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Serological Evidence of Exposure to *Toxoplasma gondii* Infection Among Pregnant Women Attending Antenatal Care in Jos, Plateau State, Nigeria

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Abstract

Background: Toxoplasmosis, caused by *Toxoplasma gondii*, is an important parasitic infection of public health concern, particularly during pregnancy due to the risk of congenital transmission. This study investigated the seroprevalence and associated risk factors of *T. gondii* infection among pregnant women in Jos, Plateau State, Nigeria.

Methods: A hospital-based cross-sectional study was conducted among 270 pregnant women attending antenatal clinics at two tertiary healthcare facilities in Jos, Plateau State, Nigeria. Participants were recruited using a systematic sampling approach. Serum samples were screened for anti-*T. gondii* IgG and IgM antibodies using a lateral flow immunochromatographic rapid diagnostic test kit. Sociodemographic characteristics and potential exposure factors were obtained using a structured questionnaire. Associations between explanatory variables and seropositivity were initially assessed using univariate analysis (Pearson's chi-square or Fisher's exact test). Variables with $p < 0.20$ were included in a multivariate logistic regression model to identify independent predictors of infection. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported.

Results: Overall, 90 participants tested positive for *T. gondii* antibodies, giving a seroprevalence of 33.3% (95% CI: 26.5–40.7). Among seropositive individuals, 60.0% had IgG antibodies, indicating past exposure, while 30.0% had IgM antibodies, suggestive of recent infection. In univariate analysis, age group, educational level, awareness of toxoplasmosis, contact with cats, cleaning cat feces, farming activities, certain obstetric history, and stage of pregnancy were associated with seropositivity ($p < 0.20$) and were included in the multivariate model. In multivariate logistic regression analysis, contact with cats (AOR ≈ 2.84; 95% CI: 1.45–5.32; $p = 0.002$) and engagement in farming activities (AOR ≈ 2.01; 95% CI: 1.08–3.92; $p = 0.031$) remained significant independent predictors of *T. gondii* infection.

Conclusion: The findings demonstrate a moderate level of exposure to *T. gondii* among pregnant women in Jos, Plateau State, Nigeria. Contact with cats and farming-related activities were identified as important risk factors. Targeted health education, improved hygiene practices, and preventive strategies during pregnancy are recommended to reduce the risk of toxoplasmosis and its potential consequences for maternal and fetal health.

Keywords: Toxoplasmosis; *Toxoplasma gondii*; seroprevalence; pregnant women; Nigeria.

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Introduction

Toxoplasma gondii is an obligate intracellular protozoan parasite that infects a wide range of warm-blooded animals, including humans and several bird species Bigna et al., 2020; Pappas et al., 2009; Sánchez-Sánchez & Besteiro, 2021. Members of the family *Felidae*, particularly domestic cats, serve as the definitive hosts and play a critical role in the environmental dissemination of infective oocysts Ag-

mas et al., 2015. Human infection commonly occurs through ingestion of tissue cysts in undercooked meat, consumption of food or water contaminated with oocysts, or transplacental transmission from mother to fetus during primary infection in pregnancy Paquet & Yudin, 2013.

Toxoplasmosis remains an important public health concern worldwide, particularly among pregnant women due to the risk of congenital toxoplasmosis. Maternal infection during pregnancy may result in miscarriage, stillbirth, neurological abnormalities, chorioretinitis, or long-term neurodevelopmental impairment in the fetus. The severity of fetal infection depends largely on the gestational age at which maternal infection occurs Fenta, 2019.

Globally, the seroprevalence of *T. gondii* varies widely, ranging from less than 10% to over 90%, depending on environmental conditions, socioeconomic factors, dietary habits, and cultural practices. In sub-Saharan Africa, environmental exposure to contaminated soil, close contact with animals, and poor food hygiene practices contribute significantly to transmission risk Iddawela et al., 2017.

In Nigeria, several studies have reported varying seroprevalence rates among pregnant women, reflecting regional differences in exposure risk. Previous studies conducted in Plateau State have reported seroprevalence rates ranging from approximately 11.7% to 46.2%. However, updated epidemiological data remain limited, particularly with regard to risk factors associated with infection among pregnant women attending tertiary health facilities in Jos Akubuilo et al., 2020.

