Co-endemicity of cysticercosis and gastrointestinal parasites in rural pigs: a need for integrated control measures for porcine cysticercosis

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Abstract. A cross-sectional study of 314 pigs naturally reared in three wards was conducted to estimate prevalence of porcine Taenia solium cysticercosis and prevalence and intensity of gastrointestinal (GIT) parasites in Kongwa district, central Tanzania. Lingual examination of 309 of the pigs estimated an overall prevalence of porcine cysticercosis of 14.9% (95% CI: 10.9-18.9) while faecal microscopy of 285 pigs estimated prevalence of 3.9% (95% CI: 1.6-6.1) Ascaris suum, 3.2% (95% CI: 1.1-5.2) Trichuris suis, 26.3% (95% CI: 21.2-31.5) strongyle species and 11.6% (95% CI: 7.8-15.3) coccidia oocysts. For pigs infected with GIT helminths, the overall egg counts ranged from 50 to 2300 eggs per gram of faeces (median 200 EPG). None of 36 pigs infected with cysticercosis had ascariosis, one had trichuriosis and seven had strongyle worm infections. Porcine cysticercosis was more prevalent in wards practising free-range pig rearing (Chi-square = 22.7, P = 0.000) while GIT helminths were more prevalent in wards practising intensive rearing (Chi-square = 30.0, P = 0.000). Ascaris suum prevalence showed significant preference in male than female pigs (P = 0.015). Strongyle worm infection was significantly higher in male than female pigs (P = 0.008) and in pigs older than eight months of age than younger ones (P = 0.001). The observed inverse occurrence between porcine cysticercosis and GIT helminth infections in this geographical setting emphasises the need to carefully integrate the control of porcine cysticercosis with that of GIT helminths in T. solium endemic areas. Further studies are needed to determine suitable integrated control strategies for porcine cysticercosis.

Keywords: Porcine cysticercosis; Gastrointestinal parasites; Inverse occurrence; Integrated control.

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Introduction

The tapeworm *Taenia solium* causes taeniasis (infection by adult worm) in humans, and cysticercosis (infection by larval form) in pigs, humans and a few other animal species, including dogs (Ito et al., 2002). When the larva of *T. solium* migrates to the human brain, it causes neurocysticercosis (NCC), a very pleomorphic disease which remains poorly understood (Carabin et al., 2011). In a recent systematic review of the literature, it was reported that 29% of people with epilepsy living in *T. solium* endemic areas had lesions of NCC in their brain (Ndimubanzi et al., 2010). Porcine and human cysticercosis has been estimated to result in 10.3 million euro and 18.6-34.2 million US dollars in monetary losses in Cameroon and the Eastern Cape Province of South Africa, respectively (Praet et al., 2009; Carabin et al., 2006). A five-year financial analysis in Tanzania revealed that a smallholder pig farmer would be progressively operating on a loss if porcine cysticercosis was not prevented (Ngowi et al., 2007). In all cases of cysticercosis, the source is at least one human taeniasis case which will contaminate the environment with embryonated eggs capable of transmitting *T. solium* larvae. On the other hand, taeniasis results in a person who has consumed meat (most commonly pork) with *T. solium* larvae.

Tanzania is among the countries in eastern and southern Africa that are highly endemic for porcine cysticercosis (Phiri et al., 2003). Mbulu district in the northern highlands of the country provided the first evidence of human and porcine cysticercosis in Tanzania (Nsengwa and Mbise, 1995; Winkler et al., 2009). Following an imaging study, it was found that neurocysticercosis lesions were more frequent in epileptic (*n* = 212) than non-epileptic (*n* = 198) individuals (*P* < 0.0001) who attended Haydom Lutheran Hospital in Mbulu district (Winkler et al., 2009). Recently, a study in the general population of 830 people living in Mbozi district, southern Tanzania, found a human active cysticercosis of 16.7% based on antigen enzyme-linked immunosorbent assay (B158/B60 Ag-ELISA) and 5.2% of taeniasis based on copro-Ag-ELISA (Mwanjali et al., 2013). A large epidemiological study on porcine cysticercosis estimated a baseline incidence rate of approximately 69% per year in sentinel pigs based on Ag-ELISA (Ngowi et al., 2008). Further analysis of the data revealed significant clustering of porcine cysticercosis within certain geographical limits encompassing 4 out of 13 wards that were included in the study (Ngowi et al., 2010). Nevertheless, due to the study design the causes of such clustering were not established.

