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SERO-PREVALENCE OF *TOXOPLASMA GONDII* INFECTION AND ITS RISK FACTORS AMONG HIV-INFECTED PATIENTS ATTENDING GAYA AND WUDIL GENERAL HOSPITALS, KANO STATE, NIGERIA

[1]Yahaya, A.,[1] Ali, Y., and [1]Ali, M. U
[1]Department of Biology, Aliko Dangote University of Science and Technology, Wudil, Kano.
P. M. B. 3244, Kano State.
* Corresponding Author e-mail:yahayabdul@yahoo.com

Abstract
The objectives of the research were to investigate the sero-prevalence, and its risk factors associated with infection among HIV-patients attending Gaya and Wudil General Hospitals, as well as to link the anti- *T. gondii* IgG/IgM titre with the CD4+ cell count and HIV-1 RNA viral load. The study was cross-sectional, in which a total of 180 people participated i.e. 110 HIV Positives patients (Cases) and (70) healthy HIV Negative were used as controls. Three mls of blood sample was obtained and serological test using ELISA Kits was performed to identify IgG and IgM antibodies against *T. gondii*, CD4+ cell count was measured by flow cytometry and Viral load calculated using PCR, respectively. Questionnaire was administrated to each consenting participant to identify the risk factors in connection to *T. gondii* infection. Data were analysed using Minitab R version 0.3.1 and association between the variable were examined by using chi-square (X^2) test. The overall prevalence of Toxoplasmosis among HIV-Patients from Gaya and Wudil was 29.44% which demonstrated evidence of toxoplasmic infection. Gaya had the highest occurrence (31.11%) while Wudil had the least (27.78%). Age frequency distributions showed highest prevalence between 26-35 age group (40.0%) case and 36-45 (45.7%) control at Gaya, 26-35 (34.5%) case and (31.4%) control at Wudil respectively. Clinical symptoms/signs of Toxoplasmosis demonstrated significant difference with chronic headache. However, other signs and symptoms; were fairly distributed between both Gaya and Wudil. There was a statistically significant difference between anti-*T. gondii* IgG/IgM titre and the CD4+ among HIV positive participants, ($P<0.05$). Moreover, there was no significant difference between HIV-1 RNA viral load and the anti-*T.gondii* IgG/IgM titre ($P>0.05$). It is concluded that *T. gondii* infection was more frequent among HIV positive patients compared to controls. It has also identified Keeping cat, soil contact, and ingestion of unwashed vegetables as the commonest risk factors for the transmission of *T. gondii*. Therefore, regular screening for toxoplasmosis in HIV positive patients as well as health education on strategies to minimize *T. gondii* infection among HIV-Patient is urged among others in the study region.
Keywords: CD4+ cell count, Gaya, HIV-Infected Patients, HIV-1 RNA, *Toxoplasma gondii*, Wudil.

INTRODUCTION

Toxoplasmosis is a widespread neglected tropical illness caused by an obligate intracellular and neurotropic apicomplexan protozoan parasite termed *Toxoplasma gondii;* infecting practically all warm-blooded vertebrates including humans (Wang *et al*. 2017). Humans usually become infected by eating raw or undercooked meat harboring viable tissue cysts, ingesting contaminated water and food or soil with oocysts shed by cats to the environment and through congenital transmission from infected mother to the foetus during pregnancy (Abdelbaset *et al*. 2020). Transmission also occurs owing to the blood

transfusion or organ transplantation (Singh and Sehgal 2010).

