

## Seroprevalence of antibodies (IgG) to *Taenia solium* among pig rearers and associated risk factors in Jos metropolis, Nigeria

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### Abstract

**Introduction:** In Nigeria, *Taenia solium* cysticercosis is a problem in rural areas where most pigs are kept and in urban areas where infected pork can be consumed.

**Methodology:** We performed enzyme linked immunosorbent assays on serum samples collected from pig rearers in Jos, Nigeria, to determine the prevalence of IgG antibodies.

**Results:** Of 125 subjects tested, 12 (9.6%) were positive for *T. solium*. Seroprevalence did not differ significantly ( $P > 0.05$ ) according to education, age, occupation, study location, gender or whether the subjects consumed pork. However, a statistical difference ( $P < 0.05$ ) in seroprevalence was observed according to type and availability of toilet used, personal hygiene after using the toilet, and type of pig management practiced. Females were about two times more likely to be seroprevalent than males (OR=1.7; 95% CI= 0.43-6.67;  $P=0.4$ ) and subjects who consumed pork were four times more likely to have anti *T. solium* antibodies than those who did not eat pork (OR=4.2; 95%CI=0.52-33.57;  $P=0.2$ ). Those who defecated in the bush were 8.3 times more likely to suffer from *T. solium* infection than those who used water system toilets (OR=8.3; 95%CI=1.56-43.7;  $P=0.01$ ). Subjects who did not wash their hands after defecating were 6 times more likely to contract *T. solium* compared to those who washed their hands with water (OR=5.5; 95% CI=1.39-21.89;  $P=0.01$ ).

**Conclusion:** Our results show that using a toilet and practicing good personal hygiene can reduce cases of *T. solium* infection in a community.

**Key words:** seroprevalence; ELISA; *T. solium*; human; risk factors; Nigeria

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### Introduction

The potentially disastrous impact of emerging and re-emerging zoonoses on human health is a growing concern around the globe [1]. Cysticercosis/neurocysticercosis, the infection caused by the larval stage of the zoonotic pork tapeworm *Taenia solium*, is considered to be the most important parasitic infestation of the central nervous system in humans in disease-endemic zones [2,3]. It is also being increasingly recognized as the single most common cause of severely acquired but preventable epilepsy in the developing world, where prevalence rates of active epilepsy are twice than those in developed countries [2-5]. Apart from the public health risk, *T. Solium* infection contributes to high levels of neurologic morbidity and some mortality in developing countries [6-8]. The cestode *T. solium* is cosmopolitan in distribution and highly endemic in Latin America, Africa and Asia where poverty, poor sanitation, and

intimate contact between humans and their livestock are common place [9-11]. Cysticercosis has been cited by the World Health Organization (WHO) and the Food and Agriculture Organization for the United Nations (FAO) as one of the neglected zoonotic diseases, and one of a few potentially eradicable diseases [12], but it is now an emerging zoonoses [13]. Approximately 50 million people worldwide are estimated to have cysticercosis infection, and 50,000 neurocysticercosis-related deaths occur annually worldwide, although estimates are probably low since many infections are subclinical with relatively little population-based data on prevalence [14-16].

*Taenia solium* has a complex two-host life cycle. Human beings are the only definitive host and harbour the adult tapeworm (taeniasis), whereas both humans and pigs can act as intermediate hosts and harbour the larvae or cysticerci. Humans acquire cysticercosis/neurocysticercosis through feecal-oral

contamination with *T. solium* eggs from tapeworm carriers [10,17,18]. However, autoinfection as a result of the entry of eggs into the stomach due to retroperistalsis or as a result of accidental ingestion of eggs from the host's own faeces due to contaminated hands is also possible [19,20]. Most worrying is the fact that people do not have to eat pork to become infected with cysticercosis. Vegetarian and other people who do not eat pork can acquire cysticercosis by putting contaminated fingers in their mouths or through ingestion of water or foods or from touching surfaces that have become contaminated with the infected faeces [21]. Water, wind, flies, and other indirect means of infection play little part in the transmission of taeniasis [22].