Currently, regular mass chemotherapy for soil transmitted helminth (STH) infections and schistosomiasis in humans is practised in several regions of Tanzania, including regions endemic for *T. solium* infections. Nevertheless, the impact of such interventions on taeniasis and cysticercosis has not been established. Integrated approaches to disease control are recommended worldwide as means to maximise the cost-effectiveness and cost-benefit of control efforts. To date many control initiatives elsewhere have considered integrating *T. solium* control with that of schistosomiasis because of the potential opportunity for using praziquantel in the treatment of both infections in humans. Combining the control of human *T. solium* infections with that of porcine cysticercosis would promote a one-health approach and more likely bring about better results.

As opposed to human taeniasis and cysticercosis treatments, there has been not effective chemotherapy available for porcine cysticercosis. A recent study in Tanzania by Mkupasi et al. (2013) found that oxfendazole at a single dose of 30 mg/kg administered orally was able to kill cysticerci present in the pig muscles but not those in the brain, results which support those of other studies elsewhere. In addition, vaccine for porcine cysticercosis has not been available commercially to date, though research has demonstrated the potential for porcine cysticercosis vaccination (Lightowlers, 2003). Potential control measures for porcine cysticercosis include health education, environmental sanitation and intensification of pig rearing, the latter being mostly advocated in many endemic areas. Nevertheless, it is very
important that the impact of any intervention is carefully analysed to guide implementation of well integrated control measures for *T. solium*. We carried a study to determine co-endemicity of porcine cysticercosis with other porcine endoparasites in a porcine cysticercosis endemic setting in Tanzania to guide integrated control measures for porcine cysticercosis.

**Materials and methods**

**Study location**

This study was carried out in 2010 in Kongwa district of Dodoma region, central Tanzania. The district is located at latitudes 6°12′00″S and longitudes 36°25′01″E, a few kilometres East of Dodoma town (figure 1). In 2010, the district had a total of 14 wards. The selection of wards and villages for inclusion in this study was based on pig-keeping popularity and representativeness to the pig rearing community in the district. Three wards, namely Hogoro, Pandambili, and Sagara were included. Hogoro ward was predominated by intensive pig rearing system although most of pig houses were of poor designs. On the other hand, Pandambili and Sagara wards were characterised by free-range pig rearing system. Four villages were selected: Hogoro (in Hogoro ward), Sagara (in Sagara ward), and Chiwe and Moleti (in Pandambili ward).

**Determination of the number of pigs for inclusion in the study**

The number of pigs to be sampled was estimated based on pig population estimates of Kongwa district and prevalence of ascariosis from a previous similar study in adjacent Morogoro region, which estimated an overall prevalence of 12% based on faecal egg counting (Esranny et al., 1997). The present study assumed a prevalence of 15% ascariosis as pigs in the study area had relatively poor management. Dodoma region was estimated in 2002 to have 43,835 pigs distributed in five districts. In this study, we estimated a regional population of 50,000 pigs and divided it by the five districts to obtain approximately 10,000 pigs in Kongwa district. We divided the district pig population equally by the 14 wards and obtained approximately 2,143 pigs in the three study wards. We rounded up this number to 2,500 pigs for simplicity. Assuming a finite population of 2,500 pigs in the three study wards, 95% confidence level and 5% precision of estimation, our estimated 15% prevalence of ascariosis could range from 10-20%.

The sample size was first calculated using the formula for a simple random sampling to estimate prevalence of a factor as described by Martin et al (1987): $n = \frac{z^2pq}{l^2}$ where, $n$ denotes sample size, $z$ is $z$-score for a given confidence level, $p$ a known or estimated prevalence $q = p - 1$, and $l$ allowable error of estimation. Our parameters were therefore, $z = 1.96$, $p = 15\%$, $q = 85\%$, and $l = 5\%$. Following this formula, we obtained a simple random sample of approximately 196 pigs. Secondly, we adjusted this sample size based on the finite population (N) of 2,500 pigs in the study area using the formula $n_2 = \frac{nN}{n + (N-1)}$ (Martin
et al., 1987), which resulted into approximately 182 pigs. Finally, we adjusted the sample size for multistage sampling by raising $n_2$ one and a half times and obtained $n_3$ equals 273 pigs. We included 314 pigs in this study (101 Hogoro ward, 103 Sagara ward, 110 Pandambili ward).