Understanding the current seroprevalence and associated risk factors is essential for informing preventive strategies and maternal health interventions. Therefore, this study aimed to determine the seroprevalence of *Toxoplasma gondii* antibodies and identify potential risk factors among pregnant women attending antenatal clinics in Jos, Plateau State, Nigeria.

Methods

Study Design and Setting

A hospital-based cross-sectional study was conducted between March and September 2023 to determine the serological evidence of exposure to *Toxoplasma gondii* infection among pregnant women in Jos, Plateau State, Nigeria. The study was carried out at Bingham University Teaching Hospital and Jos University Teaching Hospital, which serve as major referral centres for maternal healthcare and receive a large and diverse population of antenatal attendees from both urban and peri-urban communities.

Study Area

The study was conducted in Jos, Plateau State, a major urban centre in North-central Nigeria. Plateau State is characterized by a mixture of urban and agricultural communities where crop farming, livestock keeping, and close human–animal interactions are common. Unlike most regions within Nigeria's tropical zone, Plateau State experiences a relatively cooler climate with average temperatures ranging between 18 °C and 22 °C Iloeje, 2001. This climatic condition supports various agricultural and livestock activities and may favour the persistence of environmentally resistant stages of parasites, including *T. gondii* oocysts in soil and water Karshima et al., 2020; Okojokwu et al., 2021. The warmest period occurs between March and April, while the coolest months are typically between December and February due to the harmattan season.

Study Population

The study population comprised pregnant women attending antenatal clinics at the selected tertiary healthcare facilities during the study period.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Boards of Bingham University Teaching Hospital (Ref No: NHREC/21/05/2005/01051) and Jos University Teaching Hospital (Ref No: JUTH/DCS/IREC/127/XXXI/574) prior to the commencement of the study. The study was conducted in accordance with established national and international ethical guidelines for research involving human participants. Written informed consent was obtained from all participants after explaining the purpose, procedures, and potential benefits of the study. Participation was voluntary, and confidentiality and anonymity were strictly maintained.

Sample Size Determination

The sample size was determined using the single population proportion formula:

$$n = \frac{Z^2 pq}{d^2}$$

as described by Thrusfield (2007), where n is the required sample size, Z is the standard normal deviate at 95% confidence level (1.96), p is the estimated prevalence of *T. gondii* infection (11.7%) based on a previous study Okojokwu et al., 2021, $q = 1 - p$, and d is the desired precision (0.05). The calculated sample size was 300. However, a total of 270 participants were eventually enrolled due to non-response, refusal, eligibility restrictions, and time constraints. Despite this, the achieved sample size was considered sufficient to estimate seroprevalence within the desired confidence level.

Sampling Technique and Data Collection

Participants were recruited using a systematic random sampling technique. Each clinic day served as the sampling frame, and eligible participants were selected at regular intervals based on estimated daily antenatal attendance after obtaining informed consent.

Approximately 2 mL of venous blood was aseptically collected from each participant using sterile vacutainers. Samples were labelled and transported on ice to the laboratory at the Federal College of Animal Health and Production Technology, National Veterinary Research Institute, Vom. Serum was separated by centrifugation at 3000 rpm for 10 minutes and stored at −20 °C until analysis.

A structured interviewer-administered questionnaire was used to collect data on sociodemographic characteristics, obstetric history, environmental exposures, and behavioural risk factors. The instrument was adapted from previous studies and pretested among pregnant women in a similar setting to ensure clarity and reliability.

Serological Analysis

Serological testing was performed using a lateral flow immunochromatographic rapid diagnostic test kit (Aria *T. gondii* IgM/IgG Combo Rapid Test Kit, CTK Biotech, California, USA) following the manufacturer's instructions. The test qualitatively detects anti-*T. gondii* IgM and IgG antibodies in human serum, with reported sensitivity and specificity exceeding 95%.

