

# Porcine Cysticercosis—An Emerging Food Borne Parasitic Zoonosis in Urban Settings in Tanzania: Need for Immediate Control Measures

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**Abstract:** *Taenia solium* cysticercosis is an emerging food borne parasitic zoonosis in urban centres where infected pigs from rural areas are slaughtered and consumed. The public is at risk of acquiring the infection if meat inspection and control is not effective. This study was conducted to establish the prevalence of porcine cysticercosis in pigs slaughtered in Dar es Salaam City and Morogoro Municipality and assessed the existence of risk factors for its transmission. Meat inspection was performed in pigs slaughtered in official slaughter slabs where direct observation and check-list based questions were used to assess the risk factors for disease transmission. The results revealed porcine cysticercosis prevalence of 6.3% and 1.5% in pigs slaughtered in Dar es Salaam City and Morogoro Municipality, respectively. Possible risk factors for *T. solium* cysticercosis transmission included lack of centralized slaughtering facilities for pigs, inadequate meat inspectors, lack or inadequate meat inspection and control, poor knowledge among butchers and pork vendors about the parasite and possible public health implications. In addition, the findings indicated that the public was at high risk of acquiring the infection if immediate control measures were not taken. In view of this, it is recommended that the pig slaughtering should be centralized for effective inspection and pork control. Lastly, constant public health education should be provided to butchers, pork vendors and the public in general.

**Key words:** *T. solium*, pigs, pork, slaughter slabs, neurocysticercosis, health education.

## 1. Introduction

The growing population in urban areas increases the demand for food, mostly from rural areas [1]. This leads to increased production and transportation of pigs from rural areas where porcine cysticercosis is prevalent to urban centres [2]. In the course of doing so, a room for transporting and slaughtering pigs with porcine cysticercosis in urban areas is created, leading to food borne parasitic zoonosis [2, 3]. The disease causes great economic losses to pig farmers and disease among human. The life cycle of the parasite involves both human and pigs, the latter being a principal intermediate host. Humans become infected when they ingest what contains *T. solium* eggs [4]. Humans can become infested with the adult tapeworm

when they eat raw or undercooked pork infected with *T. solium* larvae. A person infected with the adult parasite can transmit the parasite to intermediate hosts, including pigs and humans through faeco-oral transmission. In the infected person, the eggs develop into cysticerci that are located in the skeletal muscles, subcutaneous and nervous tissues. Clinical signs of the condition in human depend on an anatomical location of the parasite. Neurological and usually fatal clinical manifestations occur when cysticerci lodge in central nervous tissues [5, 6].

In Tanzania, porcine cysticercosis is prevalent in most pig producing areas. It has been reported that in the northern highlands, the prevalence ranges from 0.3%-13.3% in slaughtered pigs [7, 8] and 3.2%-46.7% in smallholder pig-farming villages, based on lingual examination [9]. In the southern

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highland regions (i.e. Mbeya, Iringa and Ruvuma), the prevalence ranges from 5.5%-16.9%, based on lingual examination [10, 11] and 30%-32%, based on Ag-ELISA [12]. Porcine cysticercosis is also prevalent in Dodoma, the central region of Tanzania with the prevalence of 14.9%, based on lingual examination [13]. It is worth noting that Dar es Salaam City and other populated areas are important markets for pigs from rural disease endemic areas.

In Tanzania as well as many other developing countries, the extent of the problem may be under estimation due to limited disease surveillance, absent or unreliable data and lack of diagnostic facilities [14, 15]. Meat inspection is conducted to ensure that disease free meat, wholesome and of no risk to human health enters the food chain. This is accomplished through ante-mortem and post-mortem inspection by qualified personnel. Adequate meat inspection and control is one of the proposed control measures as it will interrupt the parasite life cycle [16]. This study was conducted to establish the prevalence of porcine cysticercosis in pigs slaughtered in Dar es Salaam City and Morogoro Municipality and assess the existence of risk factors for parasite transmission.

