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Seroprevalence and Risk Factors of Toxoplasmosis Among Pregnant Women Attending Antenatal Clinic in Uyo Nigeria

[1]Nseobong Godwin Akpan, [2]Edidiong Nse Ekanem, [3]Anthony John Umoyen, [1]Ubong Ekwerenam Etang, [1]Robinson Dodoru Tuemi and [1,4]Anietie Effiong Moses

[1]Institute for Biomedical Research and Innovations, College of Health Sciences, University of Uyo, Uyo, Nigeria
[2]Centre for Wetlands and Waste Management Studies, Faculty of Agriculture, University of Uyo, Uyo, Nigeria
[3]Department of Biological Sciences, Faculty of Science, Taraba State University, Jalingo, Nigeria
[4]Department of Medical Microbiology and Parasitology, Faculty of Basic Clinical Sciences, University of Uyo, Uyo, Nigeria

ABSTRACT

Background and Objective: Toxoplasmosis is caused by *Toxoplasma gondii* and can result in foetal and neonatal death or various congenital defects in pregnancy. This study aimed to determine the prevalence and risk factors associated with *Toxoplasma gondii* infections in pregnant women attending antenatal clinics at the University of Uyo Health Center, Uyo, Nigeria. **Materials and Methods:** This was a cross-sectional study using 150 pregnant women after obtaining their informed consent. Detection of anti-*T. gondii* antibodies were conducted using Toxo IgG/IgM Rapid test kits. A structured questionnaire was administered to the participants to collect information on socio-demographic and risk factors associated with the infection. **Results:** The seroprevalence of *T. gondii* infection among the pregnant women was 77 (51.3%), which comprised 41.3% positivity for anti-*T. gondii* IgG (62/150), 6.7% for IgM (10/150) and 3.3% (5/150) for IgG plus IgM. A significant association was observed between seroprevalence and women residing area with an odd ratio of 0.186-1.36. Individuals having a cat as a pet was 55 (36.7%), while individuals with a cat in their neighbourhood were 62 (41.3%) with an odd ratio of 2.63. Pregnant women in their first trimester had the highest anti-*T. gondii* IgG of 30 (48:4%) and IgM was the lowest (6:60%). **Conclusion:** The seroprevalence of *Toxoplasma gondii* was relatively high in this study. Thus, health education and sensitisation on the disease and its transmission to women of childbearing age among pregnant women should be encouraged during antenatal follow-up, to reduce the risk of *T. gondii* infection during pregnancy.

KEYWORDS

Seroprevalence, *Toxoplasma gondii*, toxoplasmosis, risk factors, antenatal women

INTRODUCTION

Toxoplasmosis is a parasitic infection caused by a protozoan named, *Toxoplasma gondii*[1,2]. It was estimated by researchers that one-third of the earth's population is infected by toxoplasmosis, especially in underdeveloped and developing countries[3-6]. The disease is acquired via consumption of raw or undercooked meat (pork, chicken, lamb, shellfishes like oysters, bi-valve, mussels, etc.) containing tissue

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cysts, direct contact with infected cat litters, food or water contaminated with oocysts, unpasteurized milk from infected cow or goat and soil containing cat faeces[5,6]. Congenital infections through the placenta can lead to serious complications in infants such as hydrocephaly, mental retardation and chorioretinitis[4,6]. The incidence rate of congenital toxoplasmosis was 400-4000 cases per year as reported in Zaria, Nigeria among antenatal women[7]. The prevalence of *Toxoplasma gondii* in child-bearing age women has been reported from various parts of the world such as Brazil 63.03%[8], Colombia 45.8%[9], Saudi Arabia 24.1%[10] and 34.1% in Sudan[11]. The pprevalence of toxoplasmosis was 80% among pregnant women and new deliveries in Cameroon[6]. The prevalence of toxoplasmosis varies greatly among African countries[12-15] and the least prevalence was documented in Zambia with 0.6%[15] while the highest was among Ghanaians with 92.5%[3]. The seroprevalence of human toxoplasmosis in a different geopolitical zones in Nigeria was documented with North West having 32%, North East (22%), North Central (24%) and South West (37%)[14]. The only known definitive host for *Toxoplasma gondii* are members of the family *Felidae* (domestic cats and their relatives)[2].

The disease can be passed from cats to humans through direct contact with faeces of infected cats. Cats most often become carriers of toxoplasmosis by eating infected prey[2]. Once the cat is infected, the parasite multiplies in its small intestine into immature eggs called oocysts, which are shed in millions alongside its faeces. Infected cats can shed oocysts for up to two weeks after initial infection[2,16]. These Oocysts could be picked by chickens, goats and cows during grazing and man gets infected by ingesting meat or dairy products from an infected animal[2]. *Toxoplasma gondii* has been found in the kidney, bladder and intestine of infected humans[17]. Oocysts shed in the faeces of infected cats on soil, water and bedding of animals and others may survive and infect humans, especially during pregnancy[18]. Hence, worldwide prevalence of *Toxoplasma gondii* is high in humid tropical areas and low in hot and dry areas. Nigeria being a tropical country has a climate that enhances the survival of parasitic agents of some infectious diseases[19]. Also, among other factors, its socio-economic status has enhanced the rate and distribution of most neglected tropical diseases[1,7,19-21]. This parasitic infection is one of the neglected tropical diseases out of five parasitic infections according to the USA Centres for Disease Control[22]. The other four neglected zoonotic parasitic infections in the tropics are *Treponema pallidum*, cytomegalovirus, herpes viruses and rubella[22].

In healthy individuals, *T. gondii* causes asymptomatic infection featured by the re-occuring of the parasitic protozoan mainly in the brain, heart tissues and skeletal muscle, with no clinical signs presentation, although some healthy individuals who become exposed to *T. gondii* may not be infected because the immune system keeps the parasite from causing the illness[23]. However, individuals with weakened immune systems, like HIV subjects, diabetic patients and pregnant women may be prone to serious infections, resulting to illness and have hospitalization[10,22]. In pregnant women, when disease diagnosis and treatment are delayed, it might lead to spontaneous abortion, stillbirth/preterm deliveries; as well as unavoidable and irreversible foetal damages[24]. Toxoplasmosis routine screening exercise among women of childbearing age is crucial to early diagnosis and detection of this infection and subsequently may assist in treatment/regimen to eradicate any damage this may cause to both the mother and the foetus[1,24]. This practice is essential in developing countries but this has not been introduced among the routine tests for pregnant women attending antenatal clinic facilities in Akwa Ibom State, Nigeria.

