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Toxoplasma gondii in small ruminants and assessment of attitude and practices of workers in slaughter facilities in Kaduna

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Abstract

Toxoplasmosis, caused by the protozoan parasite *Toxoplasma gondii*, is a significant zoonotic disease that often presents asymptomatically but can lead to severe complications in immunocompromised individuals. This study aimed to determine the seroprevalence of *T. gondii* infection in small ruminants and assess the attitudes and practices of slaughterhouse workers toward toxoplasmosis in Kaduna Metropolis, Nigeria. A total of 446 small ruminants, including 263 sheep and 183 goats, were sampled from six slaughter facilities. Blood samples were collected, and sera were analyzed for anti-Toxoplasma antibodies using an indirect ELISA. Demographic data such as species, age, sex, breed, and sampling location were recorded. Additionally, structured questionnaires were administered to 42 slaughterhouse workers to evaluate their attitudes and practices regarding *T. gondii* infection. The overall seroprevalence was 11.7%, with sheep showing a higher seroprevalence (13.3%) compared to goats (9.3%). There was no significant variation in seropositivity based on species, age, or sex, but significant differences were observed among goat breeds, with the highest prevalence in Red Sokoto goats (19.4%). Location-specific differences were also noted, with the highest prevalence in Unguwan Rimi (30.0%). The assessment of slaughterhouse workers revealed that 45.2% had fair attitudes, while 59.5% demonstrated poor practices concerning toxoplasmosis prevention. A significant positive correlation was found between attitudes and practices. These findings highlight the presence of *T. gondii* in small ruminants in Kaduna, posing potential health risks to consumers and slaughterhouse workers. Improved hygiene practices, proper cooking of meat, and educational interventions targeting slaughterhouse workers are recommended to mitigate infection risks and enhance public health safety.

Keywords: Kaduna, Seroprevalence, Slaughterhouse workers, Small ruminants, Toxoplasmosis, *Toxoplasma gondii*

Introduction

Toxoplasma gondii is a globally distributed zoonotic protozoan parasite, ranking fourth among food-borne parasites and posing significant public health risks (Hussain *et al.,* 2017; Aguirre *et al.,* 2019). Transmission to humans typically occurs through consumption of undercooked meat, contaminated water, or contact with infected cat faeces (Hussain *et al.,* 2017). While often asymptomatic, infection can lead to severe outcomes in immunocompromised individuals and pregnant women, including miscarriage, stillbirth, and neurological disorders in newborns (McAuley, 2014). In livestock, especially sheep and goats, *T. gondii* infection causes reproductive losses, primarily through vertical transmission during the acute infection phase (Schlüter *et al.,* 2014; Al-Malki, 2021).

Numerous studies have reported high *T. gondii* seroprevalence in small ruminants across continents, including South America, Europe, Asia, and Africa (Dubey, 2009; Ahmed *et al.,* 2016; Dong *et al.,* 2018; Tonouhewa *et al.,* 2017). Despite regional differences, the data consistently highlight significant infection rates, underscoring the zoonotic and economic importance of toxoplasmosis. In Africa, seroprevalence rates range from 8% to over 60% in small ruminants, depending on region and study design (Lahmar *et al.,* 2015; Tonouhewa *et al.,* 2017; Al-Kappany *et al.,* 2018).

In Nigeria, though the climate favours the survival of parasitic agents, data on toxoplasmosis in small ruminants remain limited. While several studies have documented human infections, especially among pregnant women, few have investigated livestock, despite their potential role in zoonotic transmission (Olusi *et al.,* 1996; Edward *et al.,* 2023). Notably, prior studies in parts of Northern Nigeria, such as Borno, Plateau, and Katsina states, have reported varying seroprevalence rates in small ruminants (Kamani *et al.,* 2010; Ishaku *et al.,* 2018), but no such data exist for Kaduna State.

This study aims to determine the seroprevalence *of T. gondii* in small ruminants at slaughter facilities in Kaduna Metropolis, identify associated risk factors, and assess the knowledge and practices of facility workers regarding toxoplasmosis.

