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## Seroprevalence of *Toxoplasma gondii* IgG and IgM antibodies and associated risk factors among pregnant women consulted in three health centers in Dschang, Cameroon

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## ABSTRACT

**Background:** Toxoplasmosis is a zoonosis caused by *Toxoplasma gondii*, an obligate intracellular protozoan responsible for one of the most common congenital infections in the world. This study aimed to determine the seroprevalence and risk factors associated with toxoplasmosis in pregnant women consulted in three health centers in the city of Dschang.

**Methods:** This study was a cross-sectional study that was conducted, with a total of 242 participants. A questionnaire was administered after obtaining the free and informed consent of the participants. Blood sample was collected to assay IgG and IgM antibodies specific to *Toxoplasma gondii* using the enzyme-linked immunosorbent assay (ELISA) kit, and potential risk factors were evaluated with the administration questionnaire using a binary logistic regression model. Statistical significance was measured at  $P < 0.05$ .

**Results:** The overall seroprevalence of toxoplasmosis was 82.7%, with a seroprevalence of toxoplasma IgG of 62.8% (152), that of IgM at 11.6% (28) and that of IgG/IgM at 8.3% (20). The Saint Vincent Paul Hospital had a seroprevalence of 43.8% IgG and 8.7% IgM; followed by the Dschang District Hospital (11.6% IgG and 2.1% IgM). The seroprevalence of toxoplasma IgG (35.5%) and IgM (6.2%) was higher in multiparous pregnant women, and in the group of women who performed their first toxoplasmosis serology in the first trimester of pregnancy, 70 (28.9%), 9 (3.7%) respectively for IgG and IgM. The multivariate logistic regression analysis showed that the possession of a cat at home or its presence in the neighborhood, the consumption of undercooked or uncooked meat and having a history of blood transfusion were found to be statistically significant risk factors associated with toxoplasmosis seroprevalence among pregnant women.

**Conclusion:** The present study revealed a high seroprevalence of toxoplasmosis. Given this high seroprevalence, screening for toxoplasmosis in women of childbearing age should be encouraged.

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## 1. Introduction

Toxoplasmosis is a zoonosis transmitted mainly orally and caused by *Toxoplasma gondii* (*T. gondii*), an obligate intracellular protozoan (Gilberto and Jack, 2008). The definitive host is the cat and humans are intermediate hosts of this parasite. *Toxoplasma gondii* comes in three parasitic forms, namely: tachyzoite, bradyzoite (tissue cyst), and sporozoites which after maturation become the mature oocyst which is the infective form present in nature (Dubey et al., 1998). The transmission of this disease is done by the ingestion of mature oocysts contained in water, food, and soil. It can also be transmitted by the consumption of undercooked or uncooked meat containing bradyzoites (Margareta et al., 2000). Depending on the condition of the placenta and the age of the pregnancy, this contamination may result in spontaneous abortions or serious fetal anomalies (Florence and Marie-Laure, 2012). Pregnant women who are not immunized (negative serology to IgG and Ig M anti-toxoplasmic antibodies) constitute an important risk group. The prevalence of toxoplasmosis varies from one country to another and within the same country, this depends on lifestyle and dietary habits and the level of knowledge of pregnant women about the disease. Previous studies have revealed seroprevalences of 68.4% in Brazil (Da Silva et al., 2015), 36.7% in France (Tourdjman et al., 2015), 42.5% in Malaysia (Andiappan et al., 2014), 9.1% in the United States of America (Jones et al., 2014), 92.5% in Ghana (Ayi et al., 2010) and 30.9% in Tanzania (Mwambe et al., 2013). In Cameroon, recent studies have reported seroprevalences of 45.5% in Mbou'o-Bandjoun (Guemgne Tadjom et al., 2019), 71.8% in Limbe (Ndassi and Kamga, 2014), 78.6% in the city of Douala (Nguefack et al., 2016) and 80% in the city of Yaoundé (Ayeah et al., 2022). Although toxoplasmosis serology is among the examinations for the first prenatal consultation, pregnant women in the city of Dschang neglect this examination because of the lack of knowledge about toxoplasmosis and the high cost of this examination. Moreover, little epidemiological data on toxoplasmosis is available in the city of Dschang, hence the importance of this study. The aim of this study was to determine the seroprevalence of toxoplasmosis and the associated risk factors in the transmission of *Toxoplasma gondii* in the city of Dschang to develop control strategies for this disease.

