scoping review of *Taenia solium* cysticercosis/taeniasis research evidence in Tanzania. 1995-2018. A study could fall under more than one category.

**Extracting and charting the results**

Data extraction and charting is a process of reading the full text of each article identified for inclusion in the review and extracting the pertinent data using a standardized data extraction/coding form. Data extraction and charting in this review included some coding of basic information targeted for narrative reporting as well as some analysis on the targeted concepts. Basic information extracted from each article include the study site, author, year of publication, aims of the study, study design, study population and sample size, outcome measure and key findings. In addition, the analytical data extraction and charting enabled further mapping of TSTC disease burden, transmission risk factors and control strategies among other aspects. The literature review was performed in ATLAS.ti 8.

**RESULTS**

**General results**

A total of 50 scientific publications published from 1995 to November 2018 were reviewed (Shonyela *et al.,* 2017; Kabululu *et al.,* 2015; Mwanjali *et al.,* 2013; Komba *et al.,* 2013; Eom *et al.,* 2011; Mkupasi *et al.,* 2011; Ngowi *et al.,* 2008; Ngugi *et al.,* 2013; Ngowi *et al.,* 2004a; Ngowi *et al.,* 2004b; Kabululu *et al.,* 2018; Braae *et al.,* 2016a; Boa *et al.,* 2006; Winkler *et al.,* 2009; Kavishe *et al.,* 2017; Mwang'onde *et al.,* 2012; Ngowi *et al.,* 2011; Mkupasi *et al.,* 2013; Ngowi *et al.,* 2007a; Nkwengulila 2014; Ngowi *et al.,* 2014;

Trevisan *et al.,* 2017c; Trevisan *et al.,* 2017a; Trevisan *et al.,* 2017b; Braae *et al.,* 2016b; Schmidt *et al.,* 2016; Trevisan *et al.,* 2016; Braae *et al.,* 2015a; Braae *et al.,* 2015b; Schmidt *et al.,* 2015; Mkupasi *et al.,* 2015; Kamuyu *et al.,* 2014; Ngowi *et al.,* 2010; Ertel *et al.,* 2017; Makundi 2015; Ngowi *et al.,* 2009; Blocher *et al.,* 2011; Ngowi *et al.,* 2007b; Maridadi *et al.,* 2011; Ngowi *et al.,* 2015; Ngowi *et al.,* 2016; Yohana *et al.,* 2013; Hunter *et al.,* 2015; Mwidunda *et al.,* 2015; Lipendele *et al.,* 2015; Braae *et al.,* 2014; Boa *et al.,* 1995; Boa *et al.,* 2002; Braae *et al.,* 2017; Nsengwa and Mbise 1995).

Of the 50 reviewed publications, 46 were full-length journal papers, three were short communications and one was an MSc dissertation. There were more publications from 2007 on with peak publication in 2015 (Figure 2). Study sites for original investigations are mapped in Figure 3, indicating clustering of studies in some parts of the country especially southern and northern highlands. Figure 4 presents the number of studies by various aspects of TSTC investigated.