## **2. Materials and Methods**

### *2.1 Study Areas and Pig Population*

The study focused on porcine cysticercosis in pigs slaughtered in Dar es Salaam City and Morogoro Municipality, Tanzania. Dar es Salaam City is located between latitude 6°46' and 6°51' S and longitude 39°14' and 39°18' E. It occupies an area of 162.5 km<sup>2</sup> with a population of 4,364,541 people [17]. Administratively, Dar es Salaam City is divided into three Municipalities namely, Ilala, Kinondoni and Temeke. On the other hand, Morogoro Municipality is a rapidly growing town, located about 200 km west of Dar es Salaam City, with a population of 315,866 people [17]. Administratively, it is divided into 19 wards. Most of the examined pigs were from rural areas. They had been transported and slaughtered in

the study areas.

### *2.2 Data Collection*

All official slaughter places in the two study areas were included in the study. In Dar es Salaam City, the study was conducted from October 2012 to January 2013, while in Morogoro Municipality, it was from October to November 2013. Pigs slaughtered during the dates of the researcher's visits, were inspected by the researcher and important information for each pig was collected, including the place of origin, sex and inspection findings.

### *2.3 Risk Factors Assessment*

Information on risk factors for taeniosis-cysticercosis transmission was gathered using a check list questionnaire and direct observation. Both butchers and pork vendors in Dar es Salaam City were interviewed in Swahili, considering that the respondents were not conversant with the English language. A total of 24 butchers and 40 pork vendors were interviewed in the three Districts of Dar es Salaam City (Tables 3 and 4) after having received their oral consent. Targeted pork vendors were those who had purchased pork and prepared for public consumption in different pork centres known as "kitimoto". The collected information focused on the knowledge of *T. solium* taeniosis-cysticercosis transmission, pig carcass inspection, encounter of *cysticercus cellulosae* and reasons for pig carcass condemnation.

In Morogoro Municipality, risk factors assessment was mainly carried out through direct observation in which information on pig inspection, pig carcass condemnation, disposal of condemned carcasses, how pigs acquire the infection, health effect to human, how human acquire the infection and preparation of pork before consumption, also the location, general layout, availability of sanitary facilities and hygiene of the slaughter slabs were assessed. Furthermore, three places where pork and brain were prepared for public

consumption were visited to observe means used for preparing the pork before public consumption.

#### *2.4 Meat Inspection*

After the pig carcass was dressed, inspection of the head and carcass was done visually, followed by incisions made according to the Tanzania and OIE general guidelines for inspection of pig carcasses, which recommend incision of the following muscles and organs: tongue, masseter, heart and triceps brachii to search for *C. Cellulosae* [18]. In Morogoro Municipality, live pigs were tongue examined before slaughtering to check for the presence of cysticercerci.

#### *2.5 Data Analysis*

The proportion of porcine cysticercosis infected pigs was determined by computing the number of infected pigs divided by total number of examined pigs, using Microsoft Excel 2007. Chi-square test ( $X^2$ ) was used to determine the association between porcine cysticercosis prevalence and pig level variables such as sex, using MedCal statistical software.

### **3. Results**

#### *3.1 General Description*

A total of 766 pigs (450 males and 316 females) and 341 (200 males and 141 females) were examined in Dar es Salaam City and Morogoro Municipality, respectively. About 12% and 55% of the slaughtered pigs came from within Dar es Salaam City and Morogoro Municipality, respectively. Of the infected pigs slaughtered in Dar es Salaam, 28 were females and 20 males and all originated from outside of the city and the difference in the level of infection between pig sex was statistically significant ( $p = 0.02$ ). The status of the examined pigs in each slaughter slab is presented in Tables 1 and 2 while risk factors are presented in Tables 3 and 4.