Toxoplasma gondii infection has been revealed to be a prevalent opportunistic infection which can progress to a life-threatening condition, especially among people infected with Human Immunodeficiency Virus (HIV). Most *T. gondii* infections in people are asymptomatic, and they also can cause severe Toxoplasmic encephalitis (TE) by acute infection or reactivation of latent infections. Over the past two decades in underdeveloped nations, *T. gondii* steadily manifests as a life-threatening illness among AIDS patients (Machala *et* al. 2009). It is predicted that 25 to 30% of the world's population is infected with Toxoplasma (Pappas *et al*. 2009). In countries like as North America, Northern Europe and in Sahelian nations of Africa low sero-prevalences of 10% to 30% are seen. In nations of Central and Southern Europe, tropical African countries and Latin America the sero-prevalence is roughly 30 to 50% (Montoya and Remington, 2014). The Prevalence population of 40.25 % reported among Nigerian pregnant women is higher than the range of 6.1-25.0% in countries like China, Mexico and Thailand. *Toxoplasma gondii* prevalence in HIV-patients in Nigeria was 31.68% corroborating with results of 36.3% and 38.0% from Thailand and South Africa (Karshima and Karshima 2020) respectively. An overall *Toxoplasma gondii* IgM antibody seroprevalence of 7.5% was observed in Kano State, similar to 8.8% obtained in Saudi Arabian Maternity Hospital, 7.6% reported from Lagos, Nigeria and 8.4% obtained in Libya and differs from 4.6% and 0.8% from Zaria, Northern Nigeria (Ibrahim *et al*. 2017). The parasite can lead to life-threatening situations for HIV/AIDS sufferers, being an opportunistic parasite. Hence, the necessity to establish baseline data that would allow health organizations to make policies targeted towards the management of the disease. Moreover, there is scarcity of evidence on the Toxoplasmosis serologic status and risk factors of *T. gondii* infection among HIV-infected patients. Therefore, this study is aimed at assessing the sero-prevalence of *Toxoplasma gondii* and any associated risk factors among HIV-infected Patients attending Gaya and Wudil General Hospitals, Kano State, Nigeria.

MATERIALS AND METHODS

Study Area

The investigation was conducted at Gaya and Wudil a Local Government Area in Kano State, Nigeria (Figure 1). Wudil is situated between latitude 11°49′ 33.73” N and longitude 8°51′ 39.19” E. and has an area of 362 km² with a population of 185,189 2006 (NPC, 2006); and the postal code of the area is 713101 (NIPOST, 2009) while Gaya LGA is situated between latitude 11°52′ 38.30″N and longitude 9°00′ 9.72″E. and has an area of 613 km² with a population of 201,016 (NCP 2006); the postal code of the area is 713102 (NIPOST 2009).Gaya and Wudil Hospitals are located at Kano South, Kano State, Nigeria. The principal occupation of the population of the studied areas is farming, Cattle rearing and fishing