The sample size was calculated based on the estimated prevalence of *Ascaris suum*, as this parasite was considered the most important GIT helminth of pig causing considerable economic losses. Thus we needed to estimate its prevalence with great precision. Nevertheless, the obtained sample size was assessed for its suitability for estimation of prevalence of porcine cysticercosis and found enough. For cysticercosis we would have estimated a prevalence of 15% in Kongwa district based on the previous studies in other districts. Following the same calculation as with the *Ascaris suum*, we would have required a total of 294 pigs.

**Selection of households and pigs for inclusion in the study**

We adopted a snowball sampling procedure to select pig keeping households, whereby a previous pig-owning household sampled guided on where the next pig-owning household could be found. This method was adopted because of haphazard distribution of households in the villages and lack of village household registers. In each household, all pigs were sampled if they were eight or fewer. However, if a household had more than eight pigs, a maximum of eight pigs was sampled. Advanced pregnant pigs and suckling piglets were excluded to avoid stress.

**Faecal sample collection and examination of pigs for cysticercosis**

Using one glove for each pig, approximately 10 g of faecal material was collected from each pig per-rectum. Each sample was transferred immediately into a sample plastic bottle and fixed with 10% formal saline to cover the sample. The bottle was covered with a lid and appropriately labelled with necessary information, which was also recorded in a data sheet. Finally, the pig mouth was opened by twisting a wooden rod between jaws and an experienced technician pulled out the pig’s tongue using a clean cotton cloth and examined the under-surface of the tongue for cysticercosis visually combine with palpation. General data were recorded for each pig examined, including number of pigs in households, sex, age, breed and treatment.

**Faecal sample analysis for gastrointestinal parasitic infections**

We used a two-chamber McMaster slide technique to count eggs of various helminth species observed under the microscope at a magnification of 100. Saturated NaCl solution was used as a floatation fluid. Coccidia oocysts were only recorded as either present or absent.

**Data handling and analysis**

Data were entered in Microsoft Excel and analysed in Stata 8.2 (StataCorp LP., 2004).

**Estimation of prevalence of porcine cysticercosis and gastrointestinal tract parasites**

The prevalence of porcine cysticercosis and that of GIT parasites were computed as the percentage of pigs that had infections among total numbers of pigs examined. We added the number of worm eggs counted in the two McMaster slide chambers for each specific worm species and multiplied the resulting number by 50 to obtain number of eggs per gram of faeces for the worm species.

**Analysis of associations between variables**

Because of the non-probability sampling design used, we first carried out univariate analyses of several important factors to examine their distribution between the study wards. Specifically, we used Chi-square tests to assess as to whether there was any uneven distribution of pig age, sex and breed between wards. These analyses revealed significant differences in the distribution of pig age and breed between wards ($P = 0.001$). Therefore, we used logistic regression to analyse associations between parasite infections and any other important factor that was recorded. The type of medication was not analysed for association as most of the pigs had undergone
same anthelmintic treatment, mostly ivermectin. Similarly, we did not examine association between the prevalence of GIT helminths and stage of lactation because of the small number of pigs that had recently delivered.

Ethical standards

Handling of animals during this study was in accordance with the Tanzania Animal Welfare Act of 2008, which provides guidelines consistent with international standards (Anonymous, 2008).

Results

General results

A total of 152 households were included in the three wards studied (54 Pandambili, 57 Sagara, 41 Hogoro). A total of 314 (152 male, 162 female) pigs were examined in the three wards (Pandambili 110, Sagara 103, Hogoro 101). The median number of pigs examined per household was 2 (range, 1-8). The age of the pigs ranged from 3 to 28 months, with 61.1% of the pigs falling under the age of 3-8 months. Approximately, 80.4% of the pigs were cross breeds between local and exotic bloods, while 12.2% and 7.4% were pure exotic and local breeds, respectively. Based on farmers’ responses, approximately, 70.5% of pigs had recently received medication, mainly ivermectin (94.5%) and rarely albendazole (1.4%). A few (11.8%) had also received multivitamins either alone or in combination with ivermectin. Only 32 (10.2%) of the pigs were reported to have delivered piglets in the past 1-7 months.