It is imperative that studies on seroprevalence of *T. gondii* infection, knowledge of the parasite, transmission route, treatments and preventions are necessary in our health facilities. There is paucity of data on toxoplasmosis infections among pregnant women in Uyo, Akwa Ibom State, to the best of knowledge.

Therefore, this study seeks to determine the seroprevalence of *T. gondii* infection and its risk factors among pregnant women attending antenatal clinic (ANC) at the University of Uyo Health Centre, Uyo. This will provide baseline information on toxoplasmosis as well as associated risk factors in the study area.

MATERIALS AND METHODS

Study design and area: A cross-sectional study was used for this research. Akwa Ibom State is located in South-South geo-political zone of Nigeria, bordering on the East of Cross River State, on the West of River State and Abia State and on the South by Atlantic Ocean. The state was estimated to have a population of 7.6 million people spread across 31 Local Government Areas (LGAs) with an annual growth rate of 3.4 (National Population Commission)[25]. The major economic activities in the region include business, agriculture (vegetables and fruits production), livestock farming and tourism. The study duration was from May, 2021 to December, 2022.

Ethical approval: Ethical approval was sought and obtained from the University of Uyo Health Ethics Committee prior to the commencement of sample collection (reference number UU/HREC/VOL 2/001 with NHREC registration number: NHREC/09/02/2022). The data collected was analysed anonymously to maintain confidentiality and protocols strictly adhered to.

Study population: A total of 150 pregnant women were recruited for this study. It consisted of all the consented pregnant women aged 19 to 54 years who attended antenatal care and those pregnant women who registered for the first time at the health centre. The purpose of the study was explained to participants and written consent was obtained. Those who declined to participate were excluded from the study. A well-structured questionnaire was administered to participants to collect information on demographic data, toxoplasmosis risk factors, pet ownership, eating of undercooked meat and awareness of the parasite, its transmission, treatment and prevention, gestational period (trimester), reproductive history (miscarriage, neonatal death, premature birth, stillbirth). The subject's local language/dialect was used to extract information from participants and their responses were recorded by ticking the appropriate boxes in the questionnaire. The subject's local language/dialect was used to extract information from participants and their responses were recorded by ticking the appropriate boxes in the questionnaire.

Sample collection and laboratory analysis: Five milliliters of venous blood were obtained from recruited participants (150 pregnant women) by qualified medical personnel. All blood samples were obtained by venepuncture under standard universal precautions. The blood samples taken were centrifuged for 5 min, serum was separated and stored at -20°C. The serum was used for screening of anti-*Toxoplasma gondii* IgG and IgM using Toxo IgG/IgM Rapid test kits (Biopanda Reagents, United Kingdom).

Statistical analysis: All statistical analysis was performed using SPSS for windows version 20.0. Relationship between antibodies seroprevalence of *Toxoplasma gondii* was determined by Pearson Chi-square Test. The Chi-square Test was carried out to determine the relationship between socio-demographic variables with respect to *T. gondii* and frequency of infections and sex, age range, religion, occupation and level of schooling; while significance level was set at 5%.

RESULTS

The distribution of socio-demographic information of participants in this study was shown in Table 1. The pregnant women were aged 17 to 55 years with a mean age of 33.2±9.9 years. Most of the pregnant women were within the age group 25-34 years, 52 (34.6%), while the age group 55-64 was the least 1(0.7%). The majority of the antenatal attendees have tertiary education 75 (50.0%), while the least have primary education 6 (4.0%). On the occupational status majority were unemployed, 62 (41.3%), while 50 (33.3%) and 35 (23.3%) were business owners and civil servants, respectively. Sixty-five (43.3%) of the participant kept cats as pets while those with the habit of eating undercooked meat were 47 (31.3%). Participants with the highest gestational age were those in the 1st trimester 76 (50.7%), while the least were in the 2nd trimester, 32 (21.3%) as shown in Table 1.

Table 1: Distribution of socio-demographic information of the participants

Characteristics	Frequency	Percentage
Age groups (years)		
15-24	32	21.3
25-34	52	34.6
35-44	45	30.0
45-54	20	13.3
55-64	1	0.7
Educational status		
Elementary	6	4.0
Secondary	46	30.0
Tertiary	75	50.0
None	23	15.3
Occupational status		
Civil servant	35	23.3
Business owner	50	33.3
Unemployed	62	41.3
Retired	3	2.0
Occupational status of husband		
Civil servant	65	43.3
Business owner	70	46.7
Unemployed	15	10.0
Cat ownership		
Yes	65	43.3
No	85	56.7
Eating uncooked meat		
Yes	47	31.3
No	103	68.7
Gestational age		
1st trimester	76	50.7
2nd trimester	32	21.3
3rd trimester	42	28.0
Parity/number of pregnancy		
0	33	22.0
1	36	24.0

A total of 33 (18.0%) miscarriages were recorded among the pregnant women in this study. In term of parity/number of pregnancy, 45 (30.0%) attendees had the highest in parity number of 2, while the least number of parity (4) was observed in 10 (6.7%) attendees. The distributions of some possible risk factors associated with toxoplasmosis among participants were shown in Table 2. Borehole was discovered to be the major source of drinking water for the participants with 51.3% (77) and might be a possible risk factor for having toxoplasmosis, while 40 (26.7%) of the participants had blood transfusion in their life time. Most of the participants eat unwashed fruit/vegetables (84, 56.0%). Out of 150 participants, only 3 (2.0%) had knowledge of toxoplasmosis while 38 (25.3%) participants were involved in chicken rearing. Frequency of meat slaughtering was highest among those that slaughter meat weekly (55, 36.7%). Thirty-nine (26.0%) of participants in out-door farming/gardening, while those that used bare hands to work in the farm were 30 (20.0%). Majority of the participants had cats in their neighbourhood (88, 58.7%) while most of the participants (61, 40.7%) lived in the urban areas as shown in Table 2.

