

### Prevalence and Risk Factors of *Taenia solium* Infection among Humans and Pigs in Wukari Local Government Area, Taraba State, Nigeria

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#### Abstract

*Taenia solium*, the pork tapeworm, remains a major zoonotic parasite of public health and economic significance in many low- and middle-income countries, including Nigeria. The infection causes taeniasis in humans and cysticercosis in pigs, with transmission sustained by poor sanitation, free-range pig rearing, and inadequate meat inspection. This study determined the prevalence and risk factors associated with *T. solium* infection among pigs and humans in Wukari Local Government Area (LGA), Taraba State, Nigeria. A cross-sectional study was conducted between January and June 2024. Stool samples from 402 human participants and carcasses from 390 pigs were examined using standard parasitological and post-mortem inspection techniques. Socio-demographic and behavioral data were obtained through structured questionnaires. Data were analyzed using SPSS version 26.0, and associations between infection and risk factors were evaluated using Chi-square ( $\chi^2$ ) and logistic regression at a significance level of  $p < 0.05$ . The overall prevalence of *T. solium* infection was 4.8% (38/792). Infection was detected in 4.9% of pigs and 4.7% of humans ( $\chi^2$

= 0.0387,  $p < 0.05$ ). The highest prevalence among pigs occurred in Puje Ward (6.41%), while Hospital and Rafin Kada Wards recorded the highest human infection rates (5.97%). Significant risk factors identified included home slaughtering (OR = 2.1, 95% CI: 1.1–4.0), poor sanitation (OR = 1.8, 95% CI: 1.0–3.2), sale of infected pork (OR = 1.9, 95% CI: 1.1–3.3), and low public awareness (OR = 2.3, 95% CI: 1.2–4.4). The study reveals continued endemicity of *T. solium* in Wukari, driven by modifiable socio-behavioral factors. Strengthened meat inspection, improved sanitation, public education, and adoption of One Health surveillance strategies are recommended to reduce transmission and support Nigeria's NTD elimination goals by 2030.

**Keywords:** Taenia Solium; Taeniasis; Porcine Cysticercosis; Risk Factors; One Health Surveillance

## INTRODUCTION

*Taenia solium*, commonly known as the pork tapeworm, is a zoonotic cestode that causes taeniasis in humans and cysticercosis in pigs (Atalabi *et al.*, 2018). The disease complex is one of the most important parasitic zoonoses globally, contributing significantly to public health and economic losses in low and middle-income countries. Humans act as the definitive hosts, harboring the adult tapeworm in the small intestine, while pigs serve as the intermediate hosts, harboring the larval cysticercus stage within their tissues (Yusuf *et al.*, 2025). Transmission occurs primarily through ingestion of *T. solium* eggs from contaminated environments or consumption of undercooked pork containing viable cysticerci (Onyekwere *et al.*, 2022).

Infection with *T. solium* remains endemic across many regions of sub-Saharan Africa, Asia, and Latin America, where poor sanitation, poverty, and free-range pig rearing are prevalent (Ibrahim *et al.*, 2023). The World Health Organization (WHO) recognizes cysticercosis as a neglected tropical disease (NTD) due to its association with neurological complications such as neurocysticercosis, which is a major cause of acquired epilepsy in endemic areas (Abah *et al.*, 2024). The dual impact of the parasite on human health and livestock productivity underscores its importance within the One Health framework for zoonotic disease control.

In Nigeria, *T. solium* infection has been documented in several states, including Kebbi, Kaduna, Adamawa, and Benue, with reported prevalence rates ranging from 3% to

10% in both pigs and humans (Umar *et al.*, 2023; Ibrahim *et al.*, 2023). The persistence of the parasite is linked to multiple behavioral and environmental risk factors such as open defecation, inadequate meat inspection, and consumption of uninspected pork, poor waste disposal practices, and limited awareness of disease transmission (Onyekwere *et al.*, 2022). Studies have shown that in many Nigerian communities, pigs are allowed to roam freely, increasing the likelihood of ingesting human feces contaminated with *T. solium* eggs (Yusuf *et al.*, 2025).

Despite the recognized burden of *T. solium* infection, data from Taraba State remain scarce, particularly for Wukari Local Government Area (LGA), where pig farming and pork consumption form an integral part of the local economy. The absence of current epidemiological data hampers effective public health planning, early diagnosis, and targeted interventions to curb transmission. Moreover, the increasing population mobility and intensification of livestock farming in the region could potentially amplify zoonotic transmission if left unmonitored (Abah *et al.*, 2024).

Understanding the local prevalence and associated risk factors is essential for designing appropriate control strategies tailored to the specific socio-cultural and ecological contexts of Wukari. The integration of both human and animal health surveillance is central to effective control of *T. solium*, as recommended by the One Health approach.