Prevalence of porcine cysticercosis and gastrointestinal parasites

The ward- and pig-level prevalence of the various parasites in Kongwa district is presented in table 1. There were some few missing data in each case due to failure to obtain samples or escape of the pig (in the case examination for cysticercosis). The overall prevalence of porcine cysticercosis was 14.9% (95% CI: 10.9-18.9, n = 309) ranging from 2 to 25.2% in different wards based on lingual examination. Approximately 30.9% of the pigs were infected with at least one GIT helminth species, while 11.6% had coccidiosis (table 1). For the pigs that were infected with GIT helminths, 94.4% were infected by a single species of helminths, 4.5% by two helminth species and 1.1% by all three helminth species. None of 36 pigs infected with cysticercosis had ascariosis, one had trichuriosis and seven had strongyle worm infections.

Porcine gastrointestinal parasite intensities

Table 2 presents egg intensities for the various GIT helminths detected in pigs in Kongwa district. Of all the pigs examined, 25 (8.6%) had considerable worm burdens (Ascaris suum/Trichuris suis/gastrointestinal strongyle species burden of >300 epg) while 64 (22.1%) had low worm burdens (1 to <300 epg).

Association between pig parasitism with other factors

The logistic regression analysis adjusting for age, sex and breed of pig revealed significant association between porcine cysticercosis as well as GIT helminth infections with ward. While cysticercosis was more prevalent in Pandambili and Sagara wards than Hogoro (Chi-square = 22.7, P = 0.000), the reverse was true for the GIT helminthosis (Chi-square = 30.0, P = 0.000) (table 1). The high prevalence of the GIT helminths was mostly contributed by high prevalence of of strongyle worms. There was no association between porcine cysticercosis and pig breed (P = 0.285), sex (P = 0.691) or age category (0.523). Ascaris suum prevalence showed significant preference in male than female pigs (P = 0.015) but was not associated with pig age (P = 0.423). The prevalence of Trichuris suis did not show any significant association with pig sex or age (P = 0.164 and 0.205, respectively). On the other hand, the prevalence of strongyle worms was significantly associated with sex and age, preferring males (P = 0.008) and pigs older than 8 months of age (P = 0.001). There was neither sex nor age effect on the prevalence of coccidiosis (P = 0.122 and 0.058, respectively).
Table 1. Ward- and pig-level prevalence (percentage) of porcine cysticercosis based on lingual examination and gastrointestinal parasites based on faecal microscopy in Kongwa district, Dodoma region, central Tanzania, 2010

<table>
<thead>
<tr>
<th>Ward</th>
<th>T. solium</th>
<th>Ascaris suum</th>
<th>Trichuris suis</th>
<th>Strongyle spp.</th>
<th>Coccidia oocysts</th>
<th>At least one GIT worm spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pandambili (n = 107, 95)</td>
<td>25.2</td>
<td>1.1</td>
<td>2.2</td>
<td>23.7</td>
<td>16.1</td>
<td>25.3</td>
</tr>
<tr>
<td>Sagara (n = 102, 99)</td>
<td>16.7</td>
<td>2.0</td>
<td>4.0</td>
<td>15.2</td>
<td>6.1</td>
<td>20.2</td>
</tr>
<tr>
<td>Hogoro (n = 100, 94)</td>
<td>2.0</td>
<td>8.6</td>
<td>3.2</td>
<td>40.9</td>
<td>12.9</td>
<td>47.9</td>
</tr>
<tr>
<td>Total (n = 309, 285)</td>
<td>14.9</td>
<td>3.9</td>
<td>3.2</td>
<td>26.3</td>
<td>11.6</td>
<td>30.9</td>
</tr>
</tbody>
</table>

\(n = \) exact number of pigs examined for the parasite. The first number in the parenthesis is for \(T.\ solium\) cysticercosis examination, the second is for the GIT parasites.