The distribution of *T. gondii* specific IgG and IgM antibodies among the participants were displayed on Table 3. The results revealed that 62 (41.3%) of samples tested were sero-positive (+) for anti-*T. gondii* IgG and IgM sero-negative (-) antibodies, 10 (6.7%) for IgG sero-negative (-) and sero-positive (+) IgM antibodies and 5 (3.3%) were sero-positve (+) for both anti-*T. gondii* IgG and IgM. The overall sero-prevalence in this study was 77 (51.3%) (Table 3). History of miscarriages was observed in 25 individuals (16.7%) for IgG positive samples, while 8 (5.3%) was observed in samples that tested

Table 2: Possible risk factors associated with toxoplasmosis among the subjects studied

Variables	Frequency	Percentage
Source of drinking water		
Stream	6	4.0
Borehole	77	51.3
Potable water	28	18.7
Borehole/potable water	39	26.0
Blood transfusion		
Yes	40	26.7
No	10	73.3
History of miscarriages		
Yes	33	22.0
No	117	78.0
Eating of unwashed fruits/vegetables		
Yes	84	56.0
No	66	44.0
Income margins (monthly in naira)		
10,000-20,000	11	7.3
20,000-40,000	27	18.0
40,000-70,000	30	20.0
70,000-100,000	38	25.3
Above 100,000	44	29.3
Knowledge of toxoplasmosis		
Yes	3	2.0
No	147	98.0
Chicken rearing		
Yes	38	25.3
No	112	74.7
Meat slaughtering frequency		
Daily	13	8.7
Weekly	55	36.7
Monthly		22.0
None	60	40.0
Worked in the abattoir		
Yes	15	10.0
No	135	90.0
Engaging in outdoor farming/gardening		
Yes	39	26.0
No	111	74.0
Use of bare hands to work in the farm		
Yes	30	20.0
No	120	80.0
Presence of cat in the neighbourhood		
Yes	88	58.7
No	62	41.3
Residential area		
Urban	61	40.7
Semi-urban	54	36.0
Rural	35	23.3

Table 3: Distribution of anti-*T. gondii* specific IgG and IgM antibodies among pregnant women

Serology results	Frequency	Percentage
IgG (+) and IgM(+)	5	3.33
IgG (+) and IgM(-)	62	41.33
IgG (-) and IgM(+)	10	6.70
Total prevalence	77	51.33

IgG (+): Immunoglobulin G sero-positive antibody, IgM (+): Immunoglobulin M sero-positive antibody, IgM (-): Immunoglobulin M sero-negative antibody and IgG (-): Immunoglobulin G sero-negative antibody

Table 4: Distribution of anti-*T. gondii* specific IgG and IgM antibodies based on age and gestational periods of the pregnant women

Age groups	No. of tested	IgG (%)	IgM (%)	IgG+/IgM+(%)	Total	OR (95% CI)	χ^2	p-value
15-24	32	7 (11.29)	1 (10.00)	0 (0.00)	7 (4.66)	1	3.71	0.45
25-34	52	21 (33.87)	5 (50.00)	1 (20.0)	27 (18.00)	0.16 (0.02-1.70)		
35-44	45	27 (43.54)	3 (30.00)	4 (80.0)	34 (22.66)	0.71 (0.07-7.03)		
45-54	20	7 (11.29)	1 (10.00)	0 (0.00)	8 (5.33)	0.29 (0.03-2.88)		
55-64	1	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.09 (0.005-1.59		
Total	150	62 (41.33)	10 (6.66)	5 (3.33)	77 (51.33)			
Gestational period								
1st trimester	76	30 (48.4)	6 (60.0)	2 (40.0)	38 (49.4)	1	9.66	0.008
2nd trimester	32	11 (17.7)	3 (30.0)	1 (20.0)	15 (19.5)	0.33 (0.07-1.64)		
3rd trimester	42	21 (33.9)	1 (10.0)	2 (40.0)	24 (31.2)	0.59 (0.11-3.55)		
Total	150	62 (41.3)	10 (6.7)	5 (3.3)	77 (51.3)			

IgG: Immunoglobulin G, IgM: Immunoglobulin M, IgG+: Immunoglobulin G sero-positive antibody, IgM+: Immunoglobulin M sero-positive antibody, OR: Odd ratio, CI: Confidence interval and χ^2: Chi-square Test

Table 5: Distribution of anti-*T. gondii* specific IgG and IgM antibodies according to educational status and occupation of the pregnant women

Educational status	Sero-positivity (IgG+IgM) (%)	Sero-negativity (%)	χ^2	p-value
Primary	2 (2.59)	7 (9.59)	4.05	0.26
Secondary	40 (51.94)	20 (27.40)		
Tertiary	15 (19.48)	33 (45.21)		
None	20 (25.97)	13 (17.81)		
Occupation				
Civil servant	25 (32.47)	15 (20.55)	1.36	0.56
Business owner	20 (25.97)	10 (13.70)		
Unemployed	32 (41.55)	45 (61.64)		
Retired	0 (0.00)	3 (4.11)		
Total	77 (100.00)	73 (100.00)		

IgG: Immunoglobulin G, IgM: Immunoglobulin M and χ^2: Chi-square test

negative to IgG. The distribution of anti-*T. gondii* specific IgG and IgM antibodies based on age and gestational period of the pregnant women were indicated in Table 4. Age group 35-44 years had the highest occurrence of IgG 27 (43.5%), followed by age group 25-34 years with 21 (33.9%). The IgM antibodies, age group 25-34 years had the highest 5 (50%), followed by age group 35-44 years and 3 (30%). Only 5 (3.3%) participants tested positive for IgG and IgM antibodies was the highest 4 (80%) among age group 35-44 years. First trimester had the highest occurrence of IgG 30 (48.4%), while the least 11 (17.7%) occurred in second trimester. For IgM antibodies, first trimester had the highest sero-positivity 6 (60%), followed by second trimester 3 (30.0%). The IgG and IgM antibodies, both first and third trimesters had similar occurrence of 2 (40%), while second trimester had the least 1 (20%). The measure of association showed that there was statistical significant association ($p = 0.008$) between the trimesters and *Toxoplasma gondii* positivity.