## 2. Material and methods

### 2.1. Study site

The present study took place in three health facilities, namely, the Dschang District Hospital, Saint Vincent de Paul Hospital, and the Catholic Center Notre Dame de la Santé of Batsingla-Dschang. All these centers are located in the Menoua division, West Cameroon Region. Fig. 1 shows the location of the different health centers.

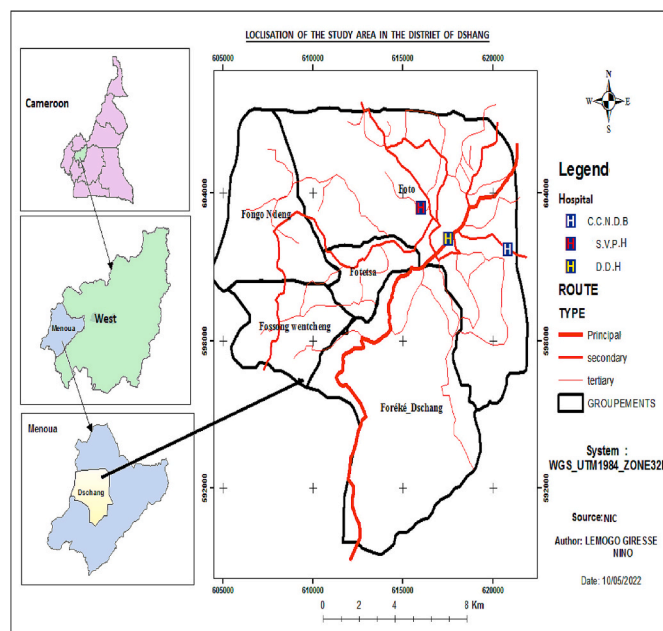


Fig. 1. Map of the city of Dschang showing the location of the different hospitals.

CCNB = Catholic Center Notre Dame de la Santé of Batsingla-Dschang.

SVPH = Saint Vincent Paul Hospital.

DDH = Dschang District Hospital.

NIC = National Institute of cartographic.

## 2.2. Study population and sample size

Our study populations were pregnant women attending antenatal consultations at the Dschang District Hospital, Saint Vincent de Paul Hospital of Dschang, and the Catholic Center Notre Dame de la Santé of Batsingla-Dschang.

The sample size was calculated using Lorenz's formula (StatCalc of EPI Info software). Using the prevalence of 47.2% in Mbouo-Bandjoun, Cameroon, with an 80% power to detect significant associations or differences and a 5% accepted margin of error, the minimal sample size estimate was 382 participants.

## 2.3. Inclusion and exclusion criteria

All pregnant women, attending antenatal consultation in these three hospitals and who signed the informed consent form were included. All pregnant women aged 16 years and whose parents signed the Informed Consent form were included. Were excluded all pregnant women with hemophilia and any pregnant women not residing in Dschang.

## 2.4. Sample Collection and ELISA test for Toxoplasmosis

Once the participant had completed the questionnaire form that covered socio-demographic characteristics and an assessment of knowledge about toxoplasmosis, she was prepared for blood sampling. The blood collection site was cleaned with alcohol and approximately 3 mL of venous blood was collected in a dry tube using a sterile syringe. The blood sample was then centrifuged to obtain serum. The serum samples were tested for *Toxoplasma gondii*-specific IgG and IgM together with an ELISA plate reader using the Toxo-DIALAB® Kit.

## 2.5. Parameters studied and prevalence

The prevalence (P) was calculated using the formula:

$$\text{Prevalence} = \frac{\text{Number of individuals infected}}{\text{Number of individual examined}} \times 100$$

## 2.6. Ethical considerations

Ethical clearance was obtained from the National Committee on Research Ethics for Human Health. This work was carried out in accordance with the Declaration of Helsinki. All ethical rules involving research with disadvantaged groups such as prisoners have been respected. Patients were free to attend the study without any outside constraints.

## 2.7. Statistical analysis

The collected data were analyzed by estimating the proportions and frequencies of variables using Excel 2016 (Microsoft Corp., Washington, USA) and the Statistical Package for the Social Sciences (SPSS Inc., Chicago, Illinois, USA) v.26. Multivariate logistic regression analysis was performed to identify the main risk factors, Chi<sup>2</sup>-square test of independence was used to test the association between the different risk factors and toxoplasmosis seroprevalence. A *P*-value of <5% (*P* < 0.05) with an Odds Ratio > 1 was considered statistically significant at 95% confidence intervals.

