Journal of Health Science Research, *Vol 6(1), 2021, 9-17*
ISSN (Online) : 2456-2688
DOI: https://doi.org/10.7324/jhsr.2021.612

Anti-*Toxoplasma gondii* Antibodies: Prevalence and Risk Factors among Pregnant Women Accessing Antenatal Care in Some Primary Health Centers in Jos Metropolis, Nigeria

Ocheme Julius Okojokwu[1]*, Innocent Ajegba Onaji[2], Entonu Elijah Entonu[1], Bashiru Shafa Abubakar[3], Maryam Bisola Adebayo[4], Nafisa Abduljalil Adamu[5], Daniel Iduh Ejembi[1], Ibrahim Abubakar Yusuf[4], Amos Obaje Ogaji[1], Murna Ahmed Ali[1], Joseph Aje Anejo-Okopi[1]

[1]Department of Microbiology, Faculty of Natural Sciences, University of Jos, Plateau State, Nigeria;
[2]Department of Pharmaceutical Microbiology, Faculty of Pharmaceutical Sciences, University of Jos, Plateau State, Nigeria;
[3]Department of Zoology, Faculty of Natural and Applied Sciences, Nasarawa State University, Keffi, Nasarawa State, Nigeria;
[4]Department of Microbiology, Faculty of Life Sciences, Ahmadu Bello University, Zaria, Nigeria;
[5]Department of Microbiology, Federal University Dutsin-Ma, Katsina State, Nigeria
Email: okojokwuoj@gmail.com

Abstract

Toxoplasma gondii infection causes a high rate of gestational and congenital infection across the globe and is considered a both a public health problem and a neglected disease. The study was carried out to determine the prevalence of anti-*T. gondii* antibodies and the associated risk factors among pregnant women attending antenatal care in some Primary Health Centers in Jos, Plateau State, Nigeria. In this cross-sectional study carried out within 5 months between January and May 2019, a total of 182 blood samples were collected from consenting pregnant women. Structured questionnaire was used to obtain data on sociodemography and risk factors. Three milliliters of blood samples were collected from the study participants. Sera were separated from the blood and evaluated for anti-*T. gondii* antibodies (IgG and IgM) using enzyme-linked immunosorbent assay. The data collected from the experiment were analyzed using Statistical Package for the Social Sciences. Out of the 182 samples examined, 84 (46.2%) had anti-*T. gondii* IgG antibody and 2 (1.1%) had IgM antibody, while 98 (53.4%) were neither seropositive for IgG nor IgM. Trimester of pregnancy was significantly associated with prevalence of anti-*Toxoplasma* IgM antibody. In conclusion, toxoplasmosis is prevalent in Jos. Eleven out of every 1000 women (i.e., 1.1%) had recent toxoplasmosis and 53.4% were not protected against primary infection, thereby underscoring the need for prevention and control during pregnancy through enlightenment.

Keywords: Jos-Nigeria, Pregnant Women, Seroprevalence, *Toxoplasma gondii*, Toxoplasmosis

1. Introduction

Toxoplasma gondii, which occurs worldwide, is an obligate intracellular apicomplexan protozoan parasite that is responsible for toxoplasmosis in animals and humans[1,2]. It is estimated that over one-third of the world human population is infected, with reported incidence rate of congenital toxoplasmosis ranging from 400 to

*Author for correspondence

How to cite this article: Okojokwu OJ, Onaji IA, Entonu EE, Abubakar BS, Adebayo MB, Adamu NA, Ejembi DI, Yusuf IA, Ogaji AO, Ali MA, Anejo-Okopi JA. Anti-*Toxoplasma gondii* Antibodies: Prevalence and Risk Factors among Pregnant Women Accessing Antenatal Care in Some Primary Health Centers in Jos Metropolis, Nigeria. *J Health Sci Res* 2021;6(1):9-17.

4000 cases per year[3,4]. The parasite is implicated for 1.2 million disability-adjusted life years annually[5].

The main transmission pathway of *T. gondii* includes vertical transmission (from pregnant mother to fetus), eating raw or undercooked meat, and consumption of vegetables, water, and foods contaminated with oocysts of the parasites[6]. Should primary infection occurs during pregnancy, the parasite could cross the placental barrier causing congenital toxoplasmosis, which may lead to myriad of health problems such as spontaneous miscarriage, stillbirth, or congenital abnormalities such as mental retardation, hydrocephalus, intracerebral calcifications, and chorioretinitis[7-11]. Awoke *et al.*[9] reported that antenatal screening of pregnant women for *T. gondii* infection is based on IgG and IgM antibodies detection and is the main means of monitoring the risk for congenital toxoplasmosis.

The danger of congenital toxoplasma infection and the seriousness of fetal harm are reliant on the gestational age when the maternal infection takes place[12]. The general danger of congenital maternal infection from primary toxoplasmosis during pregnancy varies from 20% to 50% if left untreated[13]. Prevention of congenital toxoplasmosis can be achieved by identifying non-immunized women at the onset of pregnancy and enlighten them on how to prevent the infection, and by serological follow-up. Multiple testing for *Toxoplasma*-specific IgG and IgM helps to differentiate between acute and chronic infections[12].