Materials and Methods

Study area

This study was conducted in Kaduna Metropolis, which includes the Local Government Areas (LGAs) of Chikun, Igabi, Kaduna North, and Kaduna South. Kaduna is the capital of Kaduna State, located in the central part of Nigeria's North-West zone. According to the 2006 population census, the state's population is approximately 6,066,562, with an estimated population of 1,570,331 in the metropolis (FGN, 2006). The state is situated at latitude 10°30'N and longitude 07°21'E, covering an area of 48,473 km². It is part of the Northern Guinea Savannah and Sudan Savannah zones, with a daily temperature range of 15–36℃ and relative humidity ranging from 12% to 72%. The mean annual rainfall is 1,524 mm (Kayode & Ogunleye, 2008). The majority of the population is engaged in agriculture, with about 80% of people involved in livestock and crop farming (KDSG, 2008). The state's livestock population includes an estimated 832,000 sheep and 988,000 goats (Buhari *et al.,* 2020).

Study design

A cross-sectional study was conducted from August to December 2019 to assess the seroprevalence of *Toxoplasma gondii* infection in slaughtered sheep and goats in the study area. The animals originated mainly from village markets around Kaduna and neighboring states. Data on sex and breed were recorded for each animal, and age was estimated based on the eruption of permanent incisors. Sheep and goats under 1 year of age were classified as young, while those older than 1 year were considered adults (Zeder & Pilaar, 2010).

Sample size determination

Sheep

Sample size for sheep was calculated using the formula by Thrusfield & Christley (2018) with a previously reported seroprevalence of 21.92% (Osiyemi *et al.,* 1985). The formula used was:

$$n = \frac{1.96^2 \, Pexp \, (1-Pexp))}{d^2}$$

Where, n = sample size,

d = desired absolute precision of (5%),

Pexp = previous prevalence of 21.92% by Osiyemi *et al.* (1985).

Level of confidence= 95%.

$$N = \frac{1.96^2 \times 0.2192 \times 0.7808}{(0.05)^2}$$

N = 263

The calculated sample size for sheep was 263. The samples were proportionally distributed across six sample sites (Table 1).

Goats

For goats, the sample size was calculated using the same formula with a previously reported

seroprevalence of 13.88% (Osiyemi *et al*., 1985). The calculated sample size for goats was 183, which was proportionally distributed across the selected sample sites (Table 1).

Questionnaire sample size determination
The sample size for the questionnaire survey was determined using the formula by Lisa (2006) as below:

$$n = \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{ES} \right)^2$$

with an expected prevalence of 50%. The sample size was calculated as 42, which was proportionally distributed across the six sampling sites (Table 1).

Administration of structured questionnaire
A structured questionnaire was administered to 42 respondents across the six sample sites. Respondents were selected based on their willingness to participate. The questionnaire consisted of 20 closed-ended questions, including seven questions on demographic data, seven on attitudes, and six on practices related to the risk of contracting *T. gondii* infection from slaughtered small ruminants.

Sampling technique
The study involved two major abattoirs (Kawo and Zango Tudun Wada) and four out of seventeen registered slaughter slabs, which were selected using simple random sampling. The selected slaughter slabs included Hayin Rigasa (Igabi LGA), Unguwa Rimi (Kaduna North LGA), Sabon Tasha (Chikun LGA), and Kakuri (Kaduna South LGA). Each slaughter facility was visited for three consecutive days each week until the desired sample size was reached. A systematic sampling method was employed, where one in every two animals presented for slaughter was sampled.

Consent
Approval for the study was obtained from the slaughter facility workers' union, and informed consent was provided by all participants involved.

Blood collection
A total of 446 blood samples were collected, with 263 from sheep and 183 from goats. A 10 mL plain sample bottle was used to collect 5 mL of blood from the jugular vein after slaughter. Samples were labelled with codes indicating age, sex, breed, and species, and were transported on ice to the Parasitic Zoonoses Laboratory at Ahmadu Bello University, Zaria. Sera were separated by centrifugation and stored at -20℃ until analysis.