## 3. Results

Table 1 presents the general characteristics of the study participants. This table shows that the most represented age group was (Ndamukong-nyanga et al., 2020; Hamaichat, 2020; Villard et al., 2016; Montoya et al., 2009; Mabeku et al., 2018; Mickoto et al., 2010; Nissapatorn and Azmi, 2003; Li et al., 2014; Benkacimi and Ammam, 2017; De Moura et al., 2013; Errifaiy and Moutaj, 2014) years with 116 (47.9%) women, while 121 (50%) participants had a higher level of education. Multiparous women were the most represented, with a total of 136 (56.2%). The majority of pregnant women (105) carried out their first toxoplasmosis serology test in the first trimester of pregnancy. Twenty-eight (11.6%) pregnant women had a history of spontaneous abortions and 204 (85.3%) pregnant women no longer knew their toxoplasmosis serology results from the previous pregnancy.

Table 2 shows the distribution of the study population according to the main risk factors for toxoplasmosis. The table shows that 140 (57.9%) of the pregnant women do not have any knowledge of toxoplasmosis; 152 (62.8%) did not have a cat in their home or neighborhood; 150 (62.0%) of the pregnant women had contact with the soil.

Table 3 shows the seroprevalence of toxoplasmosis according to the three hospital facilities. It can be seen from this table that the Saint Vincent de Paul Hospital had a seroprevalence of 43.8% IgG and 8.7% IgM; followed by the Dschang District Hospital (11.6% IgG and 2.1% IgM). The Catholic Center "Notre Dame de Santé de Batsingla-Dschang" had 7.4% IgG and 0.8% IgM.

Table 4 presents the seroprevalence of toxoplasma IgG and IgM in pregnant women who participated in this study according to sociodemographic characteristics. This table shows that the seroprevalence of toxoplasma IgG and IgM, which designates immunized pregnant women and those with acute infection, was higher in the age group of () years, 76 (31.4%) and 13 (5.4%) respectively for IgG and IgM. The prevalence of toxoplasmosis was also high among female students, i.e., 57 (23.6%) for IgG and 10 (4.1%) for IgM and

**Table 1**  
General characteristics of the study participant.

Variable	Modality	Number (N = 242)	Frequency (%)
Age	<b>[16–26]</b>	<b>116</b>	<b>47.9</b>
	[27–36]	106	43.8
	[37–46]	20	8.3
Level of education	Primary	16	6.6
	Secondary	105	43.4
	<b>University</b>	<b>121</b>	<b>50</b>
	Student	81	33.5
Occupation	Farmers	19	7.9
	House-wife	57	23.6
	<b>Others</b>	<b>85</b>	<b>35</b>
	Primiparous	106	43.8
Parity	<b>Multiparous</b>	<b>136</b>	<b>56.2</b>
	<b>First trimester</b>	<b>105</b>	<b>43.4</b>
Pregnancy age	Second trimester	96	39.7
	Third trimester	41	16.9
	<b>No history</b>	<b>206</b>	<b>85.1</b>
Obstetric history	Malformation	2	0.8
	Spontaneous abortion	28	11.6
	Stillbirth	6	2.5
Previous toxoplasmosis test result	<b>Unknown</b>	<b>204</b>	<b>84.3</b>
	Negative	24	9.9

**Table 2**  
Distribution of the study population according to the main risk factors for Toxoplasmosis.

Variables	Modality	Number (N = 242)	Frequency (%)
Level of knowledge	No knowledge	<b>140</b>	<b>57.9</b>
	Low	91	37.6
	Good	11	4.5
Presence of cats at home or in the neighborhood	Yes	90	37.2
	No	<b>152</b>	<b>62.8</b>
Contact with the soil	Yes	<b>150</b>	<b>62</b>
	No	92	38
Usage of gloves during contact with soil	Yes	42	17.4
	No	<b>108</b>	<b>44.6</b>
Frequent consumption of undercooked meat	Yes	75	31
	No	<b>167</b>	<b>69</b>
	0	25	10.3
Habit of tasting while cooking meat	1	<b>112</b>	<b>46.3</b>
	2	105	43.4
Frequent consumption of raw vegetable	Yes	<b>218</b>	<b>90.1</b>
	No	24	9.9
Eating meals away from home	Yes	<b>126</b>	<b>52.1</b>
	No	<b>116</b>	<b>47.9</b>
Washing fruits and eating vegetables raw	Yes	<b>239</b>	<b>98.8</b>
	No	3	1.2
	Tap water	<b>102</b>	<b>42.1</b>
Source of water	Well	6	2.5
	River	8	3.3
	Drilling	85	35.1
	Others	41	16.9
Previous blood transfusion	Yes	21	8.7
	No	<b>221</b>	<b>91.3</b>