The distribution of anti-*T. gondii* sero-positivity based on educational status and occupation of pregnant women was indicated in Table 5. Participants with secondary school education had the highest sero-positivity 40 (51.9%), while the least was observed among those with primary education 2 (2.6%). Unemployed participants had the highest sero-positivity 32 (41.6), followed by business owners 25 (32.5%). The measure via chi-square between the two variables and toxoplasma positivity was statistically not significant ($p>0.05$).

The sero-positivity and risk factors associated with *T. gondii* infection among pregnant women were displayed in Table 6. Out of 65 attendees as cats owners, 55 (36.7%) tested positive for *T. gondii* antibodies and there was statistically significant relationship ($\chi^2 = 63.3$, $p<0.001$ and odds ratio of the cat owner to be toxoplasmosis positive was 29.28 times of the participants that has no cat as pet with other variables).

Table 6: Multivariate and bivariate analysis between sero-positive and risk factors among pregnant women

Risk factors	No. of pregnant women	Sero-positive (IgG+IgM)	OR (95% CI)	χ^2	p-value
Cat ownership					
Yes	65	55 (36.7)	29.28 (6.07-141.26)*	63.3	0.001
No	85	22 (14.7)	1		
Under cooked meat					
Yes	47	32 (21.3)	2.75 (0.51-8.40)	13.42	0.001
No	103	45 (30.0)	1		
Drinking water source					
Stream	6	5 (3.3)	-	9.3	0.01
Borehole	77	38 (25.3)	1		
Portable water	28	20 (13.3)	0.28 (0.04-1.99)		
Tap	39	14 (9.3)	1.39 (0.03-58.41)		
History of blood transfusion					
Yes	40	39 (26.0)	0.68 (0.15-3.16)	46.54	0.001
No	110	38 (25.3)	1		
Eating of unwashed fruits and vegetables					
Yes	84	40 (26.7)	2.29 (0.52-10.16)	21.03	0.001
No	66	37 (24.7)	1		
Chicken rearers					
Yes	38	36 (25.3)	0.22 (0.02-1.88)	38.77	0.001
No	112	41 (27.3)	1		
Meat slaughtering frequency					
Daily	13	10 (6.7)	1	35.48	0.001
Weekly	55	39 (26.0)	0.03 (0.002-0.33)*		
Monthly	22	15 (10.0)	0.08 (0.003-2.08)		
None	60	13 (8.7)	-		
Abattoir worker					
Yes	15	10 (6.7)	0.88 (0.13-5.78)	1.57	0.210
No	135	67 (44.7)	1		
Outdoor farmers					
Yes	39	28 (18.7)	1.32 (0.14-12.13)	8.83	0.003
No	111	49 (32.7)	1		
Use of bare hands to work in the farm					
Yes	30	16 (10.7)	3.82 (0.41-35.53)	0.06	0.806
No	120	61 (40.7)	1		
Presence of cat in neighbourhood					
Yes	88	62 (41.3)	2.63 (0.57-12.12)	31.16	0.001
No	62	15 (10.0)	1		
Residential area					
Urban	61	19 (12.7)	1	22.64	0.001
Semi-urban	54	30 (20.0)	0.186 (0.02-1.55)		
Rural	35	28 (18.7)	1.36 (0.26-7.08)		

IgG: Immunoglobulin G, IgM: Immunoglobulin M, OR-Odds ratio and CI: Confidence Interval

Also, 21.3% (32) were sero-positive with the habit of eating undercooked meat and there was significant association statistically (χ^2 = 13.42, p = 0.001 and odd ratio = 2.075). Regarding sources of drinking water, it was observed that most of the attendee's source of drinking water was borehole with sero-positivity to the antibodies in 38 cases (25.3%) and there was significant relationship statistically (χ^2 = 10.83 and p = 0.013). Only 40 out of the 150 participants had blood transfusion and 39 (26.0%) of them tested positive to *T. gondii* antibodies and was statistically significant relationship (odd ratio = 73.9, χ^2 = 46.54 and p = 0.01). This suggests generally that most persons with history of blood transfusion may likely test positive compared to those without it. In this present study, 40 (26.7%) sero-positive out of 84 attendees with the habit of eating unwashed fruits/vegetables was recorded and there was no statistical association between the variables (χ^2 = 0.884 and p= 0.347). Twenty eight (18.7%) out of 39 participants were sero-positive to *T. gondii* antibodies with outdoor farmers.

DISCUSSION

This present study detected an overall seroprevalence of 51.3% for anti-*T. gondii* specific IgG and IgM among pregnant women in Uyo, Nigeria. *Toxoplasma gondii* infection was detected among HIV subjects[26]. This present study detected an overall seroprevalence of 51.3% for anti-*T. gondii* specific IgG and IgM among pregnant women in Uyo, Nigeria. This finding was similar to 52% reported in Kisumu, Kenya[27] and 51.79% at maternal and child health clinic in Mojadihu City, Somalia[28]. However, seroprevalence in this study was lower than 65.6% published among pregnant women at the University of Port Harcourt Teaching Hospital, Nigeria[24], 79.3% among AIDS subjects in South Ethiopia at the antenatal clinic of Arba Minch[26] and 80% using two health facilities in Yaounde, Cameroon[6], not agreed with current findings in Uyo, Nigeria. On the other hand, the seroprevalence in this study was higher than 27.2%, 45% and 32.3% reported at an antenatal clinic in Rivers State, Nigeria[29], at Kilimanjaro Christian Medical Centre, Northern Tanzania[30] and in selected health facilities in Jos Plateau State, North Central Nigeria[1] among pregnant women, respectively. The reason for the high prevalence of *T. gondii* infection in this study could be due to the wet and hot climate associated with *T. gondii* oocyst survival documented[31]. Also, the variations of the seroprevalence of toxoplasmosis among pregnant women in different locations may be attributed to some environmental factors, eating habits and lack of awareness of the disease transmission as earlier reported by Afonso *et al.*[31]. The *T. gondii* antibodies detected among the pregnant women in this study suggested that exposure of women to *T. gondii* infection before or after gestation is detrimental to human health.