Prevalence of congenital toxoplasmosis across the globe vary between 4.3 and 75.0% in Africa[14-17], 6.8–51.8% in Europe[18-20], 14.0–96.3% in Asia[21-23], 10.6–13.0% in North America,[24-26] and 26.3–80.0% in South America[27-29].

Despite the risk of vertical transmission of toxoplasmosis, serological tests for *T. gondii* infection are not routinely performed during pregnancy in Nigeria. Hence, prevalence and the burden of toxoplasmosis are poorly understood. The aim of this study, therefore, was to investigate the seroprevalence and risk factors of *T. gondii* infection by determining (1) the seroprevalence of IgG and IgM specific to *T. gondii* and (2) risk factors that are associated with toxoplasmosis.

2. Material and Methods

2.1. Study area and population

This cross-sectional study was carried out from January to May 2019 in Jos, located between latitude 9°55'42.56"N and longitude 8°53'31.63"E, among women attending antenatal care at some Primary Health Centers (PHC) in Jos, Plateau State Nigeria.

2.2. Ethical considerations

Ethical clearance was obtained from the Ethical Review Committee of the Plateau State Specialist Hospital, Jos, Nigeria, under the number NHREC/O5/01/2010b. A signed informed consent form was obtained from each study subject at the beginning of the study. Confidentiality of patient information and samples was ensured and maintained at all times. Spent samples were appropriately autoclaved and disposed after usage.

2.3. Collection of blood sample and sociodemographic data

This research was a cross-sectional study and it was carried out within 5 months. Samples were collected from pregnant women accessing antenatal care at some (PHC Dogo Agogo, PHC Jos Township, and PHC Jos Jarawa), Jos. Information on sociodemographic as well as some risk factors of *T. gondii* infection was collected using a structured questionnaire.

Approximately 3 ml blood samples were aspirated from each patient and coded. The samples were kept at ambient temperature to clot and were thereafter spun at 1000 g for 10 min. The sera were collected in 2-ml Eppendorf tubes and taken to Plateau State Human Virology Research Centre in an icebox where the samples were kept at −20°C until analysis[30].

2.4. Serological testing

Testing for anti-*T. gondii* antibodies (IgM and IgG) were done with enzyme-linked immunosorbent assay (ELISA kit provided by Diagnostic Automation, INC USA). The kits were used following the manufacturer's instructions and guidelines.

2.5. Statistical analysis of data

Data from this study were saved on Excel® spreadsheet and analyzed using Statistical Package for the Social Science version 23. Chi-square test was used to determine the relationships between the risk factors and seropositivity. $P \leq 0.05$ was considered statistically significant.

3. Results

Overall, 182 subjects were included in this study; 84 (46.2%) had anti-*Toxoplasma* IgG antibody, while 2 (1.1%) were positive for IgM antibody. Two study subjects that had IgM antibody were also seropositive for anti-*Toxoplasma* IgG antibody representing 2.4% (2/84) of the women who were seropositive for anti-*Toxoplasma* IgG. Ninety-eight (98 [53.4%]) of the subjects were seronegative for both anti-*Toxoplasma* IgG and IgM antibodies (Figure 1).

Although the demographic parameters show no association ($P > 0.05$) with the prevalence of anti-*Toxoplasma* antibodies, the age group 11–20 years had the highest prevalence of IgG antibody, while women within the age group 41–50 years had 0.0% prevalence of IgG antibody to *T. gondii*. On the other hand, all the 2 subjects that tested positive to IgM antibody were in the age bracket of 31–40 years. With respect to educational status, the seroprevalence anti-*Toxoplasma* IgG antibody decreased from 100% in women without formal education to 40.0% in women with tertiary level of education. The two women who were seropositive for IgM antibody had secondary level of education (Table 1). In terms of occupation of the pregnant women, majority of the women were unemployed (53.8%), while 46.2% of them were employed. The highest prevalence (66.7%) of IgG antibody was detected among students, while the least (44.2%) was detected among housewives. In similar vein, the housewives 2.3% prevalence of IgM antibody (Figure 2).

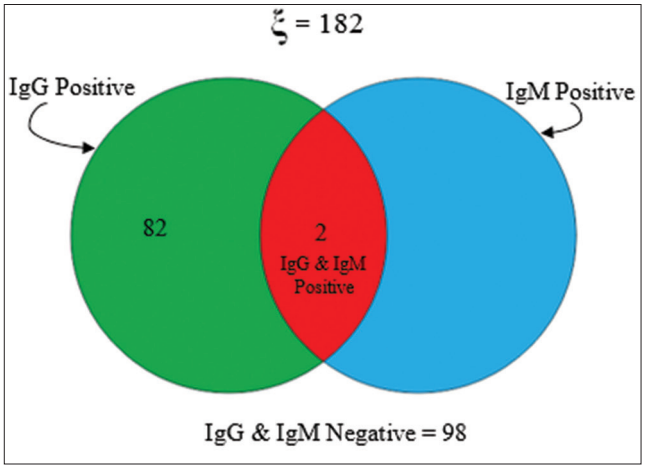

Figure 1. Relationship between Anti-*Toxoplasma* antibodies (IgG and IgM) status of the study subjects.