**Table 3**  
Seroprevalence of Toxoplasmosis according to the three hospital facilities.

Variables	Seroprevalence (N = 242) (%)			
	IgG	P	IgM	P
SVPH	106 (43.8%)	0.012	21 (8.7%)	0.298
DDH	28 (11.6%)		5 (2.1%)	
CCNB	18 (7.4%)		2 (0.8%)	

SVPH: Saint Vincent Paul Hospital, DDH: Dschang District Hospital, CCNB: Catholic Center Notre Dame de la Santé of Batsingla-Dschang; P = P-value;

**Table 4**  
Seroprevalence of toxoplasma IgG and IgM according to socio-demographic characteristics.

Variable	Séroprévalence N = 242 (%)					
	IgG	OR	P	IgM	OR	P
Age						
[16–26]	<b>76 (31.4%)</b>	0.789	0.634	<b>13 (5.4%)</b>	0.88	0.874
[27–36]	64 (26.4%)	0.984	0.975	13 (5.4%)	0.795	0.775
[37–46]	12 (5%)	–	–	2 (0.8%)	–	–
Level of education						
Primary	9 (3.7%)	–	–	2 (0.8%)	0.771	0.749
Secondary	66 (27.3%)	<b>1.034</b>	0.904	14 (5.8%)	0.716	0.424
University	<b>77 (31.4%)</b>	<b>1.361</b>	0.567	<b>12 (5%)</b>	–	–
Occupation						
Student	57 (23.6%)	0.632	0.162	10 (4.1%)	0.738	0.544
Gardened	11 (4.5%)	<b>1.091</b>	0.866	3 (1.2%)	0.554	0.419
House wife	33 (13.6%)	<b>1.091</b>	0.802	7 (2.9%)	0.742	0.587
Others	51 (21.1%)	–	–	<b>8 (3.3%)</b>	–	–
Marital status						
Single	35 (14.5%)	0.969	0.934	10 (4.1%)	0.307	0.283
Married	<b>68 (28.1%)</b>	<b>1.275</b>	0.431	<b>13 (5.4%)</b>	0.555	<b>0.042</b>
In relationship with	49 (20.2%)	–	–	5 (2.1%)	–	–

P = P-value; OR = Odds Ratio.

among married women, i.e. 68 (28.1%) and 13 (5.4%) for IgG and IgM respectively. The Risk of IgG positivity was increased with the level of education [secondary education (OR = 1.034,  $P = 0.904$ ) and higher (OR = 1.361,  $P = 0.567$ )]; the job occupation [Gardener (OR = 1.091,  $P = 0.866$ ) and Housewife (OR = 1.091,  $P = 0.802$ )]; and the marital status married [(OR = 1.275,  $P = 0.431$ )], but none of these factors was significant. Only the marital status (married) was associated with IgM positivity, however it seems to be protective (OR: 0.55,  $p = 0.042$ ).

Table 5 shows the seroprevalence of toxoplasma IgG and IgM in pregnant women who participated in the present study according to gynecological history. The seroprevalence of toxoplasma IgG and IgM was higher in multiparous pregnant women, 86 (35.5%) for IgG and 15 (6.2%) for IgM and in the group of women who performed their first toxoplasmosis serology in the first trimester of pregnancy, 70 (28.9%), 9 (3.7%) respectively for IgG and IgM. This high prevalence was also observed in the group of pregnant women who had a history of spontaneous abortion, 20 (8.3%) for IgG and 3 (1.2%) for IgM, and in those who had previous positive toxoplasmosis test results, i.e. 14 (5.8%) for IgG and negative, i.e. 1 (0.4%) for IgM. A history of spontaneous abortion increased the risk to have a positivity of IgG specific to *T. gondii* a, although it was not statistically significant (OR = 2.0,  $P = 0.676$ ). On the other hand, the multivariate logistic regression analysis of the risk factors associated with IgG positivity showed that the positive result of toxoplasmosis test during the previous pregnancy, (OR = 7,  $P < 0.001$ ) is a factor statistically significant risk associated with toxoplasma IgG seropositivity.

Regarding the positivity of IgM anti-toxoplasmosis antibodies, the multiparous status increased this risk, although it was not significant (OR = 1.128,  $P = 0.766$ ).

Table 6 presents the seroprevalence of toxoplasma IgG and IgM in pregnant women who participated in the present study according to the potential risk factors studied. This table shows that the seroprevalence of toxoplasma IgG and IgM was higher in pregnant women who did not have any knowledge about toxoplasmosis, 36.8% and 5.4% respectively. Pregnant women who did not have a cat at home or in the neighborhood had an IgG prevalence 36.4%.