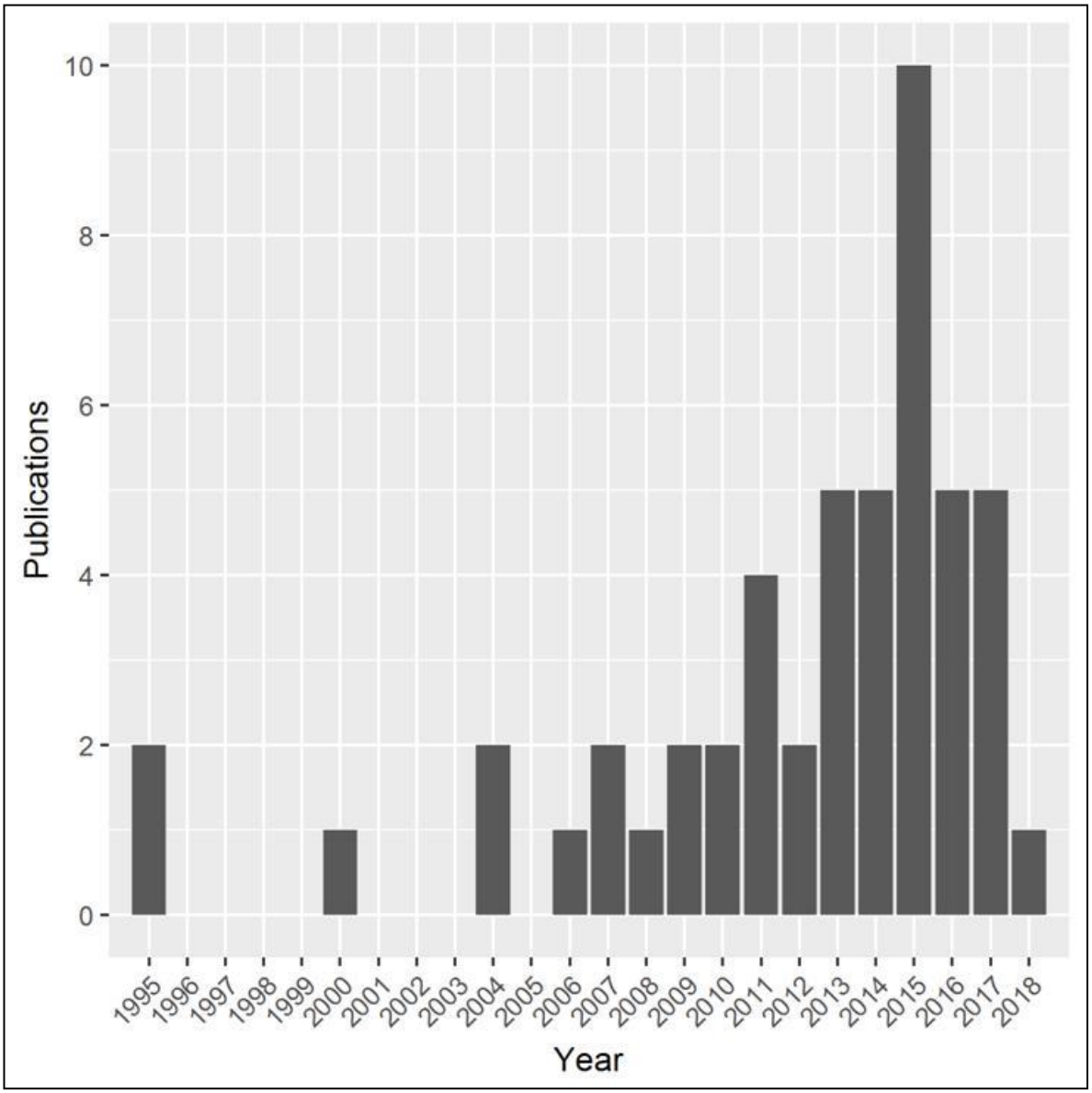


**Figure 2.** Number of *Taenia solium* publications per year in Tanzania, 1995-2018

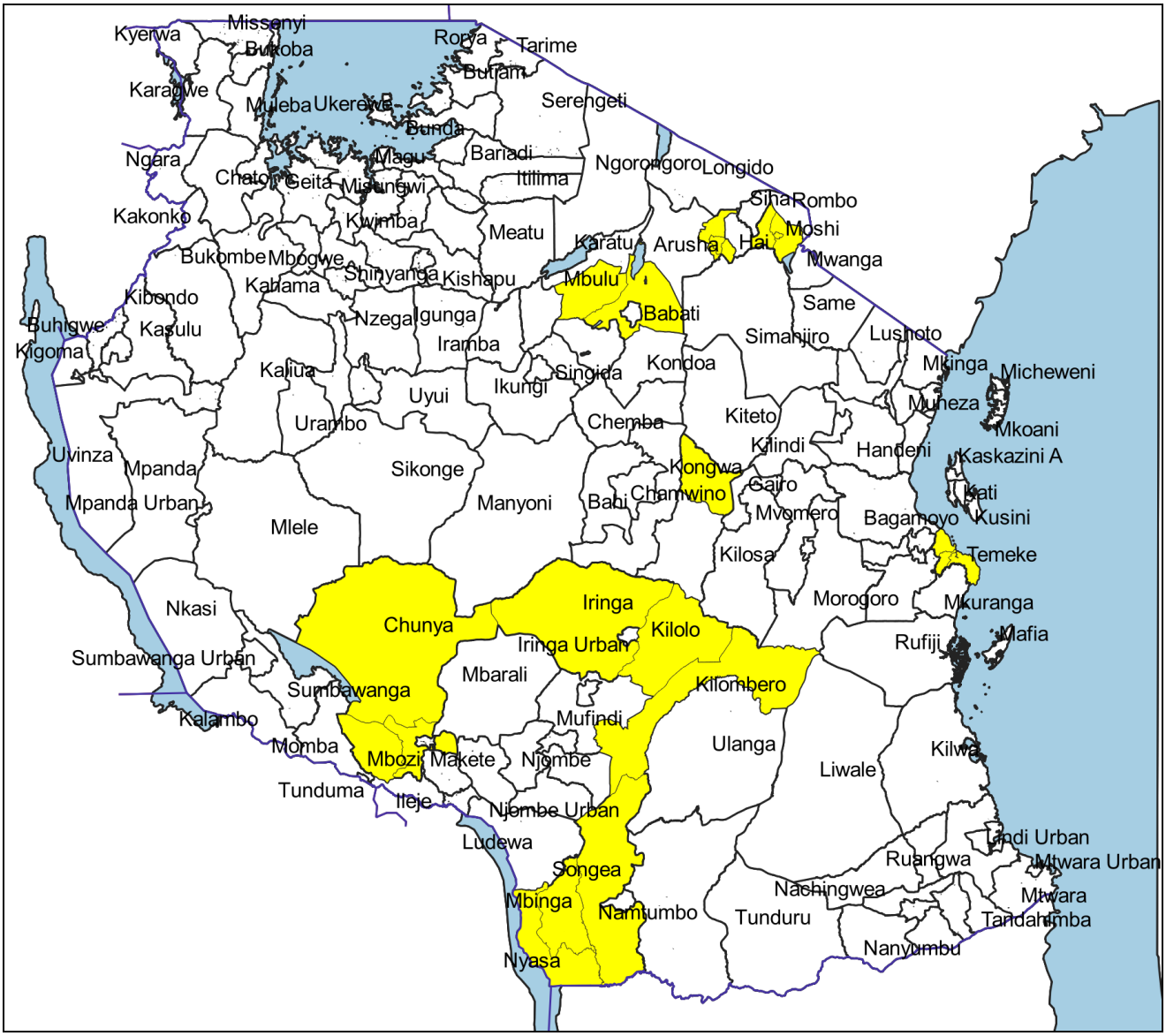


**Figure 3.** Locations (yellow) of previous studies for *Taenia solium* cysticercosis/taeniasis in Tanzania. 2018.

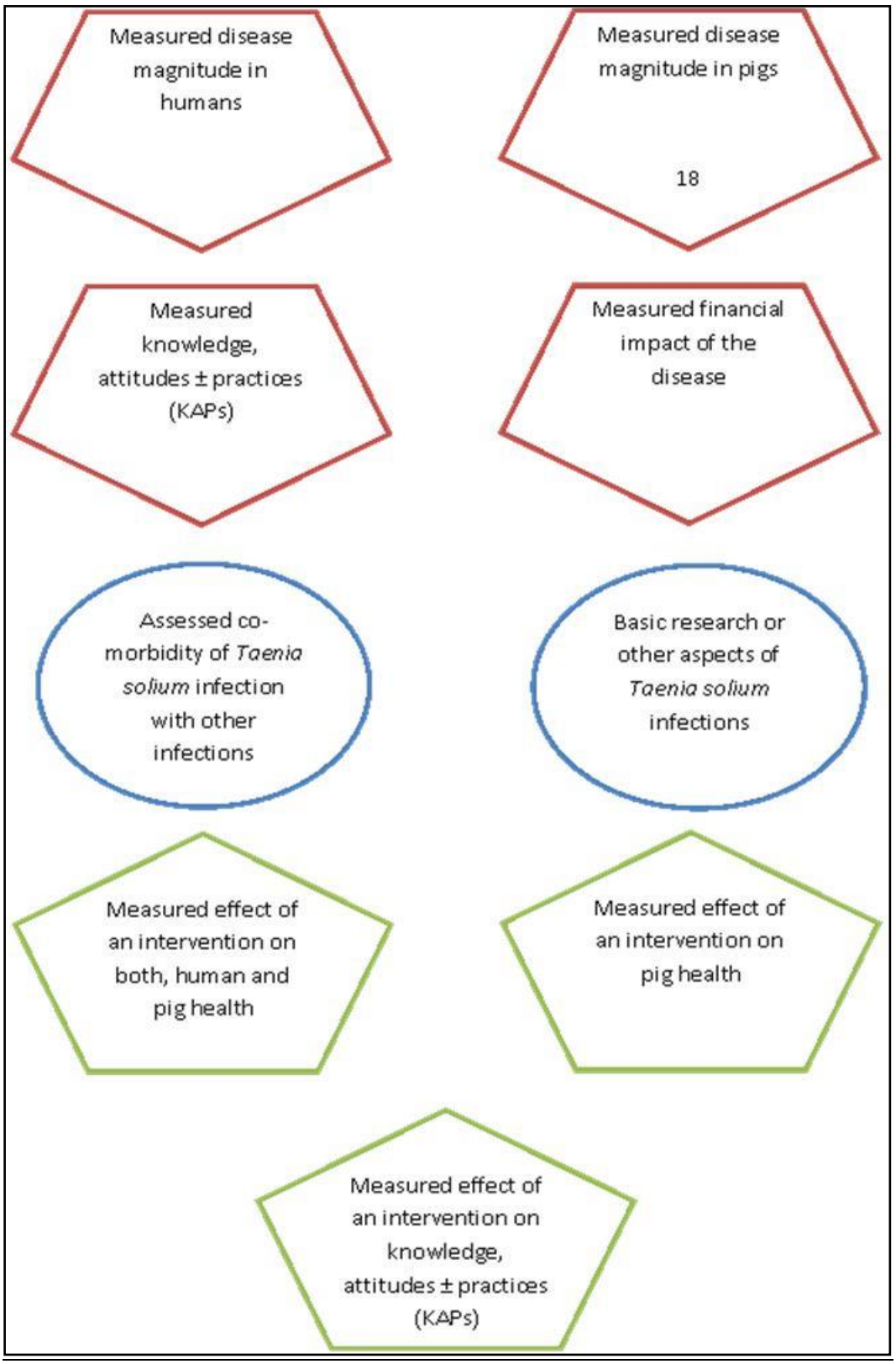


**Figure 4.** Number of previous *Taenia solium* cysticercosis/taeniasis studies by outcome in Tanzania, 1995-2018.

**Human taeniasis and cysticercosis**

Previous studies adopted various study designs, diagnostic tests, and target groups to estimate the morbidity of TSTC in humans. This scoping review presents the study results *in situ* without an attempt to compare levels of infections between studies, sites or periods. Human studies in general populations estimated