Serological testing for anti-toxoplasma antibodies
The indirect enzyme-linked immunosorbent assay (ID Screen® Toxoplasmosis Indirect Multispecies antibody test kit, ID.vet, Grabels, France) was used to detect anti-*T. gondii* antibodies in the sera according to the manufacturer's instructions.
Microtiter plates were coated with *T. gondii* antigens, and sera were added to the wells. A conjugate (horseradish peroxidase) was added after washing to form the antigen-antibody-conjugate complex. The resulting colour change, from blue to yellow upon the addition of a stop solution, was measured at 450 nm using a BioTek ELX 800 absorbent microplate reader (BioTek Instruments Inc., Vermont, USA). The

Table 1: Distribution of small ruminant samples and questionnaire respondents across six sampling sites in Kaduna Metropolis

Sampling Sites	Local Governments	Avg. daily slaughter (sheep)	Sheep Samples	Avg. daily slaughter (goats)	Goat samples	Avg. respondents	Questionnaire responses
Kawo	Kaduna North	25	38	25	26	12	8
Zango Tudun Wada	Kaduna South	40	60	40	42	14	9
Unguwan Rimi	Kaduna North	20	30	10	10	8	5
Hayin Rigasa	Igabi	40	60	20	21	10	6
Sabon Tasha	Chikun	10	15	40	42	10	6
Kakuri	Kaduna South	40	60	40	42	12	8
Total		175	263	175	183	66	42

Table 2: Demographic characteristics of animals sampled for *Toxoplasma gondii* antibodies at slaughter facilities within Kaduna Metropolis

Characteristic	Number	Frequency (%)
Species of animals		
Sheep	263	59.0
Goats	183	41.0
Total	446	100
Age		
Young	107	24.0
Adult	339	76.0
Total	446	100
Sex		
Male	132	29.6
Female	314	70.4
Total	446	100
Location		
Hayin Rigasa	79	17.7
Kakuri	98	22.0
Kawo	76	17.0
Sabon Tasha	56	12.6
Unguwan Rimi	39	8.7
Zango Tudun Wada	98	22.0
Total	446	100

percentage of positive samples was calculated based on optical density (OD) values.

Scoring of the questionnaire

The responses to attitude and practice-related questions were scored based on the method of Iyor (2005). Positive attitudes and correct practices received one point each, while negative or incorrect responses received zero. The scores were converted to percentages and categorized as follows: 0–39% (poor), 40–59% (fair), and 60–100% (good).

Data analysis

Data were analyzed using SPSS version 22. The Chi-square test was used to determine associations between the prevalence of *T. gondii* antibodies and risk factors such as species, age, sex, breed, and location. Statistical significance was set at $P \leq 0.05$.

Result

A total of 446 animals were sampled for the presence of *Toxoplasma gondii* antibodies. Among these, 183 (41.0%) were goats, and 263 (59.0%) were sheep. The sampled animals consisted of 132 (29.6%) males and 314 (70.4%) females, with 107 (24.0%) young and 339 (76.0%) adult animals. The sampling was conducted within various locations in Kaduna metropolis, including 79 (17.7%) from Hayin Rigasa, 98 (22.0%) from Kakuri, 76 (17.0%) from Kawo, 56 (12.6%) from Sabon Tasha, 39 (8.7%) from Unguwan Rimi, and 98 (22.0%) from Zango Tudun Wada (Table 2).

Out of the 446 samples tested, 52 were seropositive for *Toxoplasma gondii* antibodies, giving an overall seroprevalence of 11.7% (95% CI: 8.7%, 14.7%). The seroprevalence did not vary significantly (P = 0.394) between species, with 13.3% (95% CI: 9.2%, 17.4%) seropositive in sheep and 9.3% (95% CI: 5.1%, 13.5%) in goats (Table 3).