This high prevalence was also observed in women who had contact with the soil (gardening or cultivation), 38.4% for IgG and 7.0% for IgM; and in those who did not use gloves during gardening or cultivation, 28.5% and 5.9% for IgG and IgM respectively. Pregnant women who did not consume undercooked or uncooked meat had a high prevalence 40.5% for IgG and 8.3% for IgM.

Women who frequently consumed raw vegetables and vegetables had a high prevalence, 55.4% for IgG and 10.3% for IgM; the same was true for participants who took meals outside the home, 33.9% and 7.4% respectively for IgG and IgM. Seroprevalence was also high among those who drank tap water, 30.2% for IgG and 6.2% for IgM and among pregnant women who had never been transfused 55.0% and 10.3% for IgG and IgM respectively. The risk of seroprevalence for IgG toxoplasmosis was increased by the level of knowledge of participants about toxoplasmosis [poor (OR = 1.003,  $p = 0.999$ ) and low (OR = 1.094,  $p = 0.892$ )]; source of drinking water [borehole (OR = 1.033,  $p = 0.932$ ). However, there was no statistically significant association,  $p > 0.05$ . The multivariate logistic regression analysis of the risk factors associated with the presence of IgG showed that: possession of a cat at home or in the neighborhood (OR = 1.79,  $p = 0.042$ ); the habit of tasting meat while cooking, at least once during cooking (OR = 0.563,  $p = 0.002$ ) and at least twice during cooking (OR = 14.3,  $p < 0.001$ ) and having been transfused at least once (OR = 6.286,  $p = 0.015$ ), were found in this study to be statistically significant risk factors associated with the prevalence of IgG toxoplasmosis.

The main risk factors associated with the positivity of IgM specific to *T. gondii* are the level of knowledge on toxoplasmosis [poor (OR = 3.663,  $p = 0.078$ ) and low (OR = 2.469,  $p = 0.225$ )]; the habit of tasting meat during cooking [at least once (OR = 1.53,  $p = 0.314$ ), at least twice (OR = 1.917,  $p = 0.409$ )]; taking meals outside the home (OR = 1.767,  $p = 0.173$ ); source of drinking water [borehole (OR = 1.91,  $p = 0.275$ )] and having been transfused at least once (OR = 1.307,  $p = 0.685$ ). But there was no statistically significant association,  $P > 0.05$ .

**Table 5**  
Seroprevalence of toxoplasma IgG and IgM according to gynecological history.

Variables	Seroprevalence N = 242 (%)					
	IgG	OR	P	IgM	OR	P
Parity						
Primiparous	66 (27.3%)	0.959	0.877	13 (5.4%)	–	–
Multiparous	86 (35.5%)	–	–	15 (6.2%)	1.128	0.766
Pregnancy age						
First trimester	70 (28.9%)	0.525	0.086	9 (3.7%)	0.842	0.804
Second trimester	61 (25.2%)	0.602	0.18	16 (6.6%)	0.395	0.159
Third trimester	21 (8.7%)	–	–	3 (1.2%)	–	–
Obstetric history						
Malformation	1 (0.4%)	0.8	0.676	0 (0.0%)	–	–
Spontaneous abortion	20 (8.3%)	2	0.817	3 (1.2%)	–	–
Stillbirth	4 (1.7%)	–	–	0 (0.0%)	–	–
Previous Toxoplasmosis Test						
Negative	12 (5.0%)	–	–	1 (0.4%)	–	–
Positive	14 (5.8%)	7	0.001	0 (0.0%)	–	–

P = P-value; OR = Odds Ratio.