There was statistically significant association ($\chi^2 = 14.324$; $P = 0.001$) between trimester and prevalence of anti-*Toxoplasma* IgM antibody. None of all the other risk factors studied in the present research had association ($P > 0.05$) with anti-*Toxoplasma* antibodies (Table 2).

4. Discussion

The present study is among the few works in Nigeria that explore the seroprevalence of *T. gondii* infection

Table 1. Prevalence of Anti-*Toxoplasma gondii* antibodies with respect to demographics

Parameter	Number examined (%)	IgG positive (%)	IgM positive (%)
Age group (years)			
11–20	38 (20.9)	24 (63.2)	0 (0.0)
21–30	110 (60.6)	46 (41.8)	0 (0.0)
31–40	32 (39.0)	14 (43.8)	2 (6.3)
41–50	2 (1.1)	0 (0.0)	0 (0.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		3.521	4.740
P-value		0.318	0.192
Educational status			
No formal education	2 (1.1)	2 (100.0)	0 (0.0)
Primary	30 (16.5)	14 (46.7)	0 (0.0)
Secondary	130 (71.4)	60 (46.2)	2 (1.5)
Tertiary	20 (11.0)	8 (40.0)	0 (0.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		1.321	0.404
P-value		0.724	0.939

**Statistically significant at $P \leq 0.001$, *Statistically significant at $P \leq 0.005$

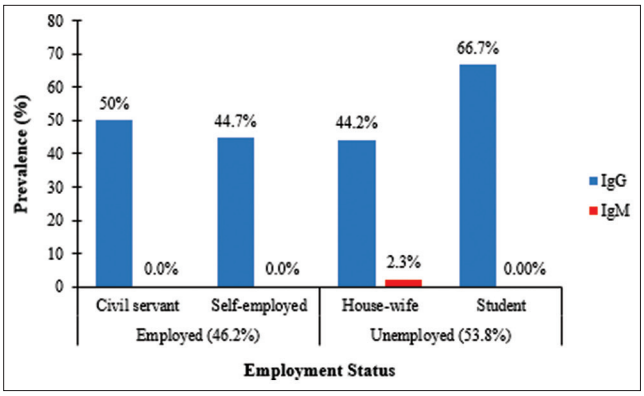

Figure 2. Prevalence of anti-*Toxoplasma* antibodies based on employment status (IgG: $\chi^2 = 1.137$; $P = 0.768$ and IgM: $\chi^2 = 1.129$; $P = 0.770$).

in pregnant women and to determine the risk factors associated with the infection in this cohort. Toxoplasmosis is a treatable though likely fatal disease. The problem with most communities with substantial prevalence of *T. gondii* infection is the long-term complications which follows congenital infections and the ability to cause opportunistic infections that are life-threatening in immunocompromised or immunosuppressed individuals[3,31].

Our findings showed that the seroprevalence of anti-*T. gondii* antibodies in women visiting antenatal clinic in PHC in Jos was 46.2% and 1.1% for IgG and IgM, respectively. This implies that 46.2% of the study subjects had been exposed and possibly recovered from the infection, while 1.1% of the women have ongoing or current *Toxoplasma* infection. Hence, the finding suggests that the parasitic infection is endemic in the study area. The anti-*T. gondii* IgG prevalence reported that in the current study was higher than previously reported ones for Sudan (41.7%), Somalia (29.6%), and Algeria (52.2%)[32]. When compared with findings from other parts of Nigeria, the seroprevalence was higher than the 32.6% and 40.6% reported by Deji-Agboola[33] and Akinbami *et al.*[34] in Lagos and 29.1% obtained among pregnant women in Zaria[35]. These various findings lend credence to the fact that *Toxoplasma* infection varies significantly within and between countries[5,36-39]. The difference in the seroprevalence of *T. gondii* infection could be attributed to the variation in geographic locations of the study areas as manifested in differences in humidity and temperature. Higher temperatures and/or humid environments favor sporulation of oocysts[40,41]. Furthermore, the variation in

Table 2. Prevalence of anti-*Toxoplasma gondii* antibodies in relation to risk factors

Parameter	Number examined (%)	IgG positive (%)	IgM positive (%)
Trimester			
First	12 (6.6)	8 (66.7)	2 (16.7)
Second	98 (53.8)	40 (40.8)	0 (0.0)
Third	72 (39.6)	36 (50.0)	0 (0.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		1.792	14.324
P-value		0.408	0.001**
HIV status			
Positive	82 (45.1)	34 (41.5)	2 (2.4)
Negative	98 (53.8)	48 (49.0)	0 (0.0)
No idea	2 (1.1)	2 (100.0)	0 (0.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		1.687	1.233
P-value		0.430	0.540
Source of water			
Well	22 (12.1)	10 (45.5)	0 (0.0)
Tap	116 (63.7)	56 (48.3)	2 (1.7)
Bore-hole	44 (24.2)	18 (40.9)	0 (0.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		0.351	0.575
P-value		0.839	0.750
Do you eat undercooked meat?			
Yes	82 (45.1)	38 (46.3)	0 (0.0)

(Contd...)