The rapid expansion of pig farming and pork consumption is raising concern in Nigeria, as it is bound to exacerbate the problems related to *T. solium* cysticercosis, not only in rural areas where most pigs are kept, but also in urban areas where infected pork can be consumed, and human carriers of the parasite can infect other people. Prevalence human taeniasis has been reported in Nigeria at 8.6% [23] with 3.7% associated with epilepsy [21,24]. Although the recognition of its status as a serious and emerging threat to public health is increasing, the incidence data in humans are very limited owing to a lack of adequate surveillance, monitoring and reporting systems; consequently, epidemiological information is not extensive. This study, therefore, was conducted to determine the prevalence of cysticercosis among pig farmers in Jos, Nigeria, to generate a base line data for planning effective control strategies and offer recommendations for prevention.

## Methodology

### *The study area*

Jos, the capital of Plateau State, is located in Nigeria's middle belt region. The state has an area of 26,899 square kilometers and an estimated population of about three million people. It is located between latitude 8°24'N and longitude 8°32' and 10°38' east. The state is named after the picturesque Jos plateau, a mountainous area in the north of the state with captivating rock formations. The altitude ranges from around 1,200 meters (about 4000 feet) to a peak of 1,829 meters above sea level in the Shere Hills near Jos. The mean annual rainfall varies from 131.75 cm (52 inch) in the southern part to 146 cm (57 inch) on the Plateau [25]. Though situated in the tropical zone, the higher altitude means that Plateau State has a near temperate climate with an average temperature of

between 18°C and 22°C. This weather makes the state favourable for pig production.

### *Study population*

Households keeping pigs in nine locations in the Jos metropolis were visited randomly (between June 2006 and April 2007) until the required number of 125 pig rearers was obtained.

### *Survey and detection of T. solium cysticercosis in humans*

In each selected household, the respondents were persons responsible for feeding and caring for the pigs. Consent forms were completed by the pig rearers, while blood donations were voluntary. Farmers selected for the interviews were based on a preset questionnaire. Information on the potential environmental, demographic, and other risk factors associated with transmission of *T. solium* within the community was recorded for each subject as the questionnaires were being answered. Ethical clearance for human sampling was obtained from the ethical committee of Jos University Teaching Hospital.

### *Serology*

Blood samples (5 ml each) were obtained from 125 pig rearers in various locations within Jos and the sera harvested according to standard methods. Sera samples were frozen at -20°C until required. All sera were analysed and screened for IgG antibodies to *Taenia solium* using the enzyme-linked immunosorbent assay (ELISA, Diagnostic Automation, Inc, Calabasas, CA, USA), according to the manufacturer's recommendations. Results were read using a spectrophotometer (Multiskan EX 355, Lab Systems, Vantaa, Finland) at 450 nm after blanking on air. An optical density (OD) reading greater than 0.35 was considered positive.

### *Statistical analysis*

All the data were recorded and the prevalence of cysticercosis was computed in percentages. Data were analysed using Chi square ( $\chi^2$ ) and Fisher Exact test on Statistix 8.0 software (Softonic, Barcelona, Spain). Values of  $P < 0.05$  were considered significant.

## Results

Twelve of the 125 (9.6%) pig farmers examined were seropositive for antibodies to *T. solium*. Seroprevalence based on different variables is presented in Table 1. Subjects above the age of 56 years of age had the highest prevalence (14.3), closely

**Table 1.** Prevalence of anti *Taenia solium* antibodies (IgG) among 125 pig rearers in Jos, Nigeria split by age, location, occupation, management system, gender, educational qualification, frequency of deworming, eating of pork, availability/type of toilet and hygiene practise after use of toilet