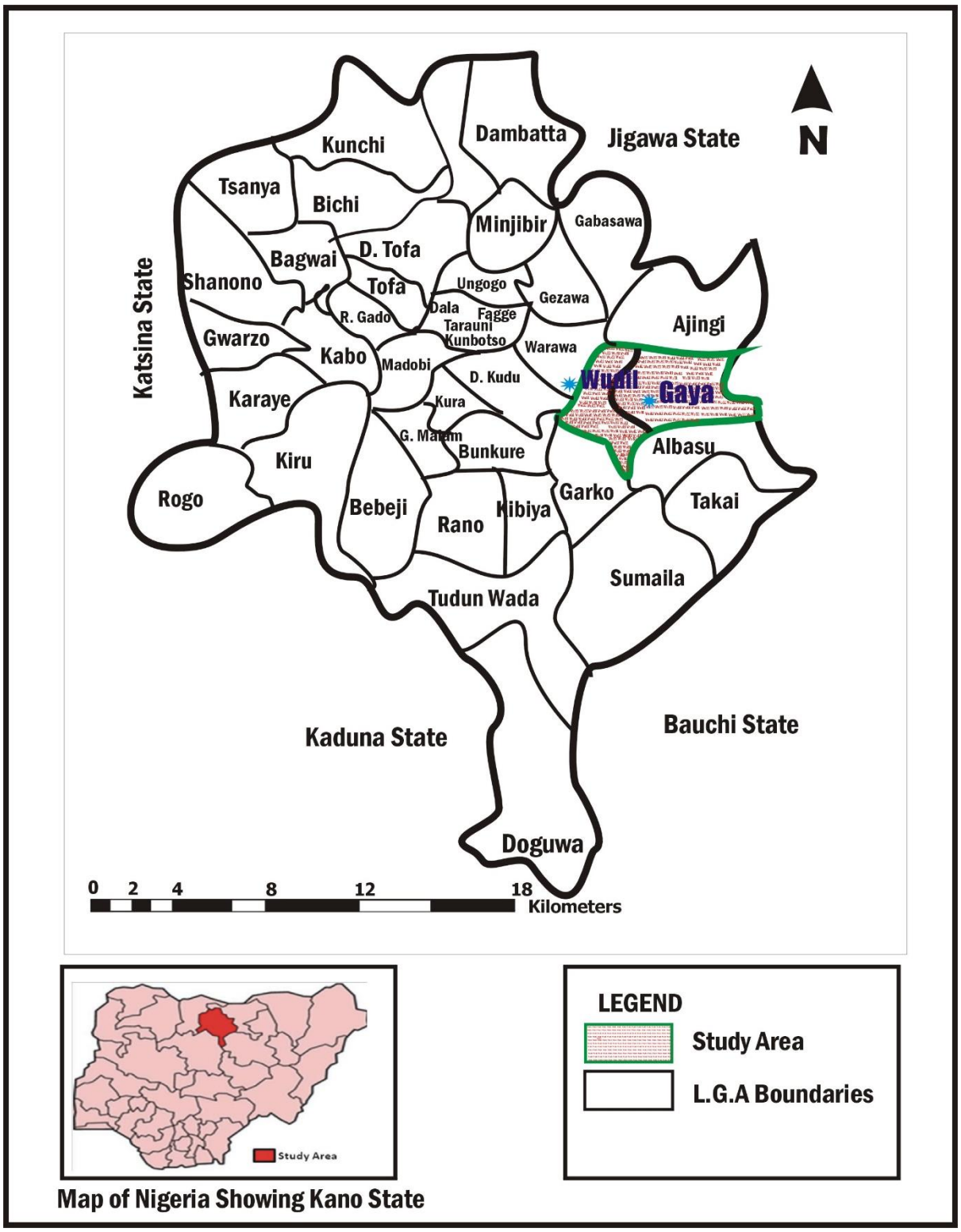

Figure 1. Map of Kano State Showing Study Areas. Source:(GIS Lab ADUSTECH, Wudil, 2021)

Ethical Consideration

Ethical clearance was obtained from the Kano State Hospitals Management Board, before commencement of the work and the patients' consent sought.

Selection Criteria

Inclusion Criteria: Only HIV patient attending Gaya

and Wudil General Hospitals, Kano State, and HIV patient who gave written informed consent in their clinic and agreed to be included in the study.

Exclusion Criteria: HIV patient who did not offer an informed consent to be included in the study, and HIV patient who did not attend Gaya and Wudil General Hospital

Study Design, Sampling Technique and Sample Size

The study design was institutional based cross-sectional study using systematic sampling technique. Sample size was decided based on statistical formula (Araoye 2004) with a previous prevalence of 7.5% from Kano state (Ibrahim *et al*.2017) and desired absolute precision of 5% with 95% C.I (Confidence Interval). Accordingly, a total of 180 subjects were recruited in the study. The study subjects were made up of 110 confirmed HIV Positive patients from Gaya and Wudil and General Hospitals, and (70) apparently healthy Age and Sex matched HIV Negative were used as controls.

Sample Collection

About 3mls of venous whole blood were drawn aseptically from each HIV patient into serum separator tubes. It was then centrifuged at 1000 rpm for 10 minutes and blood sera separated into labeled cryotubes and stored at -20ºC until use. Questionnaire was administered to each consenting participant to assess the socio-demographic characteristics, variable risk factors to *Toxoplasma gondii* infection by the individual. CD4 Cell count of each individual was measured from blood sample of the subjects.

Determination of the *T. gondii* by IgG/IgM ELISA Kit

Quantitative determination of the levels *T. gondii* IgG and antibodies in patient's serum was determined by using commercial ELISA Kit (Teco Diagnostics Kit) according to manufacturer's procedure.

Determination of CD4 Cell count by Flow Cytometry

Blood samples were analyzed for CD4 Tlymphocyte cell estimation using flow cytometry (Partec, GmbH, Germany). 20ml of CD4 PE antibody was placed into a Partec test tube and 20ml of well-mixed whole EDTA blood was added, mixed gently and incubated in the dark for 15 minutes at room temperature. The mixture was agitated during incubation every 5 minutes. Eight hundred micro liters of CD4 buffer was added to the mixture of antibody and sample and mixed gently. This was then plugged to the counter for counting as described by Akinbo *et al*. (2010).