prevalence of taeniosis ranging from 2.3% - 5,2% based on copro-antigen enzyme-linked immunosorbent assay (CoAg-ELISA) and cysticercosis of slightly more than 16% based on Ag-ELISA or IgG western blot methods (Eom *et al.,* 2011; Mwang'onde *et al.,* 2012; Mwanjali *et al.,* 2013; Braae *et al.,* 2017). Four of five studies that examined association between epilepsy and neurocysticercosis in adult populations, especially those >15 years old, found statistically significant association between epilepsy and neurocysticercosis, the latter accounting for most of epilepsy in these study populations (Winkler *et al.,* 2009; Mwanjali *et al.,* 2013; Ngugi *et al.,* 2013; Kamuyu *et al.,* 2014; Hunter *et al.,* 2015).

**Porcine cysticercosis**

As with human studies, pig studies adopted various study designs, diagnostic tests and target groups to estimate the magnitudes of porcine cysticercosis. Pig-farm based studies have reported prevalence ranging from 6.0% - 17.4% based on lingual examination method and 1.5% - 33.3% based on Ag-ELISA (Table 1). One incidence rate study in northern Tanzania estimated incidence rate of 25 per 100 pig-years based on lingual examination and 69 per 100 pig-years based on Ag-ELISA in sentinel pigs (Table 1). On the other hand, slaughter-slab studies have reported prevalence of porcine cysticercosis in slaughter pigs ranging from 0 - 18.2% based on routine meat inspection (Table 1). A longitudinal study composed of three cross-sectional surveys in Mbeya Region revealed temporal fluctuation of porcine cysticercosis seroprevalence (Braae *et al.,* 2014).