#### *3.2 Status of Slaughter Slabs*

A total of 30 slaughter slabs (24 slabs in Dar es

Salaam City and 6 slabs in Morogoro Municipality) were assessed for sanitary conditions. Also, this study assessed the pig slaughtering, inspection and pork control processes in the study areas and found that the services were inadequate as the slaughter slabs were wrongly located and poorly equipped. In addition, there were inadequate sanitary facilities, unreliable water supply, lack of lairage/resting places, and inadequate pork inspection and control mechanisms.

### **4. Discussion**

This study has established the prevalence of porcine cysticercosis and possible risk factors for *T. solium* cysticercosis transmission in pigs slaughtered in Dar es Salaam City and Morogoro Municipality. This implies that there are serious public health risks which need to be addressed promptly. In Tanzania, urban centres are the main markets for pigs raised in rural areas, where porcine cysticercosis is known to be endemic [3]. In this study, it was revealed that all pigs infected with *T. solium* cysticercerci, slaughtered in the study areas (Tables 1 and 2) originated from rural areas. Therefore, the observed prevalence of porcine cysticercosis in slaughter pigs, despite the tongue examination method for screening live pigs by traders at farm level, poses a high risk to public health.

Moreover, considering the low sensitivity of the meat inspection method employed, the observed prevalence rate is likely to be less than the actual prevalence of the infection [19]. Similarly, abattoir surveys conducted elsewhere have reported the prevalence of cysticercosis in slaughtered pigs which are collected from rural areas [20-22]. This implies inadequacies in the pig management system practiced in rural areas where pigs are raised by smallholder pig farmers. The difference in prevalence in the two study areas could be attributed to the fact that in Dar es Salaam, about 90% of slaughtered pigs originated outside of the city, with the majority coming from rural areas while in Morogoro Municipality, 45% of the examined pigs originated from outside of the study

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**Table 1 Examined slaughter slabs and infection status in Dar es Salaam City.**

Name of slaughter slab	Pigs examined	Positive for PCC	% positive cases
Riverside 1	181	13	
Riverside 2	91	6	
Riverside 3	122	7	
Ubungodarajani	118	5	
Makongo	17	0	
Materu	10	0	
Tangibovu 1	8	0	
Tangibovu 2	9	5	
Shekilango	11	1	
Mabibo 1	9	0	
Mabibo 2	10	1	
Korogwe-Kimara	8	0	
Mbezi	17	0	
Maruma	16	2	
Tabatarelini	4	0	
Karakata	35	4	
Kisukulu	8	1	
Ukongamadizini	14	0	
Kipunguni	30	3	
Sukita	5	0	
Keko 1	19	0	
Keko 2	8	0	
Kekojuu	7	0	
Kurasini	9	0	
Total	766	48	6.3

Legend: PCC—porcine cysticercosis.

**Table 2 Examined slaughter slabs and infection status in Morogoro Municipality.**

Slaughter slab	Pig examined	Positive cases by tongue examination	Positive cases by meat inspection	% positive cases
Kihonda magorofani	84	0	1	
Kihonda viwandani	60	0	2	
Mazimbu	72	0	0	
Kilakala	56	0	0	
Madizini	52	0	1	
Bigwa	17	0	1	
Total	341	0	5	1.5

area and the rest of them came from peri-urban settings, where the risk of contracting the infection is minimal.

In Tanzania, the establishment of pig slaughter slabs/houses has not been given due priority. Emphasis has been given to cattle and small ruminants, probably due to religious influence [3]. As a result, all slaughter slabs in the two study areas were not in good

conditions. They were substandard, unhygienic and lacked the basic facilities of a slaughter facility, risking the health of consumers of meat produced from the facilities. Similarly, poor hygiene and substandard conditions of slaughter facilities have been reported in other developing countries [23, 24]. The number and location of slaughter slabs observed in this study affected monitoring and control of the

facilities as the slabs were scattered all over the city, making routine meat inspection difficult. This is potentially an important predisposing factor for taeniosis-cysticercosis transmission in study area.