Table 2. ***(Continued)***

Parameter	Number examined (%)	IgG positive (%)	IgM positive (%)
No	100 (54.9)	46 (46.0)	2 (2.0)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		0.001	
P-value		0.974	1.000†
Do you have contact with cat?			
Yes	32 (17.6)	12 (37.5)	0 (0.0)
No	150 (82.4)	72 (48.0)	2 (1.3)
Total	182 (100.0)	84 (46.2)	2 (1.1)
χ^2		0.585	
P-value		0.444	1.000†

**Statistically significant at $P \leq 0.001$; *Statistically significant at $P \leq 0.005$; †Fisher's exact test.

prevalence of *T. gondii* infection could be partly due to the use of different analytic techniques such as the use of ELISA versus rapid diagnostic tool and/or polymerase chain reaction. This is because these analytic techniques have different rates of sensitivity and specificity[42]. In addition, difference in socioeconomic status of the women and variation in samples could have impacted on prevalence reported in the various findings, thus bringing about the discrepancies in the reported figures.

The correlation between sociodemographic characteristics of the pregnant women and prevalence of anti-*T. gondii* antibodies were assessed in the current study. In concordance with findings from other authors[43,44], there was no significant association between *Toxoplasma* seroprevalence and increasing maternal age, but younger women (21–30 years) were found to have a relatively higher seroprevalence rate compared to older women (>30 years). This might be explained by younger rather than older women's preference for outings overeating at home. During those outings, the women are exposed to grilled meat which might be undercooked. Fruits and salads which may be contaminated with the parasite oocysts are also often eaten in such outings hence increasing the risk of infections[45-47]. Prevalence of anti-*T. gondii* antibody (IgG) in this study decreased with increasing educational level. This finding was in accordance with the study done in Debre Tabor, Northwest Ethiopia, where pregnant women who could neither read nor write had the highest toxoplasmosis infection rate compared with those with primary, secondary, and tertiary levels of education[48,49]. Illiterate women are more likely to engage in more risky unsanitary and unhygienic practices hence are more liable to be infected by *T. gondii*. Though significant association was not observed between prevalence of anti-Toxoplasma gondii antibodies and both occupation and educational level, the prevalence increases with decrease in educational level. This is in concordance with reported findings from Africa[50-52].

However, there was a significant relationship between trimester of pregnancy and prevalence of anti-*T. gondii* IgM antibody. Women in the first trimester of pregnancy had the highest prevalence of *Toxoplasma* infection. Although the gravidity of the women was not established in this study, Mandour *et al.*[53] reported an increased percentage of multigravid women, in whom complicated pregnancy outcomes have been reported compared with primigravid females. In view of that finding, it is likely that the majority of the women in the first trimester of their pregnancy were multigravid females.

Our findings showed no association between *T. gondii* infection and contact with cats. This suggests that contact with cats does not translate to zoonosis, but more pertinent in causing zoonosis is the improper handling of cats' fecal matter[54]. While this finding disagrees with the reports of Lim *et al.*[55] and Adeniyi *et al.*,[56] where they showed a significant association between contact with cats and seroprevalence of *T. gondii* infection, it is consistent with the findings of Doehring *et al.*[57], Nijem and Al-Amleh,[40] and Wang *et al.*[58]. It was also found that though immune-compromised individuals were reported to be more prone to toxoplasmosis[59], HIV-negative women had a higher prevalence of the infection in comparison with HIV-positive pregnant counterparts. It is likely that the use of antiretroviral therapy by HIV-positive women reduced the probability of opportunistic infections.

Two pregnant women with active/ongoing toxoplasmosis were detected. This implies that their fetuses were at risk of congenital *T. gondii* infection with attendant adverse and sometime fatal consequences. The presence

of active cases of toxoplasmosis in this study, therefore, underscores the need and importance of screening of pregnant women to control congenital transmission of toxoplasmosis and its unfavorable birth outcomes such as miscarriages, hydrocephalus, cerebral calcification, poor cognitive development, and fetal death[59].

5. Conclusion and Recommendation

This study confirms prevalence of *T. gondii* infection among pregnant women accessing antenatal care in Jos metropolis, Plateau State, Nigeria. None of the risk factors studied with respect to IgG antibody was associated with toxoplasmosis. In spite of the absence of a significant association between possible risk factors and the infection, there is a need for the enlightenment of women, particularly pregnant women, on the risk factors and how to prevent the contraction of toxoplasmosis.