Determination of Viral Load

The Viral load was determined by Abbott Realtime HIV-1m2000rt which is an automated machine. The AmpliScreen HIV-1 Test, version 1.5 (v1.5) is a qualitative *in vitro* test for the direct detection of Human Immunodeficiency Virus Type 1 (HIV-1) RNA in human plasma. HIV-1 RNA in plasma can be detected by nucleic acid amplification technologies, such as the Polymerase Chain Reaction (PCR), the AmpliScreen HIV-1 Test, v1.5 uses PCR technology to achieve maximum sensitivity for the detection of HIV-1 RNA in plasma samples (Mulder *et al.* 1994).

Statistical Analyses

The data analysis was performed by Chi-square test using the statistical software: Minitab R integration packages Version 0.3.1. Chi-Square (X^2) was used to analyze the associations between sero-prevalence and influence of risk factors including Gender, Age, etc. The differences were considered statistically significant at $P<0.05$.

RESULTS AND DISCUSSION

The overall prevalence of Anti-Toxoplasma antibodies found by ELISA is presented in Table 1. Out of 110 HIV-Positive Patients sampled (Cases) and 70 HIV-Negative (Control) from Gaya and Wudil General Hospitals, 29.44% indicated symptoms of toxoplasmic infection. The maximum frequency of 31.11% was identified among patients from Gaya General Hospital whereas substantially lower prevalence (27.78%) of the infection was recorded among patients from Wudil General Hospital.

Table1: **Overall Prevalence of Toxoplasmosis among the Cases and Control Attending Gaya and Wudil General Hospitals**

Health Facility	No. Examined	No. of Case Positive	No. of Control Positive	Percentage of Positive (%)	X^2	P Value
Gaya G. H.	90	22	6	31.11%	0.783	0.376
Wudil G. H.	90	16	9	27.78%		
Total	180	38	15	29.44%		

Key: G. H. = General Hospital

Socio-Demographic Characteristics of the Study Population

The distribution of cases and controls of Age frequency is provided in Table 2. The subjects attending Gaya and Wudil General Hospitals, in both age frequency were highest among age group between 26-35 years (40.0%) for cases and (42.8%) for control at Gaya General Hospital and 34.5%for cases; but between the ages of 15-25 it was 31.4% for control at Wudil General Hospital, while age group between 56 to above years had the least prevalence of the infection for cases (9.1% and 5.5%) and controls (8.6% and 8.6%) at both Gaya and Wudil General Hospitals, respectively.

Table 2: Age Frequency Distribution of Cases and Controls Attending Gaya and Wudil General Hospitals

	Gaya		Wudil			
Age Group (Years)	**Case (%)**	**Control (%)**	**Case (%)**	**Control (%)**	**X^2**	**P-Value**
15-25	8 (14.5)	7 (20.0)	14 (25.5)	11 (31.4)	10.712	0.554
26-35	22 (40.0)	15 (42.8)	19 (34.5)	10 (28.6)		
36-45	11 (20.0)	16 (45.7)	12 (21.8)	9 (25.7)		
46-55	9 (16.4)	4 (11.4)	7 (12.7)	2 (5.7)		
56 to Above	5 (9.1)	3 (8.6)	3 (5.5)	3 (8.6)		
Gender						
Male	21 (38.2)	12 (34.3)	25 (45.5)	16 (45.7)	1.603	0.659
Female	34 (61.8)	23 (65.7)	30 (54.5)	19 (54.3)		
Educational Level						
Islamic	19 (34.6)	5 (14.3)	18 (32.7)	14 (40.0)	14.291	0.112
Primary	8 (14.5)	7 (20.0)	9 (16.4)	10 (28.6)		
Secondary	15 (27.3)	10 (28.6)	18 (32.7)	4 (11.4)		
Tertiary	13 (23.6)	13 (37.1)	10 (18.1)	7 (20.0)		

The results from Table 2 also indicated that the highest prevalence of taxoplasmosis occurred among Female (61.8%) for cases at Gaya while it was 54.5% cases at Wudil General Hospital. Male had comparatively the least prevalence cases (38.2%. 45.5%) and controls (34.3%, 45.7%) at both Gaya and Wudil General Hospitals.