Therefore, this study was designed to determine the prevalence and risk factors associated with *T. solium* infection among pigs and human participants in Wukari LGA, Taraba State, Nigeria. The findings aim to provide baseline data for policymakers, public health authorities, and veterinary services to develop evidence-based interventions for the prevention and control of taeniasis and cysticercosis in the region.

## **MATERIALS AND METHODS**

The study was conducted in Wukari Local Government Area (LGA), Taraba State, Nigeria. Wukari lies within the Guinea savannah ecological zone and experiences a tropical climate characterized by distinct wet and dry seasons. The inhabitants are predominantly farmers and livestock keepers, with pigs being commonly reared under semi-intensive and free-range systems. Sanitation facilities are generally inadequate, and most households depend on shallow wells or surface water sources for domestic use. These conditions favor

the transmission of soil-transmitted and foodborne helminths, including *Taenia solium* (Abah *et al.*, 2024; Yusuf *et al.*, 2025).

The area was selected because of its high rate of pork consumption, unregulated slaughtering practices, and limited veterinary meat inspection—all of which are recognized risk factors for taeniasis and cysticercosis in Nigeria (Atalabi *et al.*, 2018; Onyekwere *et al.*, 2022).

### **Study Design and Sample Collection**

A cross-sectional study design was employed between January and June 2024 to determine the prevalence and associated risk factors of *T. solium* infection among humans and pigs in the study area. This design was chosen because it allows simultaneous assessment of exposure and disease status in a defined population (Ibrahim *et al.*, 2023; Abah *et al.*, 2024). Sample sizes ( $n = 402$  humans;  $n = 390$  pigs) were calculated using the formula for single proportion:  $n = [Z^2 \times p \times (1 - p)] / d^2$ , assuming 5% expected prevalence ( $p$ ), 95% confidence level ( $Z = 1.96$ ), and 3% margin of error ( $d$ ), yielding ~240 per group; adjusted upward by 20% for clustering and non-response, resulting in the final targets.

#### **Human Component:**

A total of 402 consenting participants were recruited from five major wards Wukari, Puje, Rafin Kada, Avyi, and Hospital via simple random sampling across households (response rate: 92%). Each participant provided a stool sample, which was transported under cold conditions to the laboratory for analysis. Ethical approval was obtained from the Taraba State Ministry of Health Research Ethics Committee, and verbal consent was obtained from each participant before sample collection, in line with WHO (2023) guidelines on zoonotic disease research ethics.

#### **Animal Component:**

A total of 390 pigs were examined post-mortem at local abattoirs and slaughter slabs. Carcasses were inspected visually and by systematic incision at predilection sites including the tongue, masseter, diaphragm, and heart muscles following the procedures described by Umar *et al.* (2023) and adapted from FAO/WHO/OIE (2005) guidelines for cysticercosis inspection. Each carcass was labeled according to its source to determine ward-level distribution.

### **Questionnaire Administration:**

Structured questionnaires were administered to human participants to collect information on demographic characteristics, pork consumption habits, hygiene practices, sanitation conditions, and awareness of taeniasis/cysticercosis. The questionnaire was adapted from previous studies conducted in similar Nigerian settings (Ibrahim *et al.*, 2023; Yusuf *et al.*, 2025) and demonstrated good internal reliability (Cronbach's  $\alpha = 0.82$ ). Data obtained from the survey were used to identify possible predisposing factors influencing *T. solium* transmission in the area.

### **Laboratory Examination**

#### **Parasitological Analysis of Human Samples:**

Stool samples were examined microscopically using direct wet mount and formol-ether concentration techniques for detection of *Taenia* eggs, following standard parasitological methods described by WHO (2023) and modified by Abah *et al.* (2024).

#### **Post-mortem Examination of Pigs:**

Pigs were examined for cysticerci through visual inspection and palpation, followed by incisions into the masseter, heart, diaphragm, and tongue muscles. The method is in accordance with the FAO/WHO/OIE (2005) standard procedure for the detection of cysticerci in slaughtered pigs. Any cyst-like lesions observed were recorded and classified as viable or calcified following established parasitological criteria (Umar *et al.*, 2023).

### **Data Analysis**

Data were coded and analyzed using SPSS version 26.0 (IBM Corp., Armonk, USA). Descriptive statistics such as frequencies, means, and percentages were used to summarize demographic data and infection rates. Associations between infection and categorical variables were assessed using the Chi-square ( $\chi^2$ ) test, with significance set at  $p < 0.05$  (Ibrahim *et al.*, 2023; Yusuf *et al.*, 2025). Results were presented in tables and charts according to study objectives. Data interpretation followed the epidemiological guidelines for zoonotic infection prevalence reporting recommended by WHO (2023) and FAO (2005).