**Table 1.** Prevalence of porcine cysticercosis on pig farms and at slaughter slabs in Tanzania, 1995-2018

| **Author and publication year** | **Study area** | **Sample size** | **Prevalence on pig farms (%)** | | **Prevalence at slaughter slabs (%)** |
|---|---|---|---|---|---|
| | | | Lingual exam (%) | Ag-ELISA (%) | Meat inspection (%) |
| Shonyela *et al.* 2017 | Nyasa district | 698, 22, 330 for tongue, meat inspection and Ag-ELISA, respectively | 6.3 | 33.3 | 18.2 |
| Kabululu *et al.* 2015 | Mbozi and Mbeya Rural districts | 482 | | 11.5 | |
| Komba *et al.* 2013 | Mbozi district | 300 | 11.7 | 32 | |
| | Mbeya Rural district | 300 | 6.0 | 30.7 | |
| Mkupasi *et al.* 2010 | Dar es Salaam city | 731 | | | 5.9 |
| Ngowi *et al.* 2008 | Mbulu district | Pig-months of follow up in the control group was 690 and 594 by lingual and Ag-ELISA, respectively | 25/ 100 pig-years<br>Incidence rate | 69/100 pig-years<br>Incidence rate | |
| Ngowi *et al.* 2004a | Mbulu | 770 | 17.4 | | |
| Ngowi *et al.* 2004b | Mbulu, Arusha and Moshi towns | 70 | | | 0 |
| Boa *et al.* 2006 | Chunya district | 722 | 7.6 | | |
| | Iringa Rural | 808 | 8.4 | | |
| | Mbinga district | 302 | 16.9 | | |

**Table 1**. continue..

| | | | | | |
|---|---|---|---|---|---|
| Kavishe *et al.* 2017 | Babati district | 442 live pigs and 1039 pig carcasses | 13.0 | 25.0 | 8.2 |
| Ngowi *et al.* 2014 | Kongwa district | 309 | 14.9 | | |
| Makundi *et al.* 2012 | Morogoro district | 260 | | 1.5 | |
| Yohana *et al.* 2013 | Iringa Rural district | 308 | 7.5 | | |
| Lipendele *et al.* | Mbozi and Mbeya Rural districts | 142 | | 26.0 | |
| Braae *et al.* 2014 | Mbozi district | 822, 812, 998 baseline, 6 and 14 months reassessment | | 15.0, 24.0, 20.0, respectively | |
| Boa *et al.* 1995 | Mbulu, Arusha and Moshi towns | 83 | | | 13.3 |

**Risk factors for *Taenia solium* infections**

Risk factors that have been found to significantly be associated with high prevalence of porcine cysticercosis are free ranging pigs (Komba *et al.,* 2013; Ngowi *et al.,* 2014; Shonyela *et al.,* 2017; Kavishe *et al.,* 2017), lacking latrine in the household (Ngowi *et al.,* 2004a; Shonyela *et al.,* 2017), watering pigs from rivers or ponds (Komba *et al.,* 2013) and feeding pigs on potato peels (Braae *et al.,* 2015a). Only one study had assessed risk factors for human infection. The study found that hand washing by dipping (instead of running water) was significantly associated with Ag-ELISA seropositivity in humans (Mwanjali *et al.,* 2013).

**Societal impacts of *Taenia solium* infections**

Three studies had attempted to estimate economic implications of *T. solium* infections. One of the studies analysed financial benefit of smallholder pig farmers in Mbulu district, northern Tanzania, attending a health education training to control porcine cysticercosis. This study found out that, over a period of 5 years, the health education intervention would have a significant financial benefit to the smallholder pig farmers [net present value: US $3507 (95% CI: 3421 to 3591); internal rate of return: 370%] (Ngowi *et al.,* 2007a). The intervention would remain financially efficient regardless of plausible changes in costs and benefits in the pig production, as well as plausible changes in the incidence rate of porcine cysticercosis. Another study estimated pig farmers' perceived financial loss due to porcine cysticercosis and human epilepsy in Iringa Rural district (Nkwengulila *et al.,* 2014). This author estimated an annual monetary loss due to porcine cysticercosis of USD 144,449 and an annual monetary burden due to epilepsy management in hospitals and/or by traditional healers of USD 78,592. Subsequently, a comprehensive systematic review with meta-analysis study was carried out to estimate societal cost of *T. solium* cysticercosis in Tanzania at large (Trevisan *et al.,* 2017a). This study found out that, for the year 2012 the number of DALYs per thousand person-years for NCC-associated epilepsy was 0.7 (95% UI, 0.2–1.6). Around 5 million USD (95% UI, 797,535–16,933,477) were spent due to NCC-associated epilepsy and nearly 3 million USD (95% UI, 1,095, 960–5,366,038) were potentially lost due to porcine cysticercosis.