6. Authors' Contributions

OJO: Conceptualization, investigation, methodology, validation, writing original draft manuscript/review and editing. IAO: Data curation, formal analysis, review and editing of final manuscript. EEE: Supervision, validation, review and editing of final manuscript. BSA: Data curation, investigation, methodology, validation. MBA: Formal analysis, investigation, methodology, writing of original draft manuscript/review, and editing. NAA: Data curation, investigation, methodology. IAY: Data curation, investigation, methodology, validation. AOO: Data curation, methodology, resources. MAA: Data curation, investigation, review and editing of final manuscript. JAA: Formal analysis, investigation, methodology, writing of original draft manuscript/review and editing. All the authors approved the final manuscript before submission.

7. Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

8. References

1. Shimelis T, Tebeje M, Tadesse E, Tegbaru B, Terefe A. Sero-prevalence of latent *Toxoplasma gondii* infection among HIV infected and HIV-uninfected people in Addis Ababa, Ethiopia: A comparative cross-sectional study. BMC Res Notes 2009;2:213. https://doi.org/10.1186/1756-0500-2-213. PMid: 19852805; PMCid: PMC2770475.
2. Paul RT, Pierpaolo M. The global burden of congenital Toxoplasmosis: A systematic review. Bull World Health Organ 2013;91(7):501-8. PMid: 23825877; PMCid: PMC3699792.
3. Negash T, Tilahun G, Medhin G. Seroprevalence of *Toxoplasma gondii* in Nazareth town, Ethiopia. East Afr J Public Health 2008;5(3):211-4. https://doi.org/10.4314/eajph.v5i3.39005. PMid: 19374326.
4. Fong MY, Wong KT, Rohela M, Tan LH, Adeeba K, Lee YY, *et al*. Unusual manifestation of cutaneous toxoplasmosis in a HIV positive patient. Trop Biomed 2010;27(3):447-50. PMid: 21399585.
5. Torgerson PR, Mastroiacovo P. The global burden of congenital toxoplasmosis: A systematic review. Bull World Health Organ 2013;91(7):501-8. https://doi.org/10.2471/blt.12.111732. PMid: 23825877; PMCid: PMC3699792.
6. Elmore SA, Jones JL, Conrad PA, Patton S, Lindsay DS, Dubey JP. *Toxoplasma gondii*: Epidemiology, feline clinical aspects, and prevention. Trends Parasitol 2010;26(4):190-6. https://doi.org/10.1016/j.pt.2010.01.009. PMid: 20202907.
7. Tenter AM, Heckeroth AR, Weiss LM. *Toxoplasma gondii*: From animals to humans. Int J Parasitol 2000;30(12-13):1217-58. https://doi.org/10.1016/s0020-7519(01)00125-4. PMid: 11113252; PMCid: PMC3109627.
8. Sukthana Y. Toxoplasmosis: Beyond animals to humans. Trends Parasitol 2006;22(3):137-42. PMid: 16446116.
9. Awoke K, Nibret E, Munshea A. 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 2015;8(7):549-54. https://doi.org/10.1016/j.apjtm.2015.06.014. PMid: 26276286.
10. Khan K, Khan W. Congenital toxoplasmosis: An overview of the neurological and ocular manifestations. Parasitol Int 2018;67(6):715-21. https://doi.org/10.1016/j.parint.2018.07.004. PMid: 30041005.
11. Fanigliulo D, Marchi1 S, Montomoli E, Trombetta CM. *Toxoplasma gondii* in women of childbearing age and during pregnancy: Seroprevalence study in Central and Southern Italy from 2013 to 2017. Parasite 2020;27:2. https://doi.org/10.1051/parasite/2019080. PMid: 31934847; PMCid: PMC6959136.
12. Robert-Gangneux F, Darde ML. Epidemiology of and diagnostic strategies for toxoplasmosis. Clin Microbiol Rev 2012;25(2):264-96. https://doi.org/10.1128/cmr.05013-11. PMid: 22491772; PMCid: PMC3346298.
13. Dunn D, Wallon M, Peyron F, Petersen E, Peckham C,