The prevalence of IgG anti-*T. gondii* antibodies in this study were 41.3% corroborated with 42.4% and 44.10% reported in Port Harcourt, Nigeria[24] and Jos University Teaching Hospital (JUTH)[14], but was higher than 30.7% reported in Tanzania[30]. Also, the result was lower than 55.9%[32] and 92.5%[16] documented both in Ghana and in Ethiopia 68%[33] and 72.7% in Cameroon[6] among women of childbearing age. The seroprevalence variations of anti-*T. gondii* IgG antibodies among pregnant women could be attributed to climatic conditions such as rainfall, temperature, soil type, dry climate, altitude and other factors like rearing of cats, educational level, hygienic practices and feeding habits[31,34,35]. In addition, differences in the seroprevalence may be due to serological methods used and the sensitivity difference in such methods[34,35].

The presence of IgM among participants in this study indicates recent host infections. Immunoglobulin M and immunoglobulin G antibodies can linger for numerous months or years during acute toxoplasmosis as previously documented[35]. The concurrent presence of Immunoglobulin M (IgM) and Immunoglobulin G (IgG) antibodies is not always a conclusive pointer to acute toxoplasmosis, therefore it is imperative to unveil antibody kinetics using a serological controls system for at least 2-3 weeks[35]. Sometimes, the serological examination might not be completely successful during the active period of *T. gondii* infections due to low antibody titre values, making congenital toxoplasmosis in foetus undetected in high-risk condition because of mothers testing negative (active phase of *T. gondii* infections during pregnancy)[36]. In this study, the detection of *T. gondii*-specific IgM was 6.7%. This finding is higher than the 5% recorded in South-South Nigeria[29]. In contrast, our present finding was lower than 11.5% recorded in Rivers State, Nigeria[24]. Acute infection with the risk of congenital transmission and subsequent complications in unborn children was documented by Berredjem *et al.*[37], but in over study, it was detected among pregnant women. Toxoplasmosis in this study may be due to the reactivation of latent infection as indicated by a higher prevalence of IgG than IgM toxoplasma antibodies and supported by Wokem *et al.*[29].

The level of knowledge or awareness of toxoplasmosis among pregnant women in Uyo, Akwa Ibom was very low (2.0%) and several subjects had not heard of toxoplasmosis, even when the majority of the subjects had tertiary education and lived in urban areas (50.0 and 40.7%, respectively). This is consistent with other researchers in which between 96.6-98% of women had no knowledge about toxoplasmosis[8,24,38]. This may increase the risk of acquiring this infectious disease and other zoonotic diseases. However, the low knowledge in this study varies with the moderate awareness of Nigerians (53%) on toxoplasmosis. The

overall exposure to toxoplasmosis risk factors was 64%, consisting of 53% residents from North West Nigeria, 54% in North East Nigeria, 62% in North Central Nigeria, 23% from South West Nigeria, 39% in South East Nigeria and 52% in South-South Nigeria were exposure to toxoplasmosis risk factors and were significant statistically to difference in their geopolitical zone of residence[39].

The participants age between 25-34 years was recruited more in this study (52, 34.6%) but the age group between 35-44 years recorded the highest seropositivity to toxoplasma antibody. Age group in relation to seropositvity showed no significant difference statistically in the rate of infection. This is similar to reported research with the age range 30-35 years having highest infection rate among pregnant women in Almadinah, Almunuawara, Saudi Arabia[40]. In contrast, in Ethiopia[41] and Ibadan, Western Nigeria[42], it was reported that the age group between 25-29 years had the highest seropositivity to *T. gondii*. The variation in the rate of seropositivity among this age groups in different populations may be due to the number of pregnant women attending antenatal clinic at a particular environment and time of the study, differences in behavioural attributes and eating habits of younger pregnant women compared to the older pregnant women and these circumstances may have exposed them to some risk factors associated with toxoplasmosis in child gearing age[14].

The screening of toxoplasmosis in pregnancy by the clinician may help to detect seroconversion individuals and provide early treatment[43]. In this present study, the pregnant women in their first trimester had the highest *T. gondii* seroprevalence of 50.7% and there was an association between trimesters and positive toxoplasma antibodies. The highest seroprevalence (82.1%) of *T. gondii* among pregnant women in their first trimester was also documented by Yohanes *et al*.[41], supporting current findings. In contrast, a highest infection rate of toxoplasmosis was detected among Northern Tanzania pregnant women in their third trimester[30]. The variation may arise as a result of a number of subjects in their first trimester that visited the clinic at the time of sample collection. It may also be attributed to congenital toxoplasmosis being one of the most significant burdens of *T. gondii* infection in pregnant women.

Majority of the pregnant women have the habit of eating roasted meat that may not be properly cooked. These meats are mostly eaten during celebrations, restaurants, etc. Thus leading to the risk of ingesting parasite oocysts from infected meat. Women with high levels of education are more likely to consume meat than others with low levels of education due to their income level. These may have exposed them to *T. gondii* infection[44]. In this study, 21.3% of the participants ate uncooked meat and was significantly associated with *T. gondii* seropositivity ($p = 0.001$ and OR = 2.075). The rate of *T. gondii* infection was 2.075 times more likely to occur in those eating raw meat than those who did not raw meat. These findings corroborate with previously documented research from North-West Ethiopia[45] and South Ethiopia[41]. In contrast, some studies reported absence of association between *T. gondii* infection and consumption of raw meat in South-Western Ethiopia[33] and Turkey[46]. The variation difference may be due to the types of meat consumed and the rate of infection in the animals found in those countries.

The correlation between toxoplasmosis and domestic animals has been previously published by scientists[41,47]. Oocystsof *T. gondii* from infected domestic animals has been reported to transfer it to humans through their faeces[42]. Cats excrete millions of oocysts within a short period of time and play a major role in transmitting *T. gondi*[47]. Possession of infested cats will expose human to oocysts of *T. gondii* in their faeces[42]. Cats excrete millions of oocysts within a short period of time and play a major role in transmitting *T. gondi* [47]. In this study, there was a statistically significant association between cat ownership and positive *T. gondii* with other variables. These results were in disagreement with the findings observed by previous researchers in Saudi Arabia[48], Tobago[49] and Turkey[46] in which there was no significant association between cat ownership and positive *T. gondii*. Differences in the type of cat as well as the infection rate in cats may be due to the variation in the different study locations[41]. Other predictors of *Toxoplasma gondii* infection among pregnant women in this present study were unwashed fruits/vegetables, chicken rearers and sources of drinking water and were significantly association with

T. gondii sero-positivity. These findings are in agreement with the work conducted in Central Ethiopia[50] and Western Nigeria[51] in which there was a significant association between unwashed fruits/vegetables and *T. gondii* infection among pregnant women. The notable similarity in this finding may be due to the feeding habits and hygienic practices of the studied population as earlier reported[41].