Table 2. Helminth eggs per gram of faeces of 285 pigs as counted using McMaster slide technique in Kongwa district, Dodoma, central Tanzania, 2010

<table>
<thead>
<tr>
<th>Helminth egg per gram of faeces</th>
<th>Ascaris suum</th>
<th>Trichuris suis</th>
<th>Strongyle spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>96.1</td>
<td>96.8</td>
<td>73.7</td>
</tr>
<tr>
<td>1-100</td>
<td>0.7</td>
<td>1.8</td>
<td>7.4</td>
</tr>
<tr>
<td>101-300</td>
<td>1.1</td>
<td>1.1</td>
<td>12.6</td>
</tr>
<tr>
<td>301-500</td>
<td>0.0</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>501-1000</td>
<td>1.4</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>0.7</td>
<td>0.0</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Discussion

To the best of our knowledge, this study has for the first time described co-occurrence of porcine cysticercosis and gastrointestinal parasites in a porcine cysticercosis endemic setting. The information provides evidence of an inverse occurrence of the two parasites attributable to different preferences by the parasites for different pig management systems. This calls for careful planning of integrated control of porcine cysticercosis in endemic situations. Findings of this research are of global importance, particularly in porcine cysticercosis endemic countries because of shared characteristics such as environmental and pig rearing practices. The use of lingual examination to detect porcine cysticercosis might have greatly underestimated the actual prevalence as the method is only known to detect approximately 21% of infected pigs (Dorny et al., 2004). Nevertheless, the observed relationship most likely remains unaffected by the diagnostic method as the same method was used in both pig management systems.

This study estimated a high prevalence of cysticercosis caused by \(T.\ solium\) in pigs in Kongwa district of Dodoma region, central Tanzania. Based on the lingual examination method and study designs used, this prevalence is comparable to one previously reported in Mbulu district of northern Tanzania (Ngowi et al., 2004) and higher than that reported in Mbozi and Mbeya Rural districts of southern highlands of the country (Komba et al., 2013), which reported prevalence of 17.4% and 6-11.7%, respectively. The observed high level of infection of the pigs with \(T.\ solium\) cysticercosis calls for further epidemiological studies in pigs and humans to guide control measures for the parasite in order to safeguard the public and improve rural livelihoods.

There was a strong association between porcine cysticercosis and type of pig rearing, with significantly less prevalence of the parasite in an area practising intensive pig rearing. This area (Hogoro ward) was well separated geographically and by a tarmac highway from areas practising free range pig rearing, which likely minimised influx of pigs from outside the area through roaming. Despite the observed inconvenience of the housings to the animal welfare, the intensive pig-rearing system adopted by farmers in that area was able to prevent most of the pigs from cysticercosis by restricting them from roaming. On the other hand, pigs reared in Pandambili and Sagara wards were free to scavenge, and hence, more likely to consume human faeces or contaminated feeds from the environments.
Therefore, promotion of intensive pig rearing would reduce porcine cysticercosis in this study area. However, this should go hand in hand with promotion of appropriate pig-housing designs using locally affordable resources.

The present study established prevalence of several GIT parasitic infections in pigs in Kongwa district. Certainly, a mere presence of *Ascaris suum, Trichuris suis*, or strongyle species of helminths in pigs gives little information as far as economic impact is concerned, because low numbers of worms are no problem. In addition, certain worm species are less harmful to the hosts. Thus burden analysis conducted in this study was important to examine the potential health and economic impacts of the parasites. This cross-sectional study established high burdens of helminthosis in some of the pigs. Based on the existing guidelines, if more than 50% of sampled groups are found to have significant levels of specific helminth egg excretion, treatment of pigs should be considered. In the present study, approximately 8.6% of the study pigs had considerable levels of helminth egg counts. Thus there would be no need for mass deworming of the pig population in the study area. However, based on farmers’ responses, there was a high frequency of treating pigs with ivermectin, which could account for the observed small proportion of pigs with high worm burden. Further studies are needed to assess the adequacy and safety of the current farmers’ routine deworming to avoid possibilities for development of anthelmintic resistance. There is growing evidence that *A. lumbricoides, A. suum* and *T. trichiura* can infect both humans and pigs (Steenhard et al., 2000; Bendall et al., 2011; Nejsum et al., 2012). Thus zoonotic importance should be considered an addition public health impact when seeking to control soil transmitted helminths. Cross-infections between human and pig parasites are also likely to increase incidences of human and pig infections with these parasites in pig-keeping communities, leading to increased morbidities and economic losses. A genetic survey of porcine zoonotic STH species distribution in the human and pig population should give valuable information for monitoring parasite transmission dynamics for implementing strategic control programs, focus on the one-health approach.