Gilbert R. Mother-to-child transmission of toxoplasmosis: Risk estimates for clinical counselling. Lancet 1999;353(9167):1829-33. https://doi.org/10.1016/s0140-6736(98)08220-8. PMid: 10359407.
14. Zumla A, Savva B, Wheeler RB, Hira SK, Luo NP, Kaleebu P, *et al*. *Toxoplasma* serology in Zambian and Ugandan patients infected with the human immunodeficiency virus. Trans R Soc Trop Med Hyg 1991;85(2):227-9. https://doi.org/10.1016/0035-9203(91)90034-v. PMid: 1887478.
15. Khalil KM, Ahmed AA, Elrayah LE. Sero-prevalence of *Toxoplasma gondii* infection in humans in Khartoum State, Sudan. Int J Trop Med 2012;7(4):143-50. https://doi.org/10.3923/ijtmed.2012.143.150.
16. Yohanes T, Debalke S, Zemene E. Latent *Toxoplasma gondii* infection and associated risk factors among HIV-infected individuals at Arba Minch hospital, South Ethiopia. AIDS Res Treat 2014;2014:652941. https://doi.org/10.1155/2014/652941. PMid: 25431660; PMCid: PMC4241326.
17. Mirambo MM, Mushi MF, Kivambe C. High sero-prevalence of specific *Toxoplasma gondii* IgG antibodies among HIV/AIDS patients with immunological failure attending a tertiary hospital in North-Western Tanzania. Tanzan J Health Res 2016;18(1):1-4.
18. Belanger F, Derouin F, Grangeot-Keros L, Meyer L. Incidence and risk factors of toxoplasmosis in a cohort of human immunodeficiency virus-infected patients: 1988-1995. HEMOCO and SEROCO Study Groups. Clin Infect Dis 1999;28(3):575-81. https://doi.org/10.1086/515147. PMid: 10194081.
19. Daković-Rode O, Židovec-Lepej S, Vodnica-Martucci M, Lasica PV, Begovac J. Prevalence of antibodies against *Toxoplasma gondii* in patients infected with human immunodeficiency virus in Croatia. Infektol Glasnik 2010;30(1):5-10.
20. Llenas-García J, Rubio R, Hernando A, Fiorante S, Maseda D, Matarranz M, *et al*. Clinico-epidemiological characteristics of HIV positive immigrants: Study of 371 cases. Enferm Infect Microbiol Clin 2012;30(8):441-51. https://doi.org/10.1007/s10096-011-1531-4. PMid: 22365618.
21. Hagiwara E, Ito A, Shirai A, Kawada K, Okubo T, Amano T, *et al*. Seroprevalence of anti-*Toxoplasma* IgG antibody in Japanese patients with HIV infection. Kansenshogaku Zasshi 2001;75(8):703-4. https://doi.org/10.11150/kansenshogakuzasshi1970.75.703. PMid: 11558134.
22. Rostami A, Keshavarz H, Shojaee S, Mohebali M, Meamar AR. Frequency of *Toxoplasma gondii* in HIV positive patients from west of Iran by ELISA and PCR. Iran J Parasitol 2014;9(4):474-81. PMid: 25759728; PMCid: PMC4345086.
23. Rahimi MT, Mahdavi SA, Javadian B, Rezaei R, Moosazadeh M, Khademlou M, *et al*. High sero-prevalence of *Toxoplasma gondii* antibody in HIV/AIDS individuals from north of Iran. Iran J Parasitol 2015;10(4):584-9. PMid: 26811725; PMCid: PMC4724835.
24. Johns DG, Gill MJ. Seroprevalence of cytomegalovirus, *Toxoplasma gondii*, syphilis, and hepatitis B and C virus infections in a regional population seropositive for HIV infection. Can J Infect Dis 1998;9(4):209-14. https://doi.org/10.1155/1998/380687. PMid: 22346544; PMCid: PMC3250888.
25. Falusi O, French AL, Seaberg EC, Tien PC, Watts DH, Minkoff H, *et al*. Prevalence and predictors of *Toxoplasma* seropositivity in women with and at risk for human immunodeficiency virus infection. Clin Infect Dis 2002;35(11):1414-7. https://doi.org/10.1086/344462. PMid: 12439806; PMCid: PMC3119037.
26. O'Bryan TA, Okulicz JF, Bradley WP, Ganesan A, Merritt SE, Agan BK. *Toxoplasma gondii* seroprevalence: 30-year trend in an HIV-infected US military cohort. Diagn Microbiol Infect Dis 2016;84(1):34-5. https://doi.org/10.1016/j.diagmicrobio.2015.09.008. PMid: 26499204.
27. Pérez CC, Cerón AI, Fuentes LG, Zañartu SC, Balcells MM, Ajenjo HC, *et al*. Hepatitis B, C, *Treponema pallidum* and *Toxoplasma gondii* co-infections in HIV infected patients. Rev Med Chil 2009;137(5):641-8. https://doi.org/10.4067/s0034-98872009000500007. PMid: 19701553.
28. Vidal JE, Diaz AV, de Oliveira AC, Dauar RF, Colombo FA, Pereira-Chioccola VL. Importance of high IgG anti-*Toxoplasma gondii* titers and PCR detection of *T. gondii* DNA in peripheral blood samples for the diagnosis of AIDS-related cerebral toxoplasmosis: A case-control study. Braz J Infect Dis 2011;15(4):356-9. https://doi.org/10.1590/s1413-86702011000400009. PMid: 21861006.
29. Xavier GA, Cademartori BG, Cunha FN, Farias NA. Evaluation of seroepidemiological toxoplasmosis in HIV/AIDS patients in the south of Brazil. Rev Inst Med Trop Sao Paulo 2013;55(1):25-30. https://doi.org/10.1590/s0036-46652013000100005. PMid: 23328722.
30. Tian AL, Li GX, Elsheikha HM, Gardner DS, Zhang XY, Dong W, *et al*. Seroepidemiology of *Toxoplasma gondii* infection in patients with liver disease in eastern China. Epidemiol Infect 2017;145(11):2296-302. https://doi.org/10.1017/s0950268817001327. PMid: 28677516.
31. Hatam G, Shamseddin A, Nikouee F. Seroprevalence of toxoplasmosis in high school girls in Fasa district, Iran. Iran J Immunol 2005;2(3):177-81.
32. Hall S, Ryan M, Buxton D. The epidemiology of *Toxoplasma* infection. In: Joynson HM, Wreghitt TG, editors. Toxoplasmosis: A Comprehensive Clinical Guide. Cambridge: Cambridge University Press; 2001. p. 58-124.