One drop of serum was added to the sample well, followed by assay buffer. Results were interpreted within the recommended time. The appearance of a control line indicated test validity. IgM positivity (T1 line) suggested recent exposure, while IgG positivity (T2 line) indicated past exposure. The presence of both lines indicated combined reactivity. Invalid tests were repeated. However, confirmatory tests such as IgG avidity or molecular assays were not performed; therefore, IgM positivity was interpreted with caution.

Data Analysis

Data were analysed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize participant characteristics, and seroprevalence was calculated with 95% confidence intervals. Associations between independent variables and seropositivity were assessed using Pearson's chi-square or Fisher's exact test, with crude odds ratios (ORs) and 95% confidence intervals reported.

Variables with $p < 0.20$ were included in a multivariate logistic regression model to identify independent predictors while controlling for confounding. Multicollinearity was assessed prior to model fitting. Adjusted odds ratios (AORs) with 95% confidence intervals were reported. Model adequacy was evaluated using the Akaike Information Criterion (AIC), and statistical significance was set at $p < 0.05$.

Results

A total of 270 serum samples were collected from pregnant women attending antenatal clinics in two tertiary hospitals in Plateau State, Nigeria. Participants were engaged in different occupations, including farming (12.0%), civil service (21.0%), and business/trading (35.0%), while the remaining participants were involved in other occupations.

Serological analysis using a lateral flow immunochromatographic rapid test detected antibodies to *Toxoplasma gondii* in 90 of the 270 women, giving an overall seroprevalence of 33.3% (95% CI: 26.5–40.7) (Table 1). Among the seropositive individuals, 55.6% had IgG antibodies, 26.7% had IgM

Table 1: Overall Seroprevalence of *Toxoplasma gondii* Antibodies Among Pregnant Women Attending Antenatal Clinics in Jos, Plateau State, Nigeria ($n = 270$)

No. Examined	No. Positive	Prevalence (%)	95% CI
270	90	33.3	26.5–40.7

Note: CI = Confidence interval.

antibodies, and 17.7% had both IgG and IgM antibodies., indicating a mixture of past and recent infections (Figure 1).

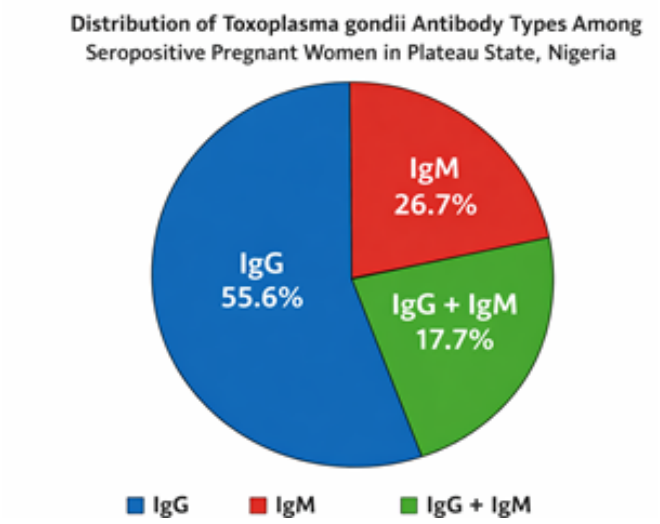

Figure 1: Distribution of *Toxoplasma gondii* Antibody Types (IgG, IgM and IgG/IgM Co-positivity) Among Seropositive Pregnant Women in Plateau State, Nigeria

Sociodemographic Factors Associated with *T. gondii* Seropositivity

The distribution of *T. gondii* seropositivity according to age, location, and educational level is presented in Table 2. Seroprevalence differed significantly across age groups ($\chi^2 = 8.53$, $p = 0.014$). Women aged ≥41 years showed the highest prevalence (50.0%), followed by those aged 20–30 years (37.9%), while women aged 31–40 years had the lowest prevalence (21.4%). However, the ≥41-year age group included only 12 participants, and the relatively high prevalence should therefore be interpreted with caution.

