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Serological Assessment of Toxoplasma gondiiInfection Among Female Patients in Western Libya

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التقييم المصلي لعدوى طفيلي Toxoplasma gondii لدى المريضات في غرب ليبيا

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Abstract:
The study aimed to estimate the prevalence of toxoplasmosis among non-pregnant females and to evaluate its association with age, geographic distribution, and temporal variation.A descriptive cross-sectional analytical study was conducted during 2024–2025, including 362 non-pregnant females from multiple medical laboratories in Western Libya. Serological testing for IgG and IgM antibodies was performed. Statistical analyses included chi-square tests, logistic regression, and trend analysis. The overall prevalence of infection was 30.4%. The highest prevalence was observed in the 31–40 age groups (41.4%). No statistically significant association was found between infection and age ($p = 0.25$) or region ($p = 0.097$). IgM positivity was rare (3.3%) and always accompanied by IgG. No significant temporal ($p = 0.52$) or seasonal variation ($p = 0.60$) was observed. Toxoplasmosis is endemic among non-pregnant females in the study area, with stable prevalence and no significant demographic predictors. Preventive strategies and public health interventions are essential to reduce infection risk.

Keywords: *Toxoplasma gondii*, seroprevalence, toxoplasmosis, Libya, epidemiology.

الملخص:
داء المقوسات هو مرض طفيلي منتشر عالميًا وله آثار صحية عامة وهامة، لا سيما بين النساء في سن الإنجاب. هدفت هذه الدراسة إلى تقدير مدى انتشار داء المقوسات بين النساء غير الحوامل، وتقييم علاقته بالعمر والتوزيع الجغرافي والتغير الزمني. أُجريت دراسة تحليلية وصفية مستعرضة خلال الفترة 2024-2025، شملت 362 امرأة غير حامل من عدة مختبرات طبية في غرب ليبيا وأُجريت اختبارات مصلية للأجسام المضادة من نوع IgG وIgM. شملت التحليلات الإحصائية اختبارات مربع كاي، والانحدار اللوجستي، وتحليل الاتجاه. بلغ معدل انتشار العدوى الإجمالي 30.4%. سُجل أعلى معدل انتشار في الفئة العمرية 31-40 عامًا (41.4%). لم يُلاحظ وجود ارتباط ذي دلالة إحصائية بين العدوى والعمر (p = 0.25) أو المنطقة (p = 0.097). كانت نسبة إيجابية الأجسام المضادة من نوع IgM نادرة (3.3%)، وكانت مصحوبة دائمًا بوجود الأجسام المضادة من نوع IgG. لم تُلاحظ أي اختلافات زمنية (p = 0.52) أو موسمية

(p= 0.60) ذات دلالة إحصائية. داء المقوسات مرض مستوطن بين الإناث غير الحوامل في منطقة الدراسة، مع معدل انتشار مستقر وعدم وجود مؤشرات ديموغرافية ذات دلالة إحصائية. تُعدّ الاستراتيجيات الوقائية وتدخلات الصحة العامة ضرورية للحد من خطر الإصابة.

الكلمات المفتاحية: الانتشار المصلي، داء المقوسات، ليبيا، علم الأوبئة.

Introduction:

Toxoplasmosis is a worldwide distributed disease caused by an obligate unicellular - celled protozoan parasite (*Toxoplasma gondii*). It is considered one of the most widespread parasitic infections affecting humans [1]. The parasite is capable of infecting a wide range of warm-blooded animals, including humans, and is primarily transmitted through the ingestion of oocysts from contaminated food or water, consumption of undercooked meat containing tissue cysts, or congenitally from mother to fetus [2].

In immunocompetent individuals, infection is often asymptomatic; however, it poses a major public health concern for women of reproductive age, especially pregnant women, due to vertical transmission risks. Congenital toxoplasmosis can cause miscarriage, stillbirth, or serious neurological and ocular complications in the newborn, including hydrocephalus, intracranial calcifications, and chorioretinitis [3]. Several epidemiological studies have estimated that approximately one-third of the world's population is infected with *Toxoplasma gondii*, with prevalence varying by region: 10–30% in North America, Southeast Asia, and Northern Europe, 30–50% in Central and Southern Europe, and up to 80% in Latin America and tropical countries [4].