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Table 3: Distribution of Risk Factors for the Transmission of *T. gondii* among Cases and Controls Attending Gaya and Wudil General Hospitals

	Gaya		Wudil			
Risk Factor	**Case (%)**	**Control (%)**	**Case (%)**	**Control (%)**	**X^2**	**P-Value**
Eating unwashed Vegetable	47 (85.4)	23 (85.4)	39 (71.0)	28 (80.0)	1.169	0.279
Eating Uncooked Meat	29 (52.7)	15 (42.8)	15 (27.3)	9 (25.7)	0.079	0.001
Soil contact	38 (69.1)	26 (74.2)	42 (76.4)	20 (57.1)	0.951	0.329
Blood Transf.	15 (27.3)	6 (17.1)	11 (20.0)	10 (28.6)	1.615	0.204
Keeping Cat	18 (32.7)	9 (25.7)	15 (27.3)	10 (28.6)	0.249	0.002
Handling cat liter	15 (27.3)	5 (14.3)	10 (18.2)	7 (20.0)	1.097	0.295
Clinical Symptoms						
Headache	17 (77.3)	11 (34.4)	10 (62.5)	8 (20.5)	0.120	0.022
Fainted	7 (31.8)	0 (0.0)	2 (12.5)	1 (2.5)	0.637	0.425
Fever	12 (54.5)	21 (63.6)	6 (37.5)	29 (74.4)	3.334	0.073
Weakness of limb	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	____	____
Weakness of mouth-side	0 (0.0)	0 (0.0)	2 (12.5)	0 (0.0)		1.000
Difficulty in swallowing	0 (0.0)	8 (24.2)	4 (25.0)	0 (0.0)		1.000
Difficulty in walking	4 (18.1)	0 (0.0)	0 (0.0)	1 (2.5)		0.000
Difficulty in speech	8 (36.4)	6 (18.1)	12 (75.0)	5 (12.8)	0.606	0.436
Cough	8 (45.5)	15 (45.4)	12 (75.0)	12 (30.7)	1.113	0.292
Difficulty in breathing	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	____	____

Moreover, the result in table 2 showed that the prevalence of the infection was highest (34.6%) among subjects that attended Islamic school for cases and 31.7% among those that attended tertiary school for control while the least prevalence was among subjects that attended primary school 14.5% for cases and 14.3% (control) for those that attended Islamic school at Gaya General Hospital. At Wudil General Hospital, the highest (32.7%) prevalence was among subjects that attended Islamic and secondary schools for cases, and 40.0% (control) while the least (16.4%) prevalence was

among subjects that attended primary school and 11.4% (control) among those that attended secondary school.

Epidemiology and Clinical Characteristics

The distributions of risk factors for the *T. gondii* infection were shown in Table 3. The result indicated that eating unwashed vegetables recorded 85.4% cases and 85.4% in controls from Gaya while 71.0% cases and 80.0% control from Wudil, (X^2 = 1.169 P = 0.279), soil contact had 69.1% cases vs 74.2% controls from Gaya and 76.4% cases vs 57.1% control from Wudil (X^2 = 0.951 P = 0.329), blood transfusion had 27.3% cases vs 17.1% controls from Gaya and 20.0% cases vs 28.6% control from Wudil (X^2 = 1.615 P = 0.204). Keeping Cat had 32.7% cases vs 17.1% control from Gaya and 27.3% cases vs 28.6% control from Wudil (X^2 = 0.249, P = 0.002). Eating undercooked meat had 52.7% cases vs 42.8% controls from Gaya General Hospital and 27.3% cases vs 25.7% control from Wudil (X^2 = 0.079, P = 0.001). The results suggest no significant difference amongst eating unwashed veggies, soil contact, blood transfusing, and handling cat liter but the result among eating undercooked meat and keeping cat reveals significant difference ($P<0.05$). Amongst the signs and symptoms two were found to be significantly commoner amongst anti-*T. gondii* positive subjects than their negative counterparts; Persistent headache had 77.3% anti-*T. gondii* positive vs 34.4% negative from Gaya General Hospital and 62.5% positive vs 20.5% negative from Wudil General Hospital (X^2 = 0.120; P = 0.022). Fainting had 31.8% anti-*T. gondii* positive vs 0.0% negative from Gaya General Hospital and 12.5% positive vs 2.5% negative Wudil General Hospital (X^2 = 0.637; P = 0.425). However, additional signs and symptoms such as weakness of leg, weakness of mouth-side, difficulties in swallowing, difficulty in walking and difficulty in breath were reasonably distributed throughout both Gaya and Wudil General Hospitals, respectively.