Seroprevalence did not differ significantly by place of residence ($\chi^2 = 1.44$, $p = 0.488$), although women residing in Jos East had a slightly higher prevalence (40.0%) compared with Jos North (34.8%) and Jos South (29.4%).

Educational level was significantly associated with seropositivity ($\chi^2 = 7.38, p = 0.025$). Women with primary education had the highest prevalence (50.0%), compared with those with secondary education (37.5%) and tertiary education (28.3%). It should be noted that the primary education category consisted of a small subgroup ($n = 12$), which may affect the stability of the estimate.

Environmental and Behavioural Risk Factors

Environmental and behavioural exposures potentially associated with infection are summarized in Table 3. Seroprevalence did not vary significantly with awareness of toxoplasmosis (Fisher's exact test, $p = 0.085$) or source of drinking water ($\chi^2 = 3.81, p = 0.430$).

However, several exposure variables showed statistically significant associations with *T. gondii* infection. Women who worked on farms or gardens had significantly higher seroprevalence (38.7%) compared with those who did not (21.4%) ($\chi^2 = 8.82$, $p = 0.003$). Similarly, contact with cats was strongly associated with infection ($\chi^2 = 11.76$, $p = 0.001$), with exposed participants having a significantly higher likelihood of seropositivity.

Cleaning of cat feces was also associated with infection (Fisher's exact test, $p = 0.021$). However, some categories included very small subgroup counts with zero or very high prevalence, and these findings should therefore be interpreted with caution.

Obstetric Characteristics and Stage of Pregnancy

The association between *T. gondii* seropositivity and obstetric history, as well as gestational stage, is presented in Table 4. Although women with a history of abortion showed higher seroprevalence (50.0%) compared with those with live birth at term history (32.4%) or stillbirth (25.0%), the difference was not statistically significant ($\chi^2 = 3.84$,

$p = 0.147$).

Similarly, seroprevalence did not differ significantly across gestational stages ($\chi^2 = 3.97$, $p = 0.136$), although the third trimester showed the highest prevalence (44.4%) compared with the first trimester (31.8%) and second trimester (28.6%).

Multivariate Logistic Regression Analysis

Variables with $p < 0.20$ in the univariate analysis were included in a multivariate logistic regression model to identify independent predictors of *T. gondii* seropositivity. As shown in Table 5, contact with cats (Adjusted OR = 2.84; 95% CI: 1.45–5.32; $p = 0.002$) and engagement in farming activities (Adjusted OR = 2.01; 95% CI: 1.08–3.92; $p = 0.031$) remained significant independent predictors of infection.

In contrast, age group, educational level, and stage of pregnancy were not independently associated with seropositivity after adjusting for confounding variables.

Discussion

This study assessed the seroprevalence of *Toxoplasma gondii* infection and associated risk factors among pregnant women attending antenatal clinics in Plateau State, Nigeria. The overall seroprevalence of 33.3% indicates that a substantial proportion of pregnant women in the study area have been exposed to the parasite, highlighting the public health relevance of toxoplasmosis due to its potential consequences for maternal and fetal health Deji-Agboola et al., 2011.

The prevalence observed in this study is comparable to reports from other regions, including Lagos, Nigeria (32.8%), Tanzania (30.8%), Sokoto, Nigeria (27.7%), and Sri Lanka (29.9%) Alayende et al., 2013; Iddawela et al., 2017; Nwachukwu et al., 2023. However, higher prevalence has been reported in some African settings such as Ethiopia Fenta, 2019. Within Plateau State, previous studies have documented prevalence estimates ranging from 11.7% to 46.2% Akubuilo et al., 2020; Nwachukwu et al., 2023; Okojokwu et al., 2021, suggesting variability across populations. Such differences may reflect variations in environmental conditions, sanitation practices, dietary habits, exposure to animals, and the diagnostic methods used Hamaichat, 2020. Climatic factors that favour the survival of *T. gondii* oocysts in the environment may also influence transmission patterns Bigna et al., 2020.