https://doi.org/10.1017/cbo9780511527005.005.
33. Deji-Agboola AM, Busari OS, Osinupebi OA, Amoo AO. Seroprevalence of *Toxoplasma gondii* antibodies amongst pregnant women attending antenatal clinic of Federal Medical Center, Lagos, Nigeria. Niger Postgrad Med J 2011;2(4):1135-9. PMid: 20539334.
34. Akinbami AA, Adewunmi AA, Rabiu KA, Wright KO, Dosunmu AO, Dada MO, *et al*. Seroprevalence of *Toxoplasma gondii* Antibodies amongst Pregnant Women at the Lagos State University Teaching Hospital, Nigeria. Niger Postgrad Med J 2010;17(2):164-7. https://doi.org/10.2147/ijwh.s24850. PMid: 20539334.
35. Ishaku BS, Ajogi I, Umoh JU, Lawal I, Randawa AJ. Seroprevalence and risk factors for *Toxoplasma gondii* infection among antenatal women in Zaria, Nigeria. Res J Med Med Sci 2009;4(2):483-8.
36. Pappas G, Roussos N, Falagas ME. Toxoplasmosis snapshots: Global status of *Toxoplasma gondii* seroprevalence and implications for pregnancy and congenital toxoplasmosis. Int J Parasitol 2009;39(12):1385-94. https://doi.org/10.1016/j.ijpara.2009.04.003. PMid: 19433092.
37. Uttah E, Ogban E, Okonofua C. Toxoplasmosis: A global infection, so widespread, so neglected. Int J Sci Res Publ 2013;3:23-8.
38. Flegr J, Prandota J, Sovičková M, Israili ZH. Toxoplasmosis-a global threat. Correlation of latent toxoplasmosis with specific disease burden in a set of 88 countries. PLoS One 2014;9(3):e90203. https://doi.org/10.1371/journal.pone.0090203. PMid: 24662942; PMCid: PMC3963851.
39. Ohiolei JA, Isaac C. Toxoplasmosis in Nigeria: The story so far (19502016): A review. Folia Parasitol (Praha) 2016;63:2016.030. https://doi.org/10.14411/fp.2016.030. PMid: 27579591.
40. Nijem KI, Al-Amleh S. Seroprevalence and associated risk factors of toxoplasmosis in pregnant women in Hebron district, Palestine. East Mediterr Health J 2009;15(5):1279-84. PMid: 20214142.
41. Kistiah KB, Winiecka-Krusnell J, Karstaedt A, Frean J. Seroprevalence of *Toxoplasma gondii* infection in HIV-positive and HIV-negative subjects in Gauteng, South Africa. S Afr J Epidemiol Infect 2011;26(4):225-8. https://doi.org/10.1080/10158782.2011.11441457.
42. Tammam AE, Haridy MA, Abdellah AH, Ahmed SR, Fayed HM, Alsammani MA. Seroepidemiology of *Toxoplasma gondii* infection in women with first trimester spontaneous miscarriage in Qena Governorate, Egypt. J Clin Diagn Res 2013;7(12):2870-3. https://doi.org/10.7860/jcdr/2013/6480.3780. PMid: 24551661; PMCid: PMC3919322.
43. Elsheikha HM, Azab MS, Abousamra NK, Rahbar MH, Elghannam DM, Raafat D. Seroprevalence of and risk factors for *Toxoplasma gondii* antibodies among asymptomatic blood donors in Egypt. Parasitol Res 2009;104(6):1471-6. https://doi.org/10.1007/s00436-009-1350-z. PMid: 19198880.
44. Alvarado-Esquivel C, Estrada-Martınez S, Pizarro-Villalobos H, Arce-Quinones M, Liesenfeld O, Dubey JP. Seroepidemiology of *Toxoplasma gondii* infection in general population in a Northern Mexican city. J Parasitol 2011;97(1):40-3. https://doi.org/10.1645/ge-2612.1. PMid: 21348604.
45. Koskiniemi M, Lappalainen M, Hedman K. Toxoplasmosis needs evaluation. An overview and proposals. Am J Dis Child 1989;143(6):724-8. https://doi.org/10.1001/archpedi.1989.02150180106030. PMid: 2658550.
46. Ghoneim NS, Hassanain N, Zeedan G, Soliman Y, Abdalhamed A. Detection of genomic *Toxoplasma gondii* DNA and anti-*Toxoplasma* antibodies in high risk women and contact animals. Glob Vet 2009;3(5):395-400.
47. Makiko S, Shunichi N, Masachi H, Hirotoshi N, Satoshi H. Anti-*Toxoplasma* antibody prevalence, primary infection rate, and risk factors in a study of toxoplasmosis in 4, 466 pregnant women in Japan. Clin Vaccine Immunol 2011;19(3):365-7. https://doi.org/10.1128/cvi.05486-11. PMid: 22205659; PMCid: PMC3294603.
48. Agmas B, Tesfaye R, Koye DN. Seroprevalence of *Toxoplasma gondii* infection and associated risk factors among pregnant women in Debre Tabor, Northwest Ethiopia. BMC Res Notes 2015;8:107. https://doi.org/10.1186/s13104-015-1083-2. PMid: 25879788; PMCid: PMC4387685.
49. Shao ER, Ndazama SG, Chacha G, Tolbert S, Mosha D, Kifaro EG, *et al*. Seroprevalence and factors associated with *Toxoplasma gondii* infection among pregnant women attending antenatal care in the referral hospital in Tanzania: Cross sectional study. Ann Clin Lab Res 2015;3(2):17-22. https://doi.org/10.21767/2386-5180.100017.
50. Zemene E, Yewhalaw D, Abera S, Belay T, Samuel A, Zeynudin A. Seroprevalence of *Toxoplasma gondii* and associated risk factors among pregnant women in Jimma town, Southwestern Ethiopia. BMC Infect Dis 2012;12:337. https://doi.org/10.1186/1471-2334-12-337. PMid: 23216887; PMCid: PMC3519766.
51. Gebremedhin EZ, Abebe AH, Tessema TS, Tullu KD, Medhin G, Vitale M, *et al*. Seroepidemiology of *Toxoplasma gondii* infection in women of child-bearing age in central Ethiopia. BMC Infect Dis 2013;13:101. https://doi.org/10.1186/1471-2334-13-101. PMid: 23442946; PMCid: PMC3598201.
52. Gelaye W, Kebede T, Hailu A. High prevalence of anti-*Toxoplasma* antibodies and absence of *Toxoplasma gondii* risk factors among pregnant women attending routine antenatal care in two hospitals of Addis Ababa, Ethiopia.