Variables	Number examined	Number (%) seropositive	$\chi^2$	P
<b>Age (years)</b>				
15-25	27	1 (3.7)	1.0	
26-35	18	1 (5.6)	0.09	0.8
36-45	25	3 (12.0)	1.26	0.3
46-55	34	4 (11.8)	1.30	0.3
>55	21	3 (14.3)	1.73	0.2
<b>Study location</b>				
Apata	26	5 (19.2)	1.0	
Abattoir	29	2 (6.9)	1.45	0.2
Angwan Rukuba	15	3 (20.0)	0.00	0.9
Chwelnep	23	2 (8.7)	0.84	0.4
Wildlife	17	0 (0.0)	3.06	0.1
Tudun Wada	15	0 (0.0)	2.71	0.1
<b>Occupation</b>				
Trader	60	6 (10.0)	1.0	
Farmer	19	3 (15.8)	0.37	0.5
Artisan	21	1 (4.8)	0.47	0.5
Civil servant	25	2 (8.0)	0.07	0.7
<b>Management system</b>				
Intensive	48	1 (2.1)	1.0	
Extensive	77	11 (14.3)	4.31	0.04*
<b>Gender</b>				
Male	44	3 (6.8)	1.0	
Female	81	9 (11.1)	0.61	0.4
<b>Level of education</b>				
None	32	2 (6.3)	1.0	
Primary	32	6 (18.8)	2.29	0.13
Secondary	45	4 (8.9)	0.18	0.7
Tertiary	16	0 (0.0)	1.04	0.3
<b>Eat pork</b>				
No	32	1 (3.1)	1.0	
Yes	93	11 (11.8)	1.79	0.2
<b>Frequency of deworming</b>				
None	50	9 (18.0)	1.0	
Once	28	2 (7.1)	1.75	0.2
$\geq$ Twice	47	1 (2.1)	6.6	0.01*
<b>Availability/ type of toilet</b>				
None	31	6 (19.4)	1.0	
Pit latrine	23	4 (17.4)	0.03	0.8
Water system	71	2 (2.8)	8.17	0.004*
<b>Personal toilet hygiene</b>				
No washing hand after toilet	20	7 (35)	1.0	
Wash with water only	45	4 (8.9)	6.67	0.009*
Wash with soap and water	60	1 (1.7)	18.52	0.000*

followed by those aged 26 to 35 years and 36 to 45 years respectively. Female pig rearers had higher prevalence than males (11.1 versus 6.8) though the difference was not significant, and females were equally 1.7 times more likely to be seropositive than male rearers (Table 2). None of the sampled subjects (16) who had a tertiary level of education was seropositive to *T. solium*, albeit 18% (6/32) and 8.8% (4/45) of those with primary and secondary education were seropositive. Significantly ( $P < 0.05$ ) more persons who do not deworm themselves were seropositive compared to those who deworm themselves twice a year. Those who raised their pigs extensively recorded significantly higher ( $P < 0.05$ ) seroprevalence than those who practise intensive management. Based on location, Angwan Rukuba had the highest prevalence (20%), followed by Apata (19.2%), Chwenlep (8.7%), and Abattoir (6.9%), while Wildlife and Tudunwada areas recorded 0% prevalence. According to occupation, farmers (arable and livestock) had the highest prevalence with 15.8%, followed by traders (10.0%), civil servants (8.0%) and artisans (4.8%).

Seroprevalence was significantly higher ( $P < 0.05$ ) among subjects who defecated in open spaces or in the bush compared to those who used water closet system. Similarly, subjects who observed strict hygiene by washing their hands with water only or soap and water (35% and 1.7%) respectively after each visit to the

toilet had significantly ( $P < 0.05$ ) lower prevalence than those who did not wash their hands after using the toilet. Those who consumed pork showed 4.2 times more seroprevalence compared to those who did not, and one of the subjects who ate pork suffered from epilepsy. Those who did not use toilet facilities were 8.3 times more likely to be seropositive compared to those who used water closet toilet facilities. Subjects who did not wash their hands after using the toilet were 31.7 times more seropositive than those who washed their hands with soap and water (Table 2).

**Discussion**

The 9.6% seroprevalence of human cysticercosis among pig rearers obtained in this study is high compared to the zero (0%) prevalence earlier reported in Nigeria [26], and the 2.4% and 1.3% prevalence reported by Zoli *et al.* [21] in endemic areas of the West African countries of Togo and Benin respectively. Our finding is close to the prevalence of 14.8% and 8.0% obtained in Mexico (an endemic area) by western blot and ELISA respectively [27]. The 9.6% seroprevalence in this study is also in agreement with the reports show that in most endemic villages, more than 10% of the general population is seropositive and seropositivity can reach up to 25% [28]. The only two cases reported previously in Nigeria were based on hospital records from surgical books and postmortem registers at University College