Age-related differences in seroprevalence were observed in the univariate analysis, with women aged ≥41 years showing the highest prevalence, which may reflect cumulative exposure over time. Similar observations have been reported in several epidemiological studies where increasing age was associated with higher seropositivity Avelar et al., 2017; Mizani et al., 2017. However, age was not independently associated with infection in the multivariate model, suggesting that the observed association may be influenced by underlying behavioural or environmental exposures.

A decreasing trend in seropositivity with increasing educational level was observed, with the highest prevalence among women with lower educational attainment. Education may influence awareness of disease prevention, hygienic practices, and food safety behaviours that reduce exposure to infection Ait Hamou & Laboudi, 2021; Moura et al., 2016. Nevertheless, educational level was not an independent predictor in the multivariate model, suggesting that its effect may operate indirectly through behavioural factors rather than acting as a direct determinant of infection risk. Similar patterns have been reported in other studies where education showed an association in crude analyses but not after adjustment for environmental exposures Hamaichat, 2020.

Contact with cats and involvement in farming or gardening activities were identified as independent predictors of infection in the multivariate analysis. Cats are the definitive hosts of *T. gondii* and shed oocysts in their feces, which can contaminate soil, water, and food sources. Consequently, direct or indirect contact with cats or contaminated soil increases the likelihood of infection Dubey et al., 2021; Teweldemedhin et al., 2019. These findings are consistent with previous epidemiological studies that identified cat exposure and soil contact as major environmental risk factors for toxoplasmosis Akubuilo et al., 2020; Okojokwu et al., 2021. However, some studies have reported no significant association between cat ownership and infection, suggesting that differences in cat management practices, environmental contamination, and hygiene behaviours may influence the strength of

Table 2: Association Between Sociodemographic Characteristics and *Toxoplasma gondii* Seropositivity Among Pregnant Women ($n = 270$)

		Seropositivity				
Variable	**Category**	**Examined**	**Positive n (%)**	**Crude OR**	**95% CI**	**p-value**
Age (years)	20–30	174	66 (37.9)	1.00	–	
	31–40	84	18 (21.4)	0.44	0.24–0.74	0.014
	≥41	12	6 (50.0)	1.63	0.49–5.43	
Location	Jos North	138	48 (34.8)	1.00	–	
	Jos South	102	30 (29.4)	0.78	0.44–1.37	0.488
	Jos East	30	12 (40.0)	1.25	0.55–2.87	
Educational level	Primary	12	6 (50.0)	1.00	–	
	Secondary	144	54 (37.5)	1.68	0.97–2.91	0.025
	Tertiary	114	30 (28.3)	2.80	0.82–9.59	

Note: OR = Odds ratio; CI = Confidence interval. Reference categories are shown as OR = 1.00.

Table 3: Environmental and Behavioural Risk Factors Associated with *Toxoplasma gondii* Infection Among Pregnant Women ($n = 270$)

		Seropositivity				
Variable	**Category**	**Examined**	**Positive n (%)**	**Crude OR**	**95% CI**	**p-value**
Awareness	Yes	6	0 (0.0)	–	–	0.085
	No	264	90 (34.1)	–	–	
Contact with cats	Yes	96	18 (18.8)	1.00	–	0.001
	No	174	72 (41.4)	3.06	1.69–5.54	
Cleaning of cat faeces	No	43	0 (0.0)	–	–	0.001
	Yes	131	72 (55.0)	–	–	
Source of drinking water	Packaged water	114	24 (21.1)	1.00	–	
	Well water	54	18 (33.3)	1.87	0.91–3.82	0.430
	Pipe water	60	30 (50.0)	3.77	1.92–7.40	
	Others	42	18 (42.9)	2.79	1.31–5.94	
Working in farms	No	84	18 (21.4)	1.00	–	0.003
	Yes	186	72 (38.7)	2.32	1.27–4.22	

Note: OR = Odds ratio; CI = Confidence interval. Fisher's exact test was used where appropriate due to small cell counts. Reference categories are indicated as OR = 1.00.

this relationship Chandrasena et al., 2016; Nguefack et al., 2016; Tegegne et al., 2016.