Among the 263 sheep tested, 35 were seropositive for *Toxoplasma gondii*, resulting in a seroprevalence of 13.3% (95% CI: 9.2%, 17.4%). There was no significant difference in seropositivity based on age (P = 0.144), with young sheep showing a prevalence of 7.7% compared to 15.2% in adults. Similarly, no significant difference was observed between sexes (P = 0.549), with males having a seroprevalence of 11.1% and females 13.9%.

By breed, Balami (18.4%) and Uda (17.6%) sheep had higher seroprevalence rates than Yankasa (11.1%), though this variation was not statistically significant (P = 0.353). Seroprevalence also did not vary significantly across sampling locations in Kaduna metropolis (P = 0.131), with the following rates recorded: Hayin Rigasa (6.9%), Kakuri (20.7%), Kawo (15.6%), Sabon Tasha (12.5%), Unguwan Rimi (10.7%), and Zango Tudun Wada (12.1%) (Table 4).

Table 3: Seroprevalence of *Toxoplasma gondii* infection in sheep and goats at slaughter facilities within Kaduna metropolis

Characteristics	Number tested	Number positive	Prevalence (%)	95% CI	P value
Species of animal					
Sheep	263	35	13.3	9.2-17.4	0.394
Goats	183	17	9.3	5.1-13.5	
Total	446	52	(52)11.7	-	

Table 4: Seroprevalence of *Toxoplasma gondii* infection in sheep based on age, sex, breed and location at slaughter facilities within Kaduna metropolis

Characteristics	Category	No. tested	No. positive	Prevalence (%)	95% CI	P value
Age	Young	65	5	7.7	1.2–14.2	0.144
	Adult	198	30	15.2	10.2–20.2	
	Total	263	35	13.3	—	
Sex	Male	54	6	11.1	2.7–19.5	0.549
	Female	209	29	13.9	9.2–18.6	
	Total	263	35	13.3	—	
Breed	Balami	49	9	18.4	7.6–29.2	0.353
	Uda	34	6	17.6	4.8–30.4	
	Yankasa	180	20	11.1	6.5–15.7	
	Total	263	37	47.1	18.9 – 77.3	
Location	Hayin Rigasa	60	4	6.7	0.4-13.4	0.131
	Kakuri	60	12	20.0	10.3-31.1	
	Kawo	38	7	18.4	5.0-26.2	
	Sabon Tasha	15	2	13.3	3.7-28.7	
	Unguwan Rimi	30	3	10.0	0.8-22.1	
	Zango Tudun Wada	60	7	11.7	3.7-20.4	
	Total	263	35	(35)13.3	-	

Table 5: Seroprevalence of *Toxoplasma gondii* infection in goats based on age at slaughter facilities within Kaduna metropolis

Characteristics	Number tested	Number positive	Prevalence (%)	95% CI	P value
Age					
Young	42	6	14.3	3.7-24.9	0.201
Adult	141	11	7.8	3.4-12.2	
Total	183	17	(17)9.3	-	

significantly across sampling locations in Kaduna.

Among the 183 goats tested, 17 were seropositive for *Toxoplasma gondii*, yielding a seroprevalence of 9.3% (95% CI: 5.1%, 13.5%). There was no significant difference (P = 0.549) between young (14.3%) and adult (7.8%) goats. However, seroprevalence differed significantly between sexes (P = 0.005), with higher rates in males (12.4%) than females (5.1%). A significant variation (P = 0.034) was also observed based on breed, with Red Sokoto goats having the highest prevalence (19.4%), followed by Kano Brown (7.7%), while no cases were detected in Sahel and West African Dwarf breeds. Additionally, there was a statistically significant difference in seroprevalence across locations (P = 0.000), with the highest rates in Unguwan Rimi (27.3%) and Zango Tudun Wada (17.5%), followed by Kawo (9.7%), Hayin Rigasa (9.5%), and Kakuri (5.0%), while no cases were detected in Sabon Tasha (Tables 5 and 6).