Due to these limitations, it was noted that some pork was sold without being inspected because of the few available meat inspectors who could not reach each slaughter slab all the time, especially in Dar es Salaam City. Therefore, some butchers sold infected pork or had the meat hidden and sold the same after the meat inspectors had left. Moreover, this study also revealed that ante mortem inspection was rarely conducted for the same reason. This was particularly evident as no inspector was available in any of the slaughter slabs in Morogoro Municipality to perform the required inspection during this study. This implies that the produced pork was sold without being inspected. The observed shortfalls in monitoring slaughter pigs compromises efforts to control meat-borne zoonoses as was also reported elsewhere in developing countries [21, 14].

It was also found that pork preparation procedures varied from one place to another. For example, in the visited places within Morogoro Municipality, deep frying was common in preparing the pork before consumption. The method may be adequate to kill the cysticerci, depending on the size of pork pieces being fried and the frying duration. In one area, barbecuing was also practiced, which might not be effective to kill the deep sitting cysticerci. Brain was wrapped and soaked into boiling cooking oil for about five minutes to get it hardened before consumption. This method is likely to be ineffective to kill the cysticerci if any.

Only a few of the butchers and pork vendors in Dar es Salaam City had formal education (standard VII) (Tables 3 and 4). Limited knowledge on *T. solium* cysticercosis among butchers and pork vendors as observed in this study is essentially among the reasons which make them employ practices which promote the transmission of the parasite, including selling or buying uninspected pork. Similar observations were reported from pig butchers in Nigeria [24]. To get rid

**Table 3 Participants characteristics on potential risk factors for *T. solium* cysticercosis transmission in Dar es Salaam City (butchers n = 24).**

Risk factors	Yes (%)	No (%)
Completed formal education	16 (67)	8 (33)
Selling inspected pork	12 (50)	12 (50)
Encountered total condemnation of pig carcass	19 (79)	5 (21)
PCC the cause of total condemnation	12 (50)	12 (50)
Heard about porcine cysticercosis	20 (83)	4 (17)
Seen cysticercus cellulosae	20 (83)	4 (17)
Understand how pigs acquire the infection	8 (33)	16 (67)
Understand the link between pig and human infections	4 (17)	20 (83)
Know clinical signs in human	5 (21)	19 (79)

Legend: PCC – Porcine cysticercosis.

**Table 4 Participants characteristics on potential risk factors for *T. solium* cysticercosis transmission in Dar es Salaam City (pork vendors n = 40).**

Risk factors	Yes (%)	No (%)
Completed formal education	18 (45)	22 (55)
Buying inspected pork	28 (70)	12 (30)
Heard about porcine cysticercosis	5 (13)	35 (87)
Seen cysticercus cellulosae	3 (8)	37 (92)
Understand how pigs acquire the infection	2 (5)	38 (95)
Understand the link between pig and human infections	1 (3)	39 (97)
Know the clinical signs in human	1 (3)	39 (97)

of this situation, education has been reported to be an effective means of controlling the parasite and other food borne zoonoses [25]. However, targeting slaughterhouses as the primary intervention point may be ineffective in developing countries because inspection and condemnation measures are inefficient as observed in this study. In addition, infected pigs may pass through clandestine markets to ultimately enter the food chain.

## 5. Conclusions and Recommendations

The present study has evidently shown that porcine cysticercosis is common to pigs slaughtered and consumed in Dar es Salaam City and Morogoro Municipality, posing high risks to the public health.

The majority of slaughter slabs are of poor standards and pig inspection and pork control is rarely done due to the limited number of meat inspectors.

In view of the observed shortfalls, pig slaughtering should be centralized in order to safeguard the public health.

*Taenia solium* cysticercosis control program targeting all actors in the pig value chain is crucial for effective and sustainable control of the parasite.

## Acknowledgement

The financial support by Danish International Development Agency (DANIDA), through securing Livelihood through Improved Pig Production (SLIPP) project, under Grant number 09-07-LIFE is highly appreciated. I am also thankful to meat inspectors, butchers and pork vendors for accepting to participate in this study.

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