The detection of IgM antibodies in 30% of seropositive individuals may suggest recent infection; however, IgM antibodies may persist for prolonged periods and can occasionally produce false-positive results due to cross-reactivity or assay limitations. Therefore, IgM positivity alone cannot reliably distinguish recent from past infection without confirmatory tests such as IgG avidity testing or molecular diagnostics. The absence of confirmatory testing in this study should therefore be considered when interpreting the IgM findings.

Several variables, including source of drinking

Table 4: Association Between Obstetric History, Gestational Stage and *Toxoplasma gondii* Seropositivity Among Pregnant Women ($n = 270$)

		Seropositivity				
Variable	**Category**	**Examined**	**Positive n (%)**	**Crude OR**	**95% CI**	**p-value**
Obstetric history	live birth	222	72 (32.4)	1.00	–	
	Abortion	24	12 (50.0)	2.08	0.90–4.81	0.147
	Stillbirth	24	6 (25.0)	0.69	0.26–1.83	
Stage of pregnancy	1st trimester	132	42 (31.8)	1.00	–	
	2nd trimester	84	24 (28.6)	0.86	0.47–1.57	0.136
	3rd trimester	54	24 (44.4)	1.72	0.89–3.32	

Note: OR = Odds ratio; CI = Confidence interval. Reference categories are indicated as OR = 1.00.

Table 5: Multivariate Logistic Regression Analysis of Factors Associated with *Toxoplasma gondii* Seropositivity Among Pregnant Women ($n = 270$)

Variable	**Adjusted OR**	**95% CI**	**p-value**
Contact with cats	2.84	1.45–5.32	0.002*
Working on farms	2.01	1.08–3.92	0.031*
Educational level	1.42	0.82–2.45	0.221
Age group	0.76	0.51–1.20	0.221
Stage of pregnancy	1.36	0.82–2.27	0.147

Note: OR = Odds ratio; CI = Confidence interval. *Statistically significant at $p < 0.05$.

water, awareness of toxoplasmosis, certain obstetric history, and stage of pregnancy, were not significantly associated with infection. This may indicate limited influence of these factors in this population or may reflect limited statistical power for some subgroup analyses.

This study has several limitations. The hospital-based design may limit the generalizability of the findings to the broader population of pregnant women, as participants attending tertiary hospitals may differ from those receiving care in other settings. In addition, the cross-sectional nature of the study prevents causal inference between potential risk factors and infection. The use of a rapid immunochromatographic test without confirmatory assays such as ELISA, IgG avidity testing, or PCR may also affect diagnostic accuracy, particularly for IgM-positive samples. Furthermore, some subgroup analyses involved small sample sizes, which may produce unstable estimates. Important exposures such as dietary habits and seasonal variation in transmission were also not assessed.

Despite these limitations, the study provides valuable insight into the burden of *T. gondii* infection among pregnant women in Plateau State and identifies key environmental exposures associated with infection. Strengthening public health education on hygienic practices, safe food handling, and avoidance of contact with contaminated soil or cat feces during pregnancy may help reduce the risk of infection.

Conclusion

This study indicates a substantial level of exposure to *Toxoplasma gondii* among pregnant women attending antenatal clinics in Jos, Plateau State. Environmental and behavioural factors, particularly soil-related activities and contact with cats, appear to contribute significantly to infection risk. In resource-constrained antenatal care settings, strengthening health education and promoting risk-reduction practices are essential. Further community-based studies using more robust diag-

nostic methods are recommended to better define the burden of infection and guide appropriate public health interventions.

What is Known About This Topic

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Funding

The authors received no specific funding for this study.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

The study was conducted in collaboration with all authors. IBS, AA, and KNS conceived and designed the study. IBS, MRI, NZ, MH, AR, EJ, AM, JS, MAA, OG, and DAA developed the data collection tools and were actively involved in field data and sample collection. WR, OG, MPO, FJL, and MO conducted the laboratory analyses, statistical analysis, and interpretation of results. The first draft of the manuscript was prepared by IBS, MRI, AM, OOD, and FJL. AA, KNS, MRI, AMH, and DLN critically reviewed the manuscript. All authors contributed to manuscript revision, read, and approved the final version for publication.

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