The demographic characteristics of the respondents working at small ruminant abattoirs/slaughter slabs within Kaduna metropolis are shown in Table 7. All respondents (100%) were male. Most workers were aged between 20 and 29 years (47.6%), with 9.5% being over 40 years. A majority (59.5%) were married, and 33.3% were smokers. Educationally, most workers (42.9%) attended secondary school, while 7.1% had no formal education.

Table 6: Seroprevalence of *Toxoplasma gondii* infection in goats based on sex, breed, and location at slaughter facilities within Kaduna metropolis

Characteristics	Category	No. Tested	No. Positive	Prevalence (%)	95% CI	P value
Sex	Male	105	13	12.4	6.1–18.7	0.090
	Female	78	4	5.1	0.2–10.0	
	Total	183	17	9.3	—	
Breed	Kano Brown	143	11	7.7	3.3–12.1	0.034*
	Red Sokoto	31	6	19.4	5.5–33.3	
	Sahel Breed	6	0	0.0	0.0–0.0	
	West African Dwarf	3	0	0.0	0.0–0.0	
	Total	183	17	9.3	—	
Location	Hayin Rigasa	21	2	9.5	3.0–22.0	0.000*
	Kakuri	42	2	4.8	1.8–23.1	
	Kawo	26	3	11.5	0.7–20.1	
	Sabon Tasha	42	0	0.0	0.0–0.0	
	Unguwan Rimi	10	3	30.0	1.0–53.6	
	Zango Tudun Wada	42	7	16.7	5.7–29.3	
	Total	183	17	9.3	—	

Table 7: Demographic characteristics of respondents involved with specific duties in small ruminants' slaughter facilities within Kaduna metropolis

Demographic data	Number	Frequency (%)
Sex		
Male	42	100
Female	0	0.0
Age		
< 20 years	5	11.9
20-29 years	20	47.6
30-39 years	13	31.0
≥ 40 years	4	9.5
Marital status		
Single	17	40.5
Married	25	59.5
Smoking status		
Smoke	14	33.3
Do not smoke	28	66.7
Educational background		
None	3	7.1
Primary	17	40.5
Secondary	18	42.9
Tertiary	4	9.5
Specific duty		
Slaughterers	6	14.3
Eviscerators	12	28.6
Meat sellers	24	57.1
Working experience		
< 1 year	0	0.0
1-5 Years	10	23.8
> 5 years	32	76.2

The workers were primarily involved in selling meat (57.1%), followed by evisceration (28.6%) and slaughtering (14.3%). The majority (76.2%) had more than five years of experience in the field.

The responses regarding the attitude of abattoir workers toward the risk of *Toxoplasma gondii* infection are presented in Table 8. A large proportion (71.4%) of workers believed that using gloves when

Table 8: Responses of slaughter facilities' workers on attitude towards the risk of *Toxoplasma gondii* infection within Kaduna metropolis

Attitude	Number	Frequency (%)
Do you think it's safe to use gloves when handling raw meat?		
Yes	30	71.4
No	12	28.6
Do you think it's proper to wash your hands with soap and water after contact with raw meat?		
Yes	39	92.9
No	3	7.1
Do you feel it is safe to eat or drink while carcass processing?		
Yes	16	38.1
No	26	61.9
Do you think eating the flesh of sheep or goat meat can be a threat to your health?		
Yes	10	23.8
No	32	76.2
Do you feel it is safe to keep cats at slaughter houses?		
Yes	20	47.7
No	22	52.3
Do you think it is safe to feed the market cat with meat and offal?		
Yes	35	83.3
No	7	16.7
If you were ill, would you admit working at an abattoir to the health officer?		
Yes	33	78.6
No	9	21.4

handling raw meat was safe, and 92.9% believed it was important to wash hands with soap and water after contact with raw meat. However, only 23.8% thought that sheep and goat meat could pose a threat to their health, and 47.7% felt it was safe to keep cats at slaughterhouses. A majority (83.3%) thought it was safe to feed market cats with meat and offal.