**Co-morbidity of *Taenia solium* infections with other infections in Tanzania**

Four of the five studies that assessed potential contribution of neurocysticercosis to epilepsy in humans reported that neurocysticercosis was a significant cause of epilepsy in adult people (Winkler *et al.,* 2009; Mwanjali *et al.,* 2013; Ngugi *et al.,* 2013; Hunter *et al.,* 2015). while one reported to find no this association in children (Kamuyu *et al.,* 2014;). Other aspects of TSTC co-morbidity with other infections are reported by single studies, which makes it impossible to draw major conclusions regarding the reported associations. For example, one study in pigs found co-morbidity of porcine cysticercosis, trichuriosis and strongyle worms (Ngowi *et al.,* 2014).

**Efficacy of *Taenia solium* control tools in Tanzania**

Four of the published studies assessed efficacy of an intervention tool for control of TSTC infection in humans and/or pigs. A health education intervention study based on educating pig farmers significantly improved their knowledge and attitude favourable to the control of TSTC (Ngowi *et al.,* 2011). Similar results were obtained from a school-based cluster-randomised trial (Mwidunda *et al.,* 2015). In addition, an electronic educational tool, The Vicious Worm, was found to be efficacious in improving knowledge of

veterinary and health professionals regarding TSTC (Ertel *et al.,* 2017). One porcine cysticercosis treatment trial proved the efficacy of a single dose of oxfendazole 30 mg/kg body weight in clearing *T. solium* cysticerci in the pig musculature but not those located in the brain (Mkupasi *et al.,* 2013).

**Effectiveness of *Taenia solium* control strategies in Tanzania**

Three studies assessed TSTC preventive effectiveness under field conditions. A village-level randomised health education intervention trial in 42 villages in northern Tanzania found out that the health education reduced the incidence rate of porcine cysticercosis by approximately 43% (Ngowi *et al.,* 2008). However, the education did not improve pig confinement or use of latrines. Another cluster-randomised trial assessing effectiveness of integrated pig management intervention programme (improved housing + improved feeding + oxfendazole treatment) found no significant effect of the intervention on porcine cysticercosis, though it significantly prevented ectoparasites and some gastrointestinal helminths of the pigs (Kabululu *et al.,* 2018). The only one study that assessed the effect of a TSTC intervention on infections in humans and pigs simultaneously revealed that three-rounds of annual mass administration of praziquantel to school-age children (primarily targeted for schistosomiasis control) combined with 'track-and-treatment' of cases significantly reduced the prevalence of taeniosis in children and adult populations as well as porcine cysticercosis (Braae *et al.,* 2016b). On the contrary two rounds of intervention were not effective as significantly fewer children were found infected after the first treatment only while no significant drop in porcine cysticercosis was observed.

**DISCUSSION**

To the best of our knowledge, this is the first comprehensive study that has collated research evidence on TSTC at country level. The standard approach adopted in this scoping review can be adapted to other countries endemic for TSTC, including those in Sub-Saharan Africa. In addition, the approach can be adapted to other health problems.

This review has revealed increasing research in TSTC in Tanzania over time, though clustered in some parts of the country, particularly in the southern and northern highland regions. While several studies have estimated disease morbidity, a negligible number has estimated economic impact of the parasite. The only reliable study in this aspect is one systematic review conducted in the country (Trevisan *et al.,* 2017a). Similarly, very few studies have measured the effect of TSTC interventions on disease morbidity, with only one measuring intervention effect on human and pig disease simultaneously on the same site (Braae *et al.,* 2016b). In addition, there is limited information to inform on spatial pattern of infections countrywide due to the clustered nature of the studies, covering only some few parts of the country. The observed higher prevalence of porcine cysticercosis during dry seasons than wet season (Braae *et al.,* 2014) needs further investigation, though it is customary for pigs to be let free during dry than wet seasons, which could partly account for the observed differences. The fact that only one wet season as opposed to two dry seasons was assessed, no hard conclusions can be drawn from these findings.