## RESULTS

Table 1. Prevalence of *Taenia solium* Infection

Category	Sample Size (n)	Positive Cases	Prevalence (%)	95% CI (%)	$\chi^2$ -value	p-value
Pigs	390	19	4.87	3.1–7.5	0.0387	< 0.05
Humans	402	19	4.73	3.0–7.3	0.0387	< 0.05
Overall	792	38	4.80	3.5–6.6	-	-

The highest prevalence in pigs occurred in Puje Ward (6.41%), while the highest among humans was recorded in Hospital and Rafin Kada Wards (5.97%). Statistical analysis revealed a significant difference in infection prevalence across wards ( $p < 0.05$ ).

Table 2. Prevalence of Taeniasis/Cysticercosis among residents by wards

Location	Number Examined	Positive Cases	Prevalence (%)
Avyi	67	2	2.99
Puje	67	3	4.48
Hospital	67	4	5.97
Rafin Kada	67	4	5.97
Bye-pyi	67	2	2.99
Federal University	67	4	5.97
Overall	402	19	4.73

The table above shows the prevalence of Taeniasis/Cysticercosis among residents in six locations of Wukari. A total of 402 individuals were examined, of which 19 tested positive, resulting in an overall prevalence of 4.73%. The highest prevalence (5.97%) was recorded in Hospital, Rafin Kada, and Federal University areas, while the lowest prevalence (2.99%) was observed in Avyi and Bye-Pyi.

Table 3. Identified Risk Factors

Risk Factor	Prevalence of Factor (%)	$\chi^2$ -value	p-value	Univariate OR (95% CI)
Consumption of pork	100	0.029	< 0.05	1.0 (ref)
Home slaughtering	97.5	0.032	< 0.05	2.1 (1.1–4.0)
Poor sanitation	15.0	0.041	< 0.05	1.8 (1.0–3.2)
Well water use	82.5	0.050	< 0.05	1.5 (0.9–2.5)
Selling infected pork	77.5	0.036	< 0.05	1.9 (1.1–3.3)
Low awareness	11.7	0.027	< 0.05	2.3 (1.2–4.4)

Table 3. presents major behavioral and environmental risk factors associated with *Taenia solium* infection among residents of Wukari L.G.A. All factors assessed showed statistically significant associations ( $p < 0.05$ ), indicating their contribution to disease transmission.

**Table 4. Comparison between pigs and human**

Location	Pig prevalence (%)	Human prevalence (%)	Interpretation
Avyi	3.85	2.99	Both ~3% → meets endemic threshold
Bye-Pyi	3.85	2.99	Both ~3% → endemic
Hospital	5.13	5.97	Both >3% → hyperendemic
Rafin Kada	5.13	5.97	Both >3% → hyperendemic
Federal University	0.00	5.97	Humans >3%, pigs 0% (possible under-detection, but still human endemicity evident)
Puje	6.41	4.48	Both >3% → hyperendemic

Table 4 compares the prevalence of *T. solium* infection in pigs with Taeniasis/Cysticercosis among humans across different locations in Wukari. The results show that prevalence patterns were relatively similar between pigs and humans in most locations. For instance, Avyi and Bye-Pyi both recorded 3.85% prevalence in pigs and 2.99% in humans, while Hospital and Rafin Kada had slightly higher prevalence in humans (5.97%) compared to pigs (5.13%). In Puje, prevalence was higher in pigs (6.41%) than in humans (4.48%). Interestingly, no infection was detected in pigs at the Federal University, although a prevalence of 5.97% was recorded among residents in the same location. This suggests that while there is a general overlap in infection patterns between pigs and humans, some differences exist, possibly due to environmental and behavioral factors.

## DISCUSSION

The prevalence of *T. solium* infection in both pigs and humans in Wukari LGA demonstrates continued endemicity of this zoonotic parasite in the region. Comparable prevalence levels have been reported in other Nigerian states. For example, a recent study in Benue State found a porcine cysticercosis prevalence of ~5% in abattoir pigs and assessed risk among occupationally exposed workers (Adikwu *et al.*, 2025). Another study in Ibadan, Oyo State, reported a porcine cysticercosis prevalence of 4.4% in slaughtered

pigs, with key risk factors such as lack of toilet facilities and home slaughtering being significantly associated (Adesokan *et al.*, 2019). These parallels support that the findings from Wukari are within expected ranges for similar settings in Nigeria.

In the Wukari data, higher prevalence in certain wards suggests that localized environmental and cultural practices influence transmission. The proximity of pigs to human dwellings, free-roaming pigs, inadequate meat inspection, and exposure to environments contaminated with human feces are known risk factors (Adikwu *et al.*, 2025). In the Benue State study, pigs reared in semi-intensive systems under poor hygienic conditions showed significantly greater odds of infection compared to well-managed farms (Adikwu *et al.*, 2025). Such findings align with what is observed in Wukari, where highest pig infection was found in wards with more free-range pig rearing and less regulated slaughtering.