**Table 6**  
Seroprevalence of toxoplasma IgG and IgM with respect to the potential risk factors studied.

Variable		Seroprevalence N = 242 (%)					
		IgG (%)	OR	p	IgM (%)	OR	p
Level of knowledge	No knowledge	89 (36.8%)	1.003	0.997	13 (5.4%)	3.663	0.078
	Low	56 (23.1%)	1.094	0.892	12 (5.0%)	2.469	0.225
	Good	7 (2.9%)	–	–	3 (1.2%)	–	–
Presence of cat at home or in the neighborhood	Yes	64 (26.4)	1.79	0.041	14 (5.8)	1.816	0.140
	No	88 (36.4)	–	–	14 (5.8)	–	–
Contact with the soil	Yes	93 (38.4)	–	–	17 (7.0)	0.941	0.883
	No	59 (24.4)	0.913	0.739	11 (4.5)	–	–
Usage of gloves during contact with soil	Yes	24 (9.9)	0.754	0.445	2 (0.8)	0.336	0.161
	No	69 (28.5)	–	–	14 (5.9)	–	–
Frequent consumption of undercooked meat	Yes	54 (22.3)	1.81	0.042	8 (3.3)	0.878	0.768
	No	98 (40.5)	–	–	20 (8.3)	–	–
Habit of tasting while cooking meat	0	7 (2.9)	–	–	2 (0.8)	–	–
	1	56 (23.1%)	5.563	0.002	11 (4.5)	1.530	0.314
	2	89 (36.8%)	14.304	0.001	15 (6.2)	1.917	0.409
Frequent consumption of raw vegetables	Yes	134 (55.4)	0.532	0.199	25 (10.3)	0.907	0.881
	No	18(7.4)	–	–	3 (1,2)	–	–
Eating meals away from home	Yes	82 (33.9)	1.225	0.447	18 (7. 4)	1.767	0.173
	No	70 (28.9)	–	–	10 (4.1%)	–	–
Washing fruits and eating vegetable raw	Yes	150 (62.)	–	–	28 (11.)	–	–
	No	2 (0.8%)	0.843	0.890	0 (0.0)	–	–
Source of water	Tap water	73 (30.2%)	0.508	0.077	15 (6.2)	0.994	0.991
	Well	4 (1.7%)	0.639	0.627	0 (0.0)	–	–
	River	5 (2.1%)	0.767	0.738	0 (0.0)	–	–
	Drilling	47 (19.4%)	1.033	0.932	7 (2.9)	1.910	0.275
	Others	23 (9.5%)	–	–	6 (2.5)	–	–
Previous blood transfusion	Yes	19 (7.9)	6.286	0.015	3(1.2)	1.307	0.685
	No	133(55.0)	–	–	25(10.3%)	–	–

P = P-value; OR = Odds Ratio.

#### 4. Discussion

This study aimed to establish the seroprevalence of toxoplasmosis and its risk factors among pregnant women followed at the antenatal clinic in three health facilities of Dschang. This study represents the first published data analysis of toxoplasmosis seroprevalence in the city of Dschang, in the Western Region of Cameroon.

The overall seroprevalence of toxoplasmosis reported by this study was 82.7% (62.8% for IgG, 11.6% for IgM and 8.3% for IgG/IgM), which is close to the 78.6% reported by Nguefack et al. in the city of Douala, Cameroon (Nguefack et al., 2016). The seroprevalence obtained in this study is significantly higher than in most studies conducted in Cameroon: 34.5% in the Bamenda Regional Hospital (Nguemaim et al., 2020), 32.5% in Buea (Ndamukong-nyanga et al., 2020), and 45.5% in Mbouo-Bandjoun, Western Region of Cameroon (Guemgne Todjom et al., 2019). This high prevalence obtained in the present study is probably due to the fact that



pregnant women in the city of Dschang are unconsciously exposed to the main risk factors associated with toxoplasmosis. Such variations in toxoplasmosis seroprevalence may be due to differences in geographical location, characteristics of pregnant women such as age, educational level, cat handling, hygienic and feeding habits. The use of different serological methods may also be responsible for discrepancies (Hamaichat, 2020).

The majority (62.8%) of pregnant women were seropositive for IgG antibodies specific to *Toxoplasma gondii*, indicating that most infections were old or latent. The presence of IgM antibodies suggests a recent infection (Ndamukong-nyanga et al., 2020). In this study, the specific IgM seroprevalence was 11.6%, higher than the 1.3% reported by Nkain et al. (Ayeah et al., 2022) in Yaounde, Cameroon. This could be explained by the fact that pregnant women in the town of Dschang are exposed to toxoplasma risk factors, thus increasing the risk of seroconversion. The low IgM seroprevalence reported in this study is due to the fact that during *T. gondii* infection, IgM antibodies tend to appear earlier and are therefore the first class of antibodies detected after a primary infection. However, they also disappear very quickly compared to IgG antibodies and this is probably why most of the antibodies detected by seroprevalence studies are of IgG type (Villard et al., 2016). This could also be an indication of the low active transmission of toxoplasmosis.

The high seroprevalence of toxoplasma IgG may indicate that most pregnant women were infected perhaps 6–12 months before pregnancy, as reported by previous authors (Montoya et al., 2009). Generally, women who are infected with toxoplasmosis before pregnancy do not usually transmit the infection to their fetuses as they are thought to have acquired immunity (Hamaichat, 2020).