The practices of abattoir workers regarding the risk of *Toxoplasma gondii* infection are shown in Table 9.

Most workers (85.7%) sourced their water from boreholes, but none of the workers used gloves or facemasks when handling meat or washing knives. Three respondents (7.1%) had been injured by knives while working.

The categorization of respondents' attitudes and practices revealed that the majority had fair attitudes (45.2%) but poor practices (59.5%). None of the respondents exhibited good practices (0.0%), while a minority demonstrated good attitudes (40.5%). A positive Pearson's correlation of 0.612 was found between attitudes and practices, which was statistically significant ($p< 0.05$) (Table 10).

Discussion

This study aimed to determine the seroprevalence of *Toxoplasma gondii* infection in small ruminants and assess the attitudes and practices of slaughterhouse workers toward toxoplasmosis in Kaduna state, Nigeria. Our findings revealed an overall seroprevalence of 11.7%, with sheep showing prevalence of 13.3% and goats, 9.3%. Although sheep had a higher seroprevalence than goats, the difference was not statistically significant. This suggests that species may not have been a determining factor for *T. gondii* infection in this study population. However, the overall prevalence observed in Kaduna is in line with findings from other regions, where *T. gondii* seropositivity in small ruminants has been linked to factors such as environmental exposure, management practices, and geographical variations. For example, research in northeastern Colombia reported a higher seroprevalence (23.5%), with sheep having a notably higher prevalence than goats (Martínez-Rodriguez *et al*., 2020). Similarly, studies from Ethiopia (Tilahun *et al.,* 2018) and South Africa (Masombuka *et al.,* 2024) also found higher *T. gondii* prevalence in sheep than in goats, supporting the hypothesis that sheep might be more susceptible to infection due to their feeding habits and higher exposure to oocysts in the environment. These findings suggest that breed and feeding behaviours could be significant factors

Table 9: Responses of abattoir/slaughter slab workers on practices towards risk of *Toxoplasma gondii* infection within Kaduna Metropolis

Practice items	Number	Frequency (%)
Is well water your source of water?		
Yes	6	14.3
No	36	85.7
Is borehole water your source of water?		
Yes	36	85.7
No	6	14.3
Do you handle raw sheep or goat meat with your naked hands?		
Yes	42	100
No	0	0.0
Do you use a facemask while working?		
Yes	0	0.0
No	42	100
Do you wash the knife with soap and water after use on a particular animal?		
Yes	0	0.0
No	42	100
Have you been injured with a knife while working?		
Yes	3	7.1
No	39	92.9

Table 10: Categorization and correlation of attitude and practices of respondents

Score	Category	Attitude	Practice	Rho
0-39	Poor	6(14.3%)	25(59.5%)	0.612*
40-59	Fair	19(45.2%)	17(40.5%)	
60-100	Good	17(40.5%)	0(0.0%)	

contributing to *T. gondii* prevalence, with certain ruminant species potentially at higher risk of acquiring the parasite. Conversely, a study from Borno State, Nigeria, reported a lower seroprevalence of 6.7% in sheep and 4.6% in goats (Kamani et al., 2010), highlighting the considerable variation in *T. gondii* infection rates even within Nigeria. This difference may reflect local variations in management practices, climate conditions, and the presence of definitive hosts (e.g., cats) in the environment. The relatively lower prevalence observed in Borno may also be attributed to differences in farming systems, with a higher focus on extensive grazing systems in this part of northern Nigeria compared to more intensively managed farms in other parts. These findings emphasized the importance of considering local environmental and farming practices when assessing the risk of *T. gondii* transmission.

The global variation in *T. gondii* prevalence in small ruminants was further emphasized by studies from the Caribbean. Research conducted in Dominica, Grenada, and Montserrat reported significantly higher seroprevalence rates, ranging from 48% to 89% in sheep and goats (Hamilton *et al*., 2014). These rates are considerably higher than the 13.3% observed in sheep in our study. The difference could be attributed to different ecological factors, including higher cat populations, more extensive free-range systems, and greater contact with contaminated water sources in the Caribbean. In contrast, the lower prevalence in our study may reflect a relatively lower risk of environmental contamination with oocysts, which could be influenced by the more urbanized setting of Kaduna Metropolis compared to the rural areas of the Caribbean.