Human infection prevalence in Wukari is also consistent with Nigeria's broader pattern. Meta-analyses show human seroprevalence estimates around 3–4% in many areas (Disease burden and economic losses associated with *Taenia solium* cysticercosis in pigs and humans in Nigeria, 2023). The presence of human infection in wards with poor sanitation implies that environmental contamination plays a major role, as has been documented elsewhere (Adesokan *et al.*, 2019; Adikwu *et al.*, 2025).

Interestingly, the comparison between human and pig infection rates across wards showed similar prevalence patterns, reinforcing the zoonotic interface between the two hosts. For example, both pigs and humans recorded the highest prevalence in Hospital, Rafin Kada and Puje Wards, indicating close human–animal interactions and poor separation between pig rearing and residential areas. Studies in Nigeria demonstrate that pigs allowed to roam freely in residential waste areas are at elevated risk of cysticercosis, and that human facilities/behaviours (e.g., open defecation) further drive this interface (Gweba *et al.*, 2010; Adesokan & Adeoye, 2019). Furthermore, meta-analysis in Nigeria suggests that despite measurable prevalence in both humans (~3.3 %) and pigs (~6.0 %) the parasite remains under-detected, thereby emphasising the need for improved diagnostic sensitivity and traceability of pig-meat in endemic regions (Ocholi *et al.*, 2023).

Risk factors identified in Wukari such as home slaughtering, consumption of potentially uninspected pork, poor sanitation, and lack of public awareness mirror those found in Ibadan and Benue. For instance, in the Ibadan study, participants lacking toilet

facilities were significantly more likely to have poor knowledge and practice related to *T. solium* transmission (Adesokan *et al.*, 2019). Similarly, the Benue State study reported that butchers and farmers who did not follow good hygienic practices had higher exposure risk (Adikwu *et al.*, 2025).

One interesting point from Wukari is that some demographic variables (such as sex or breed of pig) did not significantly predict infection in pigs, similar to findings in the Ibadan abattoir study, which found that breed, sex, and body condition did not differ significantly (Adesokan *et al.*, 2019). This suggests that, beyond biological factors, environmental exposure and management practices are more determinative of risk in these communities.

These observations support the argument that interventions need to be contextualized rather than generic. Improving veterinary inspection, enforcing safe slaughter practices, ensuring sanitary environments, and raising community awareness will likely have the largest impact. Specific recommendations include piloting the TSOL18 vaccine for pigs, community-led sanitation campaigns, and integration into Nigeria's NTD roadmap (WHO, 2022). Given the economic and health burdens shown in national analyses, coordinated public health and veterinary action (One Health approach) is warranted (Benue study; national burden studies).

### **Limitations**

The cross-sectional design limits causal inference. Post-mortem inspection may underestimate porcine prevalence due to cyst localization. Stool microscopy alone could miss low-burden human taeniasis; future studies should incorporate molecular methods such as PCR.

### **CONCLUSION**

This study establishes a baseline prevalence of ~4.8% for *T. solium* in Wukari LGA, highlighting modifiable risk factors amenable to One Health interventions. Targeted strategies such as enhanced meat inspection and education could substantially reduce transmission, informing national efforts to eliminate taeniasis/cysticercosis by 2030.

## Recommendations

Based on the findings, the following evidence-based recommendations are proposed to mitigate *T. solium* transmission in Wukari LGA and similar endemic areas:

1. Strengthen Meat Inspection Protocols: Implement mandatory veterinary inspections at all abattoirs and slaughter slabs, including training for local inspectors on FAO/WHO/OIE guidelines to detect cysticerci more effectively (FAO/WHO/OIE, 2005).
2. Promote Community Education and Awareness: Launch targeted campaigns through local health centers and schools to educate residents on proper pork cooking (to  $\geq 71^{\circ}\text{C}$ ), hand hygiene, and the risks of open defecation, addressing the low awareness identified (11.7%) (WHO, 2022).
3. Improve Sanitation Infrastructure: Prioritize the construction of household latrines and regulated waste disposal systems in high-prevalence wards (e.g., Puje and Rafin Kada) to reduce environmental contamination, in collaboration with local government authorities.
4. Adopt Pig Management Practices: Encourage confined rearing systems for pigs to limit access to human feces, and pilot the TSOL18 recombinant vaccine in high-risk farms to interrupt the lifecycle (Yusuf *et al.*, 2025).
5. Integrate Surveillance under One Health: Establish joint human-animal health monitoring programs, aligned with Nigeria's NTD roadmap, including annual serological surveys and data sharing between veterinary and public health sectors (WHO, 2023).

These measures, if implemented collaboratively, could achieve a significant reduction in prevalence within 3–5 years, contributing to global NTD elimination goals.

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