Int J Infect Dis 2015;34:41-5. https://doi.org/10.1016/j.ijid.2015.03.005. PMid: 25759324.
53. Mandour AM, Mounib ME, El-Deek HE, Ahmad AA, Mouhamad AR, Kader AR. Prevalence of congenital toxoplasmosis in pregnant women with complicated pregnancy outcomes in Assiut governorate, Egypt. J Adv Parasitol 2017;4(1):1-8. https://doi.org/10.14737/journal.jap/2017/4.1.1.8.
54. Dabritz HA, Conrad PA. Cats and *Toxoplasma*: Implications for public health. Zoonoses Public Health 2010;57(1):34-52. https://doi.org/10.1111/j.1863-2378.2009.01273.x. PMid: 19744306.
55. Lin YL, Liao YS, Liao LR, Chen FN, Kuo HM, He S. Seroprevalence and sources of *Toxoplasma* infection among indigenous and immigrant pregnant women in Taiwan. Parasitol Res 2008;103(1):67-74. https://doi.org/10.1007/s00436-008-0928-1. PMid: 18327612.
56. Adeniyi OT, Adekola SS, Oladipo OM. Seroprevalence of toxoplasmosis among pregnant women in Osogbo, Southwestern, Nigeria. J Infect Dis Immun 2018;10(2):8-16.
57. Doehring E, Reiter-Owona I, Bauer O, Kaisi M, Hlobil H, Quade G, *et al*. *Toxoplasma gondii* antibodies in pregnant women and their Newborns in Dar es Salaam, Tanzania. Am J Trop Med Hyg 1995;52(6):546-8. https://doi.org/10.4269/ajtmh.1995.52.546. PMid: 20619261.
58. Wang T, Liu M, Gao XJ, Zhao ZJ, Chen XG, Lun ZR. *Toxoplasma gondii*: The effects of infection at different stages of pregnancy on the offspring of mice. Exp Parasitol 2011;127(1):107-12. https://doi.org/10.1016/j.exppara.2010.07.003. PMid: 20619261.
59. Dogruman-Al F, Aslan S, Yalcin S, Kustimur S, Turk S. A possible relationship between *Toxoplasma gondii* and Schizophrenia: A seroprevalence study. Int J Psychiatry Clin Pract 2009;13(1):82-7. https://doi.org/10.1080/13651500802624738. PMid: 24946126.