**Table 2.** A comparison by odds ratio of prevalence among gender, pork eating, deworming, availability/type of toilet, personal hygiene after use of toilet and management system

Parameters	Odd ratio	$\chi^2$	95% CI	P
Female v. Male	1.7	0.61	0.43-6.67	0.47
Eat pork v. do not eat pork	4.2	2.08	0.52-33.57	0.18
No toilet v. pit latrine	1.1	0.85	0.28-4.62	0.85
No toilet v. water system	8.3	8.7	1.56- 43.7	0.01*
Do not wash hands after toilet v. Wash hands with water only	5.5	6.7	1.39-21.89	0.01*
Do not wash hands after toilet v. wash hands with soap and water	31.7	18.52	3.59-280.95	0.001*
Do not deworm v. deworm at least twice a year	10.1	6.6	1.22-83.16	0.01*
Extensive v. intensive management	7.8	5.07	0.97-62.76	0.02*

Hospital (UCH), Ibadan [23], and the examination of stool samples [29]. Our findings show that there was no significant difference in relation to location ( $P > 0.05$ ), possibly because the same conditions favourable for transmission and maintenance of the infection prevail in the entire area.

In this study, females had a higher seroprevalence and were 1.7 times more prone to infection than males (11.1% versus 6.8%). This observation might be due to risky behavior (such as the habitual tasting of food on the fire when it is not yet cooked), associated, for instance, with food preparation, which is mostly done by women. Furthermore, most of the pig farmers who participated in the study were women (64.8% versus 35.2%). These statistics agrees with those of earlier reports showing that close personal contact with or food preparation by women who are tapeworm carriers favours the transmission of the parasite [19].

The analysis of age-stratified data in the study indicated that the age group 15 to 25 years had the lowest seroprevalence (3.7%), while the age group older than 56 years had the highest seroprevalence (14.3%), which agrees with the findings of earlier studies [30] which showed that older age groups were among the risk factors included for human infection. However, this difference was not significant ( $P > 0.05$ ), indicating that the same conditions favour the transmission and sustenance of the epidemiological chain in all ages. None of the 16 pig rearers with tertiary education in the study was seropositive for cysticercosis compared with those with low or no education. This observation agrees with those of previous reports showing that the cestode is a public health problem in most developing countries where illiteracy and poor formal education is common [30,31]. However, the study did not find any significant relationship  $P > 0.05$  with educational status.

Respondents who dewormed themselves twice a year using the antiparasite drugs albendazole and praziquantel, which block the transmission of infection, had significantly ( $P < 0.05$ ) lower seroprevalence (2.4%) than those who never dewormed themselves (18.0%).

In the present study, there was a higher prevalence (19.4%) of infection in subjects who used the open bush to defecate compared to those who had a water closet system (2.6%). This statistic agrees with those of other reports that the life cycle of the cestode is sustained due to deficient sanitary infrastructures, which permit free-ranging pigs access to contaminated feces from a tapeworm carrier and that the contact of

swine and people with infected human feces are among factors promoting and maintaining such disease transmission [9,11,12,32]. Individuals who wash their hands with soap following each toilet use had the least seroprevalence (1.6%) compared to those who do not wash their hands with soap (8.9%). Personal hygiene associated with toilet use reduces the risk of cysticercosis. Those subjects who consumed pork had a higher seroprevalence of cysticercosis (11.8%) than those that did not consume pork (3.1%) but the difference was not statistically significant ( $P > 0.05$ ). This may due to the fact that subjects who were interviewed explained that pork is usually properly boiled and then fried before consumption. This practice completely destroys the cysticerci, thereby preventing transmission of the agent.

## Conclusion

The study shows that risk factors for *T. solium*/cysticercosis in the study are availability/type of toilet; personal hygiene after using the toilet; the management system practiced; and whether the subjects dewormed regularly. Successful control requires instituting a nationwide epidemiological survey; a community-based public health education that emphasizes the need to practice the intensive system of pig management; and thorough meat inspection by abattoir personnel. Treatment of pigs would also be very helpful as part of mass cysticercosis control programmes, as it would decrease the porcine reservoir of cysticercosis. It is also important to assess the impact of these parasites both in the agriculture and health sectors as this could help the government to consider these as priority targets for community development.

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