Studies indicated that blood transfusion is one means of transmitting *T. gondii* infection as reported by Afonso *et al*.[31]. In this study, 40 (26.7%) of the participants had a previous history of blood transfusion and 26.0% of participants were *T. gondii* sero-positive. The 26.0% observed in this study was lower than 79.6% reported in southern Ethiopia among pregnant women[41]. In contrast, current results were higher than the 6.2% reported in Ibadan, Southwestern Nigeria[42]. Transfusion of toxoplasmosis through blood transfusion in this study and other populations may be possible if the donor has currently been infected by this parasitic protozoan called *T. gondii* during blood collection. The examination of blood for *T. gondii* antibodies is not routinely done in antenatals hospitals in Nigeria. Other researchers reported toxoplasmosis acquired during pregnancy may result congenital toxoplasmosis[52-54]. Additionally, risk factors for *T. gondii* infection included outdoor farming[55] and contaminated environment with oocysts was previously published[56]. Regular hand washing habits after contact with soil can minimise the risk of oocyst contamination[31].

The seroprevalence and risk factors of *T. gondii* have been established in Uyo among pregnant women based on the findings of this study. The following are recommendations:

- Sero-prevalence of congenital toxoplasmosis should be conducted in Uyo, Nigeria
- Sero-prevalence of toxoplasmosis among pregnant women in another part of Akwa Ibom, Nigeria using a larger sample size should be investigated

CONCLUSION

The overall seroprevalence of *T. gondii* (51.3%) in this study was established among pregnant women visiting the University of Uyo Health Center, Nigeria. Educational level, outdoor gardening, blood transfusion and consumption of uncooked meat were identified as possible risk factors associated with toxoplasmosis. Other behavioural risk factors were eating unwashed fruits/vegetables and drinking untreated water which did not show a significant association with seroprevalence of *T. gondii*. However, follow-up studies on IgM antibody status among pregnant women and their babies are vital because they are possible indicators of recent infection or exposure to toxoplasmosis.

SIGNIFICANCE STATEMENT

Seroprevalence of *T. gondii* infection, transmission route, treatments and preventions are necessary in antenatal health facilities. There is a dearth of information on toxoplasmosis among pregnant women in Uyo, Akwa Ibom State. This study revealed a relatively high sero-prevalence of toxoplasmosis and majority of subjects were positive for anti-*Toxoplasma gondii* Immunoglobulin G (IgG). There was a significant association between sero-prevalence of *T. gondii* infection and women residing in semi-urban areas. Thus, health education, sensitisation and its transmission should be encouraged during the antenatal clinic to reduce the risk of toxoplasmosis. This finding could aid health providers to create awareness and be useful in planning/implementation of *Toxoplasma gondii* comprehensive diagnosis, prevention and control strategies by relevant public health agencies.

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REFERENCES

1. Okojokwu, O., E. Nwachukwu, M. Ali and Y. Agabi, 2023. Seroprevalence of anti-toxoplasma IgG and IgM among pregnant women attending antenatal clinic in Jos-North, Plateau State, Nigeria. Microb. Infect. Dis., 4: 285-295.
2. Dubey, J.P., 2009. Toxoplasmosis of Animals and Humans. 2nd Edn., CRC Press, Boca Raton, Florida, ISBN: 9780429092954, Pages: 336.
3. Mose, J.M., J.M. Kagira, D.M. Kamau, N.W. Maina, M. Ngotho and S.M. Karanja, 2020. A review on the present advances on studies of toxoplasmosis in Eastern Africa. BioMed Res. Int., Vol. 2020. 10.1155/2020/7135268.
4. Robert-Gangneux, F. and M.L. Darde, 2012. Epidemiology of and diagnostic strategies for toxoplasmosis. Clin. Microbiol. Rev., 25: 264-296.
5. Moncada, P.A. and J.G. Montoya, 2012. Toxoplasmosis in the fetus and newborn: An update on prevalence, diagnosis and treatment. Expert Rev. Anti-Infect. Ther., 10: 815-828.
6. Ayeah, J.N., A. Oladokun, I.U.N. Sumbele, A.O. Ilesanmi and O.N. Bekindaka, 2022. Seroprevalence of gestational and neonatal toxoplasmosis as well as risk factors in Yaoundé, Cameroon. J. Parasitol. Res., Vol. 2022. 10.1155/2022/6406259.
7. Ishaku, B.S., I. Ajogi, J.U. Umoh, I. Lawal and A.J. Randawa, 2009. Seroprevalence and risk factors for *Toxoplasma gondii* infection among antenatal women in Zaria, Nigeria. Res. J. Med. Med. Sci., 4: 483-488.
8. da Silva, M.G., M.C. Vinaud and A.M. de Castro, 2015. Prevalence of toxoplasmosis in pregnant women and vertical transmission of *Toxoplasma gondii* in patients from basic units of health from Gurupi, Tocantins, Brazil, from 2012 to 2014. PLoS ONE, Vol. 10. 10.1371/journal.pone.0141700.
9. Rosso, F., J.S. Remington, G.A. Tunubala, J.A. Chaves and A. Agudelo *et al*., 2008. Prevalence of infection with *Toxoplasma gondii* among pregnant women in Cali, Colombia, South America. Am. J. Trop. Med. Hyg., 78: 504-508.
10. Aqeely, H., E.K. El-Gayar, D.P. Khan, A. Najmi and A. Alvi *et al*., 2014. Seroepidemiology of *Toxoplasma gondii* amongst pregnant women in Jazan Province, Saudi Arabia. J. Trop. Med. 10.1155/2014/913950.
11. Elnahas, A., A.S. Gerais, M.I. Elbashir, E.S. Eldien and I. Adam, 2003. Toxoplasmosis in pregnant Sudanese women. Saudi Med. J., 24: 868-870.
12. Negash, T., G. Tilahun and G. Medhin, 2008. Seroprevalence of *Toxoplasma gondii* in Nazaret Town, Ethiopia. East Afr. J. Public Health, 5: 211-214.
13. Pappas, G., N. Roussos and M.E. Falagas, 2009. Toxoplasmosis snapshots: Global status of *Toxoplasma gondii* seroprevalence and implications for pregnancy and congenital toxoplasmosis. Int. J. Parasitol., 39: 1385-1394.
14. Dawet, A., K. Yusuf, C.H. Golnaan, E.T. Lengnen, M.N. Buhari and D.P. Yakubu, 2022. Sero-prevalence of *Toxoplasma gondii* in pregnant women attending ante natal care in Jos University Teaching Hospital (JUTH). J. Infect. Dis. Epidemiol., Vol. 8. 10.23937/2474-3658/1510285.
15. Frimpong, C., M. Makasa, L. Sitali and C. Michelo, 2017. Seroprevalence and determinants of toxoplasmosis in pregnant women attending antenatal clinic at the university teaching hospital, Lusaka, Zambia. BMC Infect. Dis., Vol. 17. 10.1186/s12879-016-2133-7.
16. Ayi, I., S. Edu, K.A. Apea-Kubi, D. Boamah, K.M. Bosompem and D. Edoh, 2009. Sero-epidemiology of toxoplasmosis amongst pregnant women in the greater Accra Region of Ghana. Ghana Med. J., 43: 107-114.
17. Tenter, A.M., A.R. Heckeroth and L.M. Weiss, 2000. *Toxoplasma gondii*: From animals to humans. Int. J. Parasitol., 30: 1217-1258.
18. Goldstein, E.J.C., J.G. Montoya and J.S. Remington, 2008. Management of *Toxoplasma gondii* infection during pregnancy. Clin. Infect. Dis., 47: 554-566.
19. Weiss, L.M. and K. Kim, 2004. The international congress on toxoplasmosis. Int. J. Parasitol. Mar., 34: 249-252.
20. Ohiolei, J.A. and C. Isaac, 2016. Toxoplasmosis in Nigeria: The story so far (1950-2016): A review. Folia Parasitol., Vol. 63. 10.14411/fp.2016.030.