Regarding the study sites, the seroprevalence of toxoplasmosis was found to be higher at the Saint Vincent de Paul Hospital in Dschang (43.8%) compared to the other hospitals. The difference in IgG seroprevalence between Saint Vincent de Paul Hospital in Dschang and the other hospitals was statistically significant. However, this was not the case for IgM seroprevalence, ( $p = 0.012$ ). This could be explained by the unequal number of pregnant women consulted in each hospital.

Although the (Ndamukong-nyanga et al., 2020; Hamaichat, 2020; Villard et al., 2016; Montoya et al., 2009; Mabeku et al., 2018; Mickoto et al., 2010; Nissapatorn and Azmi, 2003; Li et al., 2014; Benkacimi and Ammam, 2017; De Moura et al., 2013; Errifaiy and Moutaj, 2014) years age group had a higher prevalence of toxoplasma IgG and IgM (31.4% and 5.4%, respectively), it was not found to be a risk factor for toxoplasmosis seropositivity, as age was not statistically significant in this study. This result is in agreement with that reported by Nguemaim et al. (Nguemaim et al., 2020). This could be justified by the fact that it is during this part of life that women are sexually active and therefore pregnant. Furthermore, a 16 year old child had not had enough time to have University education. On the other hand, age was a statistically significant risk factor associated with toxoplasma IgG positivity in a study conducted by Nkain et al. (Ayeah et al., 2022) on the Seroprevalence of Gestational and Neonatal Toxoplasmosis as well as Risk Factors in Yaoundé, Cameroon. This highlight the importance of educating young women of childbearing age about the risk factors for Toxoplasma infection.

The results of the present study reported a high seroprevalence among pregnant women with a secondary level of education (27.3%) and among those with a higher level of education (31.4%), but was not significantly associated with toxoplasmosis seroprevalence. This result corroborates that of Hamaichat et al. in Morocco (Hamaichat, 2020), so the level of education does not affect the immune status of pregnant women butare contradictory to those of Nkain et al. who reported that pregnant women with primary education were 3.9 times more likely to be infected with *T. gondii* than those with secondary education (Ayeah et al., 2022). This probably indicates that a low educational level is a risk factor associated with toxoplasmosis in pregnant women. Since women with a high level of education are more aware of the parasitic disease, it can be said that the high level of education (mostly higher in the present study) is an aid to the knowledge of toxoplasmosis due to the presence of great opportunities to acquire scientific knowledge.

The occupation of pregnant women (23.6% for students and 21.1% for those in occupations other than those mentioned in the survey form) was found to be a non-statistically significant toxoplasmic risk factor. This observation was reported by Nkain et al. (Ayeah et al., 2022). This could be explained by the fact that employed women are always in contact with their family and friends, which facilitates the exchange of information and the dissemination of knowledge. This result contrasts with that obtained by Kouitcheu et al. in Penka-Michel, who reported a statistically significant association between pregnant housewives and the seroprevalence (47.4%) of toxoplasmosis (Mabeku et al., 2018). This could be explained by the fact that the majority of participants in this study were in occupations (students and others) that did not expose them to *T. gondii*.

Regarding marital status, a statistically significant association was observed in married women with seroprevalence (28.1% IgG and 5.4% IgM). This result is close to the 34.1% reported by Mpiga in Gabon (Mickoto et al., 2010), which could be due to the fact that the population of pregnant women who took part in this study was mainly married women with almost no knowledge of toxoplasmosis. In contrast, Nkain et al found no significant association between marital status and toxoplasmosis seroprevalence. This discrepancy could be explained by the difference in sensitivity and specificity of the analytical methods (Ayeah et al., 2022).

The results of the present study revealed a high seroprevalence of 35.5% in multiparous pregnant women, multivariate logistic regression analysis showed that there was no statistically significant association between parity and seroprevalence of toxoplasmosis. This is in line with the study conducted by Nkain et al in the city of Yaoundé (Ayeah et al., 2022) and by Hamaichat in Morocco (Hamaichat, 2020). This result could be due to the fact that the difference in numbers between multiparous and primiparous participants was not great. In contrast, a study by Nissapatorn (Nissapatorn and Azmi, 2003) in Malaysia found a significant association between high seroprevalence rates and parity.

The seroprevalence of toxoplasmosis in pregnant women in the first trimester of pregnancy was 28.9% IgG and 3.7% IgM, but no significant association was reported between the age of pregnancy and toxoplasmosis seroprevalence, which is in agreement with the results reported by Nkain (Ayeah et al., 2022).