Laboratory Characteristics

Table 4 indicated the distribution of CD4+ cell counts between HIV-infected anti-*T. gondii* positive participants and their anti-*T. gondii* negative counterparts. The CD4+ cell counts ≥ 500 cells/µl; 9.1% positive vs 42.4% negative from Gaya and 31.2% positive vs 33.3% negative from Wudil, 200-499 cells/µl; 31.8% positive vs 33.3% negative from Gaya and 18.8% positive vs 41.1% negative from Wudil, below 200 cells/µl; 59.1% positive vs 24.3%nagetive from Gaya and 50.0% positive vs 25.6% negative from Wudil, respectively. The results revealed that there was considerable statistical variation in the prevalence across the four categories of Cd4+ Cell Count (χ^2= 13.239, p = 0.039). The distribution of HIV-1 RNA viral load and anti-*T. gondii* sero-status amongst HIV-infected subjects showed HIV-1 RNA viral load ≥30,000 copies/ml i.e. 50.0% positive vs 27.3% negative from Gaya and 25.0% positive vs 17.9% negative from Wudil General Hospital, 5,000-30,000 copies/ml with 31.8% positive vs 33.3% negative from Gaya and 43.8% positive vs 30.8% negative from Wudil and <5000 copies/ml with 18.2% positive vs 39.4% negative from Gaya and 31.2 % positive vs 51.3% negative from Wudil, respectively. There was statistically significant correlation between the CD4+ cell count and the HIV-1 RNA viral load of HIV-positive patients in the research group. Moreover, the data indicated inverse connection between CD4+ cell count and viral burden.

Table 4: Distribution of Cd4+ Cell Count and Anti-*T. gondii* Status of the Study Population Attending Gaya and Wudil General Hospitals

	Anti- *T. gondii* Status					
	Gaya		Wudil			
CD4 Cell	**Positive (%)**	**Negative (%)**	**Positive (%)**	**Negative (%)**	**X^2**	**P-Value**
≥ 500	2 (9.1%)	14(42.4%)	5(31.2%)	13(33.3%)	13.239	0.039
200-499	7(31.8%)	11(33.3%)	3(18.8%)	16(41.1%)		
0-199	13(59.1%)	8(24.3%)	8(50.0%)	10(25.6%)		
Total	22(100%)	33(100%)	16(100%)	39(100%)		
Viral Load						
> 30,000	11 (50.0%)	9 (27.3%)	4 (25.0%)	7 (17.9%)	5.898	0.435
5000-30000	7 (31.8%)	11(33.3%)	7 (43.8%)	12 (30.8%)		
< 5000	4 (18.2%)	13 (39.4%)	5 (31.2%)	10 (51.3%)		
Total	22 (100%)	33 (100%)	16 (100%)	39 (100%)		

The overall prevalence (29.44%) of toxoplasmosis among HIV-Patients from Gaya and Wudil General Hospitals indicated signs of toxoplasmic infection. *T. gondii* seroprevalence and can be classified as relatively low in the study area when compared to previously reported figures in certain studies done in the region such as 41.67% in Kwara, 35.62% in Kaduna, 34.05% in Lagos and 41.13% in Rivers (Karshima and Karshima 2020). This finding is similar to those of other studies of sero-prevalence rate, 20%, 22.2%, and 27% which were reported in Eastern Nigeria, Abuja, Nigeria, and Sudan correspondingly (Uttah *et al*. 2013, Ogoina *et al*. 2013, 2018, Mustafa *et al*. 2019). Seropositivity of 27% was also found for *T. gondii* in healthy immunocompetent people in Mali, Africa (Uneke *et al*., 2005). However, the seroprevalence of toxoplasmosis in HIV positive people exhibited a small fluctuation in certain other studies, including 40.8% in Western Iran (Nazari *et al*., 2018), 36.3% in Mazandaran, North of Iran (Rahimi *et al*., 2015). Much lower *T. gondii* sero-prevaleces of 10.8% were reported in Benue (Amuta *et al*., 2012) and 7.53% in Edo (Ogefere *et al*., 2019) while some studies reported a higher sero-prevalence of 44.9%, 49.1%, 60.7%, and 80.8% (Ouologuem *et al*., 2013, Nissapatorn *et al*., 2002, Sukthana, 2006, Daryani *et al*., 2014). These variations in the seroprevalence rate may be attributed to disparity in the sample size, study techniques applied, changes in their way of life, geographical area, climatic conditions as well as prevailing socio- demographic factors pushing the spread of the parasite in the two localities. A study conducted in Northwest Ethiopia (Muluye *et al*. 2013), with lower sample size of study participants, showed much higher (76.5%) prevalence compared to the current study.