21. Gelaye, W., T. Kebede and A. Hailu, 2015. High prevalence of anti-toxoplasma antibodies and absence of *Toxoplasma gondii* infection risk factors among pregnant women attending routine antenatal care in two Hospitals of Addis Ababa, Ethiopia. Int. J. Infect. Dis., 34: 41-45.
22. Zumla, A. and A. Ustianowski, 2012. Tropical diseases: Definition, geographic distribution, transmission, and classification. Infect. Dis. Clin. North Am., 26: 195-205.
23. Daher, D., A. Shaghlil, E. Sobh, M. Hamie and M.E. Hassan *et al*., 2021. Comprehensive overview of *Toxoplasma gondii*-induced and associated diseases. Pathogens, Vol. 10. 10.3390/pathogens10111351.
24. Oboro, I.L., O.K. Obunge and K.T. Wariso, 2016. Sero-epidemiology of Toxoplasmosis among pregnant women in the University of Port Harcourt Teaching Hospital, Nigeria. Niger. Health J., Vol. 16.
25. Essien, E. and S. Cyrus, 2019. Detection of urban development in Uyo (Nigeria) using remote sensing. Land, Vol. 8. 10.3390/land8060102.
26. Luft, B.J. and J.S. Remington, 1992. Toxoplasmic encephalitis in AIDS. Clin. Infec. Dis., 15: 211-222.
27. Nisbet, A.I., G. Omuse, G. Revathi and R.D. Adam, 2018. Seroprevalence data at a private teaching hospital in Kenya: An examination of *Toxoplasma gondii*, cytomegalovirus, rubella, hepatitis A, and *Entamoeba histolytica*. PLoS ONE, Vol. 13. 10.1371/journal.pone.0204867.
28. Yusuf, A.A., A.A. Hassan-Kadle, A.M. Ibrahim, M.A. Hassan-Kadle and A.M. Yasin *et al*., 2021. Prevalence of anti-*Toxoplasma gondii* and anti-*Brucella* spp. antibodies in pregnant women from Mogadishu, Somalia. Front. Reprod. Health, Vol. 3. 10.3389/frph.2021.672885.
29. Wokem, G.N., E. Onosakponome and F.O.I. Arene, 2018. Toxoplasmosis among pregnant women attending antenatal clinic in a health facility in Port Harcourt, Rivers State, Nigeria. Niger. J. Parasitol., 39: 96-100.
30. Paul, E., I. Kiwelu, B. Mmbaga, R. Nazareth and E. Sabuni *et al*., 2018. *Toxoplasma gondii* seroprevalence among pregnant women attending antenatal clinic in Northern Tanzania. Trop. Med. Health, Vol. 46. 10.1186/s41182-018-0122-9.
31. Afonso, E., E. Germain, M.L. Poulle, S. Ruette and S. Devillard *et al*., 2013. Environmental determinants of spatial and temporal variations in the transmission of *Toxoplasma gondii* in its definitive hosts. Int. J. Parasitol. Parasites Wildl., 2: 278-285.
32. Addo, S.O., T.O. Asare, C. Arthur, K. Amoateng, K. Addo and J.A. Larbi, 2023. *Toxoplasma gondii* among pregnant women attending antenatal care in a district hospital in Ghana. Public Health Challenges, Vol. 2. 10.1002/puh2.82.
33. Zemene, E., D. Yewhalaw, S. Abera, T. Belay, A. Samuel and A. Zeynudin, 2012. Seroprevalence of *Toxoplasma gondii* and associated risk factors among pregnant women in Jimma town, Southwestern Ethiopia. BMC Infect. Dis., Vol. 12. 10.1186/1471-2334-12-337.
34. Ahmad, N., Z. Iqbal, M. Mukhtar, M. Mushtaq, K.M. Khan and M. Qayyum, 2015. Seroprevalence and associated risk factors of toxoplasmosis in sheep and goats in Pothwar Region, Northern Punjab, Pakistan. Pak. J. Zool., 47: 161-167.
35. Abamecha, F. and H. Awel, 2016. Seroprevalence and risk factors of *Toxoplasma gondii* infection in pregnant women following antenatal care at Mizan Aman General Hospital, Bench Maji Zone (BMZ), Ethiopia. BMC Infect. Dis., Vol. 16. 10.1186/s12879-016-1806-6.
36. Liesenfeld, O., J.G. Montoya, N.J. Tathineni, M. Davis and B.W. Brown *et al*., 2001. Confirmatory serologic testing for acute toxoplasmosis and rate of induced abortions among women reported to have positive *Toxoplasma immunoglobulin* M antibody titers. Am. J. Obstet. Gynecol., 184: 140-145.
37. Berredjem, H., H. Aouras, M. Benlaifa, I. Becheker and M.R. Djebar, 2017. Contribution of IgG avidity and PCR for the early diagnosis of toxoplasmosis in pregnant women from the North-Eastern Region of Algeria. Afr. Health Sci., 17: 647-656.
38. Pereboom, M.T.R., J. Manniën, E.R. Spelten, F.G. Schellevis and E.K. Hutton, 2013. Observational study to assess pregnant women's knowledge and behaviour to prevent toxoplasmosis, listeriosis and cytomegalovirus. BMC Pregnancy Childbirth, Vol. 13. 10.1186/1471-2393-13-98.