Pregnant women with a history of spontaneous abortion had a high risk of being seropositive for toxoplasma IgG and IgM. However, there was no statistically significant association. This is in agreement with the results of Li et al. who reported that pregnant

women with a history of spontaneous abortion were more infected with *T. gondii* than those without obstetrics history (Li et al., 2014). This obstetrics history may also be due to other conditions that have the same effects as toxoplasmosis in pregnant women. These include syphilis, cytomegalovirus, rubella, and others.

It was also noted in this study that pregnant women with positive toxoplasmosis result in the previous pregnancy were significantly seropositive (5.8%) to toxoplasma IgG, but not to IgM. These results could be explained by the fact that a first toxoplasmic infection induces the production of specific IgM and IgG antibodies against *T. gondii*, IgG can induce a lifetime protective immunity (Hamaichat, 2020).

Regarding the level of knowledge about toxoplasmosis, women with no knowledge had a seroprevalence of 36.8% and 23.1% for those with low knowledge. This observation clearly shows that seroprevalence is higher when pregnant women do not know about the disease. However, no significant association was reported between the level of knowledge and toxoplasmosis seropositivity. These results are consistent with those obtained by Kacimi and Ammam (Benkacimi and Ammam, 2017). This could be due to the lack of information characterized by the absence of awareness on the part of the health authorities.

Cat ownership at home or neighborhood was found to be a statistically significant risk factor associated with the seroprevalence (26.4%) of toxoplasma IgG. This result corroborates that reported by Guemgne et al. in a study conducted in Mbouo-Badjoun (Guemgne Todjom et al., 2019) and that reported by Nguetack et al (Nguetack et al., 2016). This could be explained by the fact that the presence of a cat at home can cause zoonosis facilitated by the handling of cat litter. Nguemaim et al. (Nguemaim et al., 2020) on the other hand, demonstrated the opposite in a study conducted at the Bamenda Regional Hospital.

Agriculture and gardening (contact with soil) were not significantly associated with toxoplasma IgG and IgM seropositivity. This result corroborates that of Nguemaim et al. (Nguemaim et al., 2020). This result could be explained by the fact that pregnant women in the present study were mostly engaged in activities other than agriculture, and by the fact that the frequency of cats in Dschang is likely to be low. Since the frequency of contamination largely depends on the density of cats contaminating the soil through their defecation.

Observations from this study showed that the consumption of undercooked or uncooked meat and the habit of tasting meat during cooking (at least once or twice) are statistically significant risk factors associated with the seropositivity of toxoplasmosis. This result corroborates that reported by Hamaichat in Morocco (Hamaichat, 2020), who found a positive correlation between the consumption of undercooked or uncooked meat and the seroprevalence of toxoplasmosis. This is probably due to the fact that undercooked or uncooked meat contains tissue cysts of the *T. gondii* parasite. Contrary to our results, Nguetack et al. (Nguetack et al., 2016) did not find a significant correlation between the consumption of undercooked or uncooked meat and the potential risk of acquiring toxoplasmic antibodies. This difference could be explained by the different dietary habits of the participants in each study. It could also be explained by the analytical methods used in these studies.

Frequent consumption of raw vegetables was not a statistically significant risk factor. These same results were observed by Errifaiy (Errifaiy and Moutaj, 2014). On the other hand, studies conducted by Iharti (Iharti and Moutaj, 2019) and Akourim (Akourim and Moutaj, 2016) showed that there is no correlation between the consumption of raw vegetables and *T. gondii* infection.

The results of the present study showed that pregnant women with a history of blood transfusion were 6.286 times more likely to test positive for *T. gondii* than those who had not. This can be explained by the fact that *T. gondii*-specific antibodies in a donor's blood are likely to be transfused to the recipient. The same is true for tachyzoites, which may be transfused if the donor has an acute toxoplasma infection (Hamaichat, 2020).

## 5. Conclusion

In general, this study reveals that there were pregnant women with recent toxoplasmosis infection and pregnant women who were not immune to toxoplasmosis in the different health facilities of the city of Dschang and that they were at risk of giving birth to children with congenital toxoplasmosis. Despite the high rate of immunity observed in these pregnant women and those with recent infections, screening for toxoplasmosis in women of childbearing age should be encouraged. Toxoplasmosis surveillance should be strengthened to reduce the burden of congenital toxoplasmosis in Cameroon.

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## Authors' contributions

NACN, YC, SNSR and KFHL conceived the idea and designed the study. LGN, NDA, NOC, DDE and NKJA performed the experiments. YC and LGN analyzed and interpreted the data. NACN, SNSR and YC drafted the manuscript. All authors read and approved the final manuscript.

## Declaration of Competing Interest

The authors declare that no conflicts of interest exist.



## Data availability

All data generated and analyzed are included in this research article.

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