In the present study the highest sero-prevalence of taxoplasmosis recorded in the age group between 26-35 years among the patient for both cases and control at Gaya and Wudil General Hospitals, respectively; clearly indicated that there is variation in the prevalence of *T. gondii* with age of HIV tested individuals as affirmed by many authors and this result is in close conformity with the report of Walle *et al*. (2013) who reported the highest prevalence rate in the 21-30-year age group as well as that of Onosakponome *et al*. (2020) who reported highest sero-prevalence of *T.*

gondii among age groups 25-29 years, whereas Zhang *et al*. (2015) showed that the highest prevalence of the disease was in 3rd and 4th decades of life. However, in contrast to our data, Nazari *et al*. (2018), in a comparable study revealed that sero-prevalence was the greatest in the 46 - 60 year age group. Nevertheless, these anomalies can probably be elucidated by the protracted exposure time as the patient continues to age. Although there were no significant correlations between age groups and the sero-prevalence of Toxoplasma spp., it was observed that the seroprevalence of Toxoplasma spp. infection increases with age ascribed to the waning immunity and gradual inception of aging (Uneke *et al*. 2005, Uttah *et al*. 2013). Moreover, age group is recognized as a potential determinant in the prevalence of the condition (Teweldemedhin *et al*. 2019). This might be explained by the assenting interplay between a rise in age and a prolonged risk of exposure to *Toxoplasma gondii* oocysts and viable tissue cysts (bradyzoites) from the flesh of infected animals throughout time (Bigna *et al*. 2020). Furthermore, this can be attributed to the rising tendency of the people to eat raw or undercooked meats, fast foods (burgers and sausages), and/or increased close contact with pet cats as their age increases (Rouatbi *et al*. 2019).

It is found from the present study that females HIV patients had the greatest sero-prevalence of taxoplasmosis than their male counterpart in cases and control at both institutions. This conclusion is in agreement with (Hassan *et al*. 2017, Karshima and Karshima 2020 and Onosakponome *et al*., 2020). Similarly, the sero-prevalence percentages were close to those found in related studies in Abuja (Uttah *et al*. 2013, Malaysia (Nazari *et al*. 2018), Western Iran (Nazari *et al*. 2018), and Northern Mexico (Daryani *et al*. 2014), demonstrating that *T. gondii* seroprevalence was not sex-related. However, in contrast to this, Walle *et al*. (2013) showed a considerably greater prevalence rate of toxoplasma infection in males than females in a multivariate model and may be attributable to variations in socializing behavior or environmental exposure of males compared to females.

In this study it was observed that majority of Islamic subjects were identified amongst the cases, while on the other hand most of the control subjects had tertiary level of education. This finding may reflect lack of education or ignorance as one of the variables responsible for the acquisition of both HIV and *T. gondii* infection amongst the study population. The results demonstrate similarity with those of Olusi *et al*. (2018) and Mustafa *et al*. (2019) who reported lack of knowledge about toxoplasmosis among pregnant women in Osogbo, Sothwestern, Nigeria and among apparently immunocompetent Sudanese women, respectively.

The distribution of occupation was highest among House women 32.7% (Cases) versus Students 34.3% (Control) from General Hospital Gaya and Housewives 25.5% (Cases) versus Civil servant with 28.6% (Control) from Wudil General Hospital, respectively. There was no meaningful statistical difference in the prevalence across the different types of occupation. The results demonstrate consistency with findings of (Hassan *et al*. 2017 and Olusi *et al*. 2018). According to this study, eating uncooked vegetables, consuming undercooked meat and contact with soil were factors that strongly influenced the spread of toxoplasmosis. This finding supported the observations in earlier investigations (Uttah *et al*. 2013, Nazari *et al*. 2018). Although not significant, it has also been shown that blood transfusion, and handling cat liter considerably adds to toxoplasmosis as similarly described by Wang *et al*. (2017) and Nguemaïm *et al*. (2020). The Cats play a crucial role in the epidemiology of *T. gondii* and are substantial producers of viable oocysts for environmental contamination (Jiang *et al*. 2018). They can acquire the illness by the ingestion of raw meat with tissue cysts (bradyzoites) from infected animals (Foroutan *et al*. 2016).