39. Ode, S.A., A.J. Jubril and B.O. Emikpe, 2021. Awareness and habits of Nigerians towards toxoplasmosis and risk factors. PAMJ-OH, Vol. 4. 10.11604/pamj-oh.2021.4.15.28586.
40. Imam, N.F., A.A. Esra'a and A.A. Attia, 2016. Seroprevalence of *Toxoplasma gondii* among pregnant women in Almadinah Almunawwarah KSA. J. Taibah Univ. Med. Sci., 11: 255-259.
41. Yohanes, T., Z. Zerdo, N. Chufamo and A. Abossie, 2017. Seroprevalence and associated factors of *Toxoplasma gondii* infection among pregnant women attending in antenatal clinic of Arba Minch Hospital, South Ethiopia: Cross sectional study. Transl. Biomed., Vol. 8. 10.2167/2172-0479.1000105.
42. Dairo, M.D., T. Ogunjimi and A.B. Ayinmode, 2018. Knowledge, risk factors and prevalence of toxoplasmosis among pregnant women at primary health care level in Ibadan, Southwestern Nigeria. Afr. J. Biomed. Res., 21: 267-271.
43. Elsheikha, H.M., 2008. Congenital toxoplasmosis: Priorities for further health promotion action. Public Health, 122: 335-353.
44. Bamba, S., M. Cissé, I. Sangaré, A. Zida, S. Ouattara and R.T. Guiguemdé, 2017. Seroprevalence and risk factors of *Toxoplasma gondii* infection in pregnant women from Bobo Dioulasso, Burkina Faso. BMC Infect. Dis., Vol. 17. 10.1186/s12879-017-2583-6.
45. Awoke, K., E. Nibret and A. Munshea, 2015. Sero-prevalence and associated risk factors of *Toxoplasma gondii* infection among pregnant women attending antenatal care at Felege Hiwot Referral Hospital, Northwest Ethiopia. Asian Pac. J. Trop. Med., 8: 549-554.
46. Ertug, S., P. Okyay, M. Turkmen and H. Yuksel, 2005. Seroprevalence and risk factors for *Toxoplasma* infection among pregnant women in Aydin Province, Turkey. BMC Public Health, Vol. 5. 10.1186/1471-2458-5-66.
47. Galal, L., F. Ariey, M.A. Gouilh, M.L. Dardé and A. Hamidović *et al*., 2022. A unique *Toxoplasma gondii* haplotype accompanied the global expansion of cats. Nat. Commun., Vol. 13. 10.1038/s41467-022-33556-7.
48. Al-Eryani, S.M., A.M. Al-Mekhlafi, L.A. Al-Shibani, M.M.K. Mahdy and A.A. Azazy, 2016. *Toxoplasma gondii* infection among pregnant women in Yemen: Factors associated with high seroprevalence. J. Infect. Dev. Ctries., 10: 667-672.
49. Ramsewak, S., R. Gooding, K. Ganta, N. Seepersadsingh and A.A. Adesiyun, 2008. Seroprevalence and risk factors of *Toxoplasma gondii* infection among pregnant women in Trinidad and Tobago. Rev. Panamericana de Salud Publ., 23: 164-170.
50. Gebremedhin, E.Z. and G. Tadesse, 2015. A meta-analysis of *Toxoplasma gondii* infections in animals and humans in Ethiopia. Parasite Vectors, Vol. 8. 10.1186/s13071-015-0901-7.
51. Deji-Agboola, A.M., O.S. Busari, O.A. Osinupebi and A.O.J. Amoo, 2011. Seroprevalence of *Toxoplasma gondii* antibodies among pregnant women attending antenatal clinic of federal medical center, Lagos, Nigeria. Int. J. Biol. Med. Res., 2: 1135-1139.
52. Madi, J.M., R. da Silva de Souza, B.F. de Araújo, P.F. de Oliveira Filho and R.L. Rombaldi *et al*., 2010. Prevalence of toxoplasmosis, HIV, syphilis and rubella in a population of puerperal women using Whatman 903® filter paper. Braz. J. Infect. Dis., 14: 24-29.
53. Walle, F., N. Kebede, A. Tsegaye and T. Kassa, 2013. Seroprevalence and risk factors for *Toxoplasmosis* in HIV infected and non-infected individuals in Bahir Dar, Northwest Ethiopia. Parasites Vectors, Vol. 6. 10.1186/1756-3305-6-15.
54. Modrek, M.J., M. Mousavi and R. Saravani, 2014. *Toxoplasma gondii* seroprevalence among blood donors in Zahedan, Southeastern Iran. Int. J. Infect., Vol. 1. 10.17795/iji-21111.
55. Cook, A.J., R.E. Gilbert, W. Buffolano, J. Zufferey and E. Petersen *et al*., 2000. Sources of toxoplasma infection in pregnant women: European multicentre case-control study. Br. Med. J., Vol. 321. 10.1136/bmj.321.7254.142.
56. Lopes-Mori, F.M.R., R. Mitsuka-Breganó, L.H.F. de Barros Bittencourt, R.C.F. Dias and D.D. Gonçalves *et al*., 2013. Gestational toxoplasmosis in Paraná State, Brazil: Prevalence of IgG antibodies and associated risk factors. Braz. J. Infect. Dis., 17: 405-409.