While porcine cysticercosis was significantly lower in the area practising intensive pig rearing, the prevalence of GIT helminths was significantly higher in this area. The vice versa was observed in the free-range system. This is because the indoor pigs were more likely to consume each other's faeces or faeces due to their closer proximity and their coprophagic behaviour. Because GIT parasites as opposed to cysticercosis are transmitted via consumption of pig faeces, there is a higher chance of GIT parasite transmission in indoor-reared than free-range pigs. Some studies elsewhere have found presence of false positive GIT helminth infections in some pigs as some worm eggs ingested via pig faeces could be excreted before establishing infections (Boes et al., 1997). The present cross-sectional study could not assess false positivity because of the study design. It should also be born in mind that worm egg excretion is intermittent, meaning that those pigs which were found to have no eggs detected in their faeces in this study were not necessarily free from infections. Repeated sampling at different times of the day is required to increase the accuracy of the faecal egg counts.

This study found no significant difference in the prevalence of porcine cysticercosis between sexes or age groups. On the other hand, there was significantly higher prevalence of ascariosis in male than female pigs but was not associated with age of the pigs. Similar findings were reported in human, whereby a significantly higher prevalence of *A. lumbricoides* in boys than girls. This is evidence that that *A. suum* and *Trichuris suis* can infect both humans and pigs (Steenhard et al., 2000; Bendall et al., 2011; Nejsum et al., 2012). Thus zoonotic importance should be considered an addition public health impact when seeking to control soil transmitted helminths. Cross-infections between human and pig parasites are also likely to increase incidences of human and pig infections with these parasites in pig-keeping communities, leading to increased morbidities and economic losses. A genetic survey of porcine zoonotic STH species distribution in the human and pig population should give valuable information for monitoring parasite transmission dynamics for implementing strategic control programs, focus on the one-health approach.
an inhibitory effect against helminth infections. For example, Dobson (1964) found that male lambs were more susceptible to *Oesophagostomum columbianum* infections than female lambs. On the other hand, these authors found that *Haemonchus contortus*, a superficial migrator, did not show the same responses to the host endocrines as *O. columbianum*. The authors concluded that parasites which have extensive somatic migrations in their life cycles are more likely to be affected by the hormone balance of the host than worms which do not have this somatic phase. Studies with *Trichinella spiralis* have reported similar findings (Reddington et al., 1981). In the present study, there were no significant differences in the prevalence of *Trichuris suis* or strongyle worms between pig sexes, probably because of their non-tissue-migratory behaviours as opposed to *Ascaris suum*. To the contrary, studies with cestodes have shown that testosterone hinders while oestrogen favours infection with cysticercosis. Studies with *T. solium* and *T. crassiceps* have confirmed this (Valdés et al., 2006; Morales-Montor and Larralde, 2005; Morales et al., 1996). Consequently, castration of male hosts removes the sex difference in the susceptibility to parasitic infections. In both nematodes and cestodes, progesterone favours parasitic infections (Dobson, 1966; Morales et al., 1996). In the present study, information on whether or not a male pig was castrated was not collected. This makes it difficult to rule in the effect of castration on the observed absence of sexual difference in the prevalence of porcine cysticercosis. The higher prevalence of GIT helminths in older age could be argued on the basis of waning of maternal immunity and longer exposure of pigs to contaminated environments.

As we are moving towards control of cysticercosis, a careful situational analysis is needed to ensure that control strategies are integrative. For example, while promoting indoor pig-rearing to control cysticercosis, measures should be in place to control potential increase in the incidence of GIT parasitic infections, which are favoured by pig confinement. Strategic deworming of confined pigs need to be done to control such parasites. As there is no effective treatment for porcine cysticercosis currently available in many endemic countries, it is important to promote behaviour change with regard to environmental sanitation and pig management practices to prevent cysticercosis while focusing on strategic deworming of indoor-reared pigs to reduce incidence of GIT parasitism. Infection by *Taenia solium* in humans can be prevented by fully cooking pork meat before eating it. Moreover, proper sanitation and hygiene including proper disposal of human faeces can prevent the occurrence of eggs in the environment that could lead to cysticercosis. Thus education campaigns are needed in *T. solium* endemic populations. Prior socioeconomic and sociocultural studies are need to determine factors hindering free-range pig rearing communities from adopting the indoor system as well as factors enabling some farmers to practise intensive system. Such holistic analysis would help to design parasite control strategies suitable to each specific context, and hence, more likely to be sustainable.

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