Amongst these signs and symptoms two were shown to be considerably amongst anti-*T. gondii* positive

people than their negative counterparts; persistent headache, fainted, difficulty in speech, and cough, from Gaya and Wudil General Hospitals, respectively. However, additional indications and symptoms; weakness of Limb, weakness of mouth-side, difficulty in swallowing, difficulty in walking and difficulty in breath were fairly distributed throughout both Gaya and Wudil General Hospitals.

The distribution of CD4+ cell counts amongst HIV-infected anti-*T. gondii* positive participants with <200 cells/μL showing they were more immonucompromised than *T. gondii* negative. The results suggested there was major statistical difference in the prevalence across the different groups of CD4+ cell count. This finding demonstrated consistency with the findings of (Oluwatoyin *et al*. 2015 and Hassan *et al*. 2017). This is not surprising given past investigations by Wong and co-workers have demonstrated that various opportunistic infections in the setting of HIV/AIDS (particularly parasitic) can induce drop in CD4+ cell counts without necessarily producing an increase in viral replication rate (Zanger *et al*., 2011). Reactivation of latent toxoplasmosis has been identified as the most prevalent form of the infection in HIV/AIDS patients and is related with toxoplasma encephalopathy notably in individuals with CD4 count< 200 cells/μL (Mukherjee and Kumar 2017). Moreover, CD4+ T cells played a vital part in fortification against intracellular protozoan parasites such as *T. gondii* since the cells produce critical effector cells that help control the parasite recrudescence during HIV infection (Zhou *et al*. 2011, Kodym *et al*. 2015).

There is a higher toxoplasma seroprevalence in both HIV infected and non-infected persons that is statistically substantially different between the two categories. Studies from Mozambique (Sitoe *et al*. 2010) found similar higher toxoplasmosis occurrence in the HIV-positive groups as compared to HIV-negative groups that according to the author could be ascribed to an increase in risky behavior in toxoplasma infected individuals that leads to increased exposure to HIV infection. Such a change in behavior could be related to parasite-driven personality alterations, as observed in toxoplasma-infected persons by others (Fleger *et al*. 1996). According to Walle *et al*. (2013) toxoplasma infection is a marker of exposure to dangerous social connections or habits, which correlates with early HIV infection. The distribution of HIV-1 RNA viral load and anti-*T. gondii* sero-status amongst HIV-infected subjects is rather clear as anti-*T. gondii* positive people represented a considerable majority amongst subjects. A similar observation was made by (Azovtseva *et al*. 2020 and Made *et al*. 2021). The observed disparities in prevalence of anti- *T. gondii* antibodies could be attributable to differences in geographical distribution and/ or probable risk factors and socioeconomic conditions (Alvarado-Esquivel *et al*. 2012) contributing to contracting the infection.

CONCLUSION

The study has demonstrated that *T. gondii* infection is more prevalent among HIV positive persons compared to controls. Gaya General Hospital has the maximum frequency while the Wudil General Hospital has least prevalence. It has been found that keeping cat, soil contact, intake of unwashed vegetables, and undercooked meat were the commonest risk factors for the transmission of *T. gondii*. Fever, Persistent headache and problems in speech were identified to be the commonest signs of toxoplasmic infection among anti-*T. gondii* positive HIV-infected people.

There was an inverse correlation between the anti-*T. gondii* IgG titre and the CD4+ cell count of HIV-infected patients as the CD4 cell count decreases, the viral load increases. Moreover, anti-*T. gondii* positive patients have been demonstrated to have a dramatically lower mean CD4+ cell count, and a relatively higher mean HIV-1 RNA virus load compared to their negative counterparts. Measures should also be taken to prevent stray cats from entering homes. More research is needed in Kano State to adequately identify the epidemiology of Toxoplasmosis.

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