Further comparison with findings from Europe offers valuable insights. In Northern Italy, a study found a much higher seroprevalence in sheep (59.3%) compared to goats (41.7%) (Gazzonis *et al.,* 2015). Similarly, studies in Romania reported a higher prevalence of T. gondii in adult sheep (61.1%) compared to lambs (26.4%) (Paștiu *et al.,* 2023). These findings suggest that farm management practices, such as grazing patterns and feed strategies, may influence the spread of *T. gondii*. Although our study showed a higher seroprevalence in sheep compared to goats, this difference was not statistically significant, indicating that species-specific susceptibility may not be a major factor in this

population. Nonetheless, other studies have reported variations between species, which may reflect differences in management and environmental exposure. Therefore, while our results do not support a significant species effect, tailored control measures that consider farm practices and potential exposure risks in both sheep and goats remain important for reducing infection.

In this study, breed-specific differences were also noted, with Red Sokoto goats showing the highest seroprevalence (19.4%). This finding mirrors a report from Borno State, where environmental factors and breed characteristics influenced *T. gondii* infection rates. Research from other parts of Africa also shows that indigenous goat breeds, such as the Red Sokoto, are often more exposed to environmental contaminants due to their extensive grazing habits (Tilahun *et al.,* 2018). It is likely that local variations in grazing systems and farm management practices contribute significantly to the differences observed in prevalence between goat breeds. Further studies exploring the impact of breed characteristics and management practices on infection risk are warranted.

The attitudes and practices of slaughterhouse workers in Kaduna Metropolis revealed critical gaps in knowledge and hygiene practices. A significant portion of workers (45.2%) had fair attitudes toward *T. gondii* prevention, while 59.5% exhibited poor practices, such as inadequate personal protective equipment (PPE) use and improper handling of meat. These results are of serious concern, as improper handling of meat is a well-established risk factor for zoonotic transmission of *T. gondii* (Feng *et al.,* 2017). Similar findings were reported in the Caribbean, where a study highlighted the risks associated with undercooked meat consumption and lack of awareness among workers (Hamilton *et al*., 2014). Our results emphasize the need for targeted interventions to improve the knowledge and hygiene practices of slaughterhouse workers. Educational programs focused on safe meat handling, proper PPE use, and awareness of zoonotic risks could significantly reduce the chances of *T. gondii* transmission to humans.

The positive correlation observed between attitudes and practices suggests that enhancing the knowledge base of workers could directly improve their practices. This is in line with studies from other regions that have shown the effectiveness of training and awareness campaigns in improving food safety practices and reducing the risk of zoonotic infections (Masombuka *et al*., 2024). Moreover, considering the lack of proper cooking practices, public health campaigns encouraging consumers to cook meat thoroughly and adopt better hygiene practices could further reduce the risk of infection.

In conclusion, this study provides important insights into the seroprevalence of *T. gondii* in small ruminants in Kaduna Metropolis and the associated risk factors for both animals and humans. While the seroprevalence rates in Kaduna are lower than those observed in other parts of the world, the significant findings in sheep and certain goat breeds emphasise the need for targeted control measures. Farm management practices, particularly those involving grazing and breed selection, should be optimized to minimize the risk of *T. gondii* exposure. Furthermore, the poor hygiene practices observed among slaughterhouse workers highlight the urgent need for educational interventions aimed at improving both the awareness and the food safety practices of individuals involved in meat handling. In light of these findings, further research into the molecular characterization of *T. gondii* strains, as well as an investigation of environmental factors influencing transmission dynamics, is necessary to design more effective control strategies. Ultimately, an integrated approach involving improved animal management, public health education, and consumer awareness will be key to reducing the burden of *T. gondii* infection in both animals and humans.

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