Previous studies have detected taeniosis in the general population based on both antigen detection and microscopy of human faecal material. As both of these methods cannot identify *Taenia* eggs to species level, there is some possibility that some of the taeniosis cases are due to *T. saginata*, the beef tapeworm. One molecular study confirmed that one of four Taenia egg positive cases was due to *T. solium* (Eom *et al.,* 2011). The reported prevalence of human cysticercosis of more than 16% based on antigen detection in the general population is alarming. Furthermore, the significant association between epilepsy and neurocysticercosis in adults found by most studies is consistent with finding from studies elsewhere (Ndimubanzi *et al.,* 2010). Washing hands by dipping instead of using running water puts the person at a significant risk of contracting cysticercosis (Mwanjali *et al.,* 2013). The prevalence of porcine cysticercosis estimated by previous studies by lingual exam and Ag-ELISA both show that porcine cysticercosis is endemic in Tanzania. Free ranging of pigs (Komba *et al.,* 2013; Ngowi *et al.,* 2014; Shonyela *et al.,* 2017; Kavishe *et al.,* 2017), lacking latrine in the household (Ngowi *et al.,* 2004a; Shonyela *et al.,* 2017), watering pigs from rivers or ponds (Komba *et al.,* 2013) and feeding pigs on potato peels (Braae *et al.,* 2015a). have been associated with high prevalence of porcine cysticercosis. Health education could help in improving practices to the control of TSTC transmission.

One intervention study conducted previously has revealed that the annual schistosomiasis control programme involving treatment of school-age children using praziquantel significantly reduced prevalence of taeniosis in children and adult populations as well as porcine cysticercosis if at least three rounds of annual mass deworming are conducted (Braae *et al.,* 2016b). This suggests a potential for integrating the control of TSCT with that of schistosomiasis in Tanzania. Similarly, one health education intervention study found a reduction in the incidence rate of porcine cysticercosis of approximately 43% attributable to the intervention (Ngowi *et al.,* 2008). Further analysis proved financial efficiency of the health education

intervention to the smallholder farmer receiving it (Ngowi *et al.,* 2007a). Nevertheless, the health education could not improve pig confinement or use of latrines (Ngowi *et al.,* 2008). It is speculated that, farmers might have changed some other important but unobservable practices, which could partly explain the observed reduction in the incidence rate of porcine cysticercosis. Finally, one porcine cysticercosis treatment trial proved the efficacy of oxfendazole 30 mg/kg body weight in clearing *T. solium* cysticerci in the pig musculature but not those in the brain (Mkupasi *et al.,* 2013, which is consistent with findings from other studies elsewhere.

## CONCLUSIONS

- Alarmingly high morbidity of TSTC infections in humans and pigs have been reported by previous studies in Tanzania.
- Risk factors for porcine cysticercosis transmission include free-ranging pigs, lack of latrines in the household, watering pigs with water sourced from rivers or ponds and feeding pigs on potato peels. Risk factor associated with human cysticercosis include hand-washing by dipping (instead of using running water) before eating.
- TSTC causes considerable economic and disease burden in Tanzania as a result of pork condemnation and disability of people with neurocysticercosis-associated epilepsy.
- *Taenia solium* is an important cause of epilepsy in Tanzania that could be prevented by controlling *T. solium.*
- Health education has proven efficacious in improving knowledge and attitudes favourable for control of TSTC and effective in reducing porcine cysticercosis incidence under field conditions.
- Treatment of infected pigs with a single dose of oxfendazole 30 mg/kg body weight clears cysts in the meat (but not brain) within 4 months after treatment. Oxfendazole was registered in Tanzania officially in 2018, henceforth an opportunity for porcine cysticercosis control. However, this should be coupled with health education to avoid the risk of infection from potentially infected pig brains.
- Three rounds of deworming of school-age children as per the ongoing national mass-drug administration programme for schistosomiasis control significantly reduce human taeniosis and porcine cysticercosis in Tanzania, providing an opportunity for integrated control of the parasits in schistosomiasis and TSTC co-endemic areas.

### Implications for research and practice

The observed considerable societal burden of TSTC and significant contribution of neurocysticercosis to epilepsy in Tanzania warrants an urgent intervention to safeguard public health and improve livelihood. More studies are needed to better estimate cost-effectiveness of TSTC control options in order to implement cost-beneficial TSTC control measures in Tanzania.

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