In the United States, more than 40 million people are estimated to be infected [5]. Another analysis, based on 152 studies including 648,010 individuals, found that 166,225 tested positive for *T. gondii*. Prevalence in these studies ranged from 8.5% to 87.7%, with a global average of 25.7%. Across continents, Africa showed the highest rate at 61.4%, followed by Oceania at 38.5%, South America at 31.2%, and Europe at 29.6%. In the United States and Canada, prevalence was about 17.5%, while Asia had the lowest rate at 16.4% [6]. Serological testing is one of the essential tools for diagnosing toxoplasmosis among women. Measurement of IgG and IgM antibodies helps differentiate between recent and past infections. Women of reproductive age are particularly at risk due to thepossibility of vertical transmission to the fetus, which may result in miscarriage, stillbirth, or congenital malformations. Several factors include raw meat and food, which are a concern due to the presence of *Toxoplasma gondii* cysts. Cats are also a risk factor as they are the definitive host, especially through exposure to their feces or direct contact. Low levels of awareness among individuals also contribute to the risk, and women of childbearing age are at the highest risk due to the potential for transmission to the fetus during pregnancy.

In Libya, toxoplasmosis represents a significant public health concern due to the widespread prevalence of infection, traditional dietary habits involving undercooked meat, and the common practice of keeping domestic cats. Assessing the seroprevalence of *T. gondii* among Libyan women is therefore a crucial step toward raising awareness, implementing screening programs, and reducing risks for pregnant women, ultimately contributing to public health improvement [7]. This project investigates the prevalence of *Toxoplasma gondii* infection among women in Western Libya by detecting IgG and IgM antibodies using recent laboratory data. It also seeks to explore how infection rates vary across different age groups and to relate the findings to demographic factors such as age and area of residence.

Ultimately, the study intends to provide up-to-date local information that can support the development of awareness programs and public health strategies for women of childbearing age. Understanding these patterns is crucial because *Toxoplasma gondii* infection can have serious consequences during pregnancy, including miscarriage and congenital complications. The lack of current epidemiological data in this region limits targeted prevention efforts and health education initiatives, highlighting the need for evidence-based strategies. This study assumes that the seroprevalence of toxoplasmosis among female patients in our region is higher than expected and may be affected by several local risk factors. These factors include contact with cats, eating undercooked meat, poor food hygiene, and limited awareness about the modes of transmission of the infection. In addition, it is expected that IgG antibodies will be detected more frequently than IgM antibodies, which indicates previous exposure to the parasite rather than a recent infection among the studied females.

Literature review:

Toxoplasmosis is a globally prevalent parasitic infection caused by *Toxoplasma gondii*, an obligate intracellular protozoan belonging to the phylum Apicomplexa [8]. Human infection commonly occurs through ingestion of contaminated food or water or exposure to oocysts shed in cat feces [9]. Due to the severe consequences of primary infection during pregnancy, particularly congenital toxoplasmosis, numerous studies have focused on assessing the seroprevalence of *T. gondii* among women of reproductive age.

A systematic review conducted in Iran synthesized data from 83 studies published between 1994 and 2017 and reported a pooled seroprevalence of 43% among pregnant women and 33% among girls and women of childbearing age. The study identified age, gestational age at conception, and contact with cats as significant risk factors, highlighting that a substantial proportion of women remained seronegative and therefore susceptible to primary infection [10].

In contrast, lower seroprevalence rates have been reported in developed and high-income settings. A study conducted in the United States between 2011 and 2014 analyzed data from 13,507 participants and found an overall seroprevalence of 11.14%, with a prevalence of 7.5% among women aged 15–44 years. Most seropositive cases exhibited high IgG avidity, suggesting past rather than recent infection, which is consistent with the typically asymptomatic and latent nature of toxoplasmosis in immunocompetent individuals [11].

Moderate prevalence rates have been observed in Middle Eastern countries. In Saudi Arabia, a national study involving 13,597 women of reproductive age reported a seroprevalence of 27.8%, with infection rates increasing significantly with age [12]. Similarly, variations in seroprevalence within Iran have been documented. A study conducted in eastern Iran reported a relatively low seroprevalence of 8.3% among women of reproductive age and confirmed a significant association between infection and contact with cats [13]. These findings emphasize the influence of regional, environmental, and behavioral factors on infection rates.

Several studies have demonstrated marked differences in *T. gondii* seroprevalence between rural and urban populations. A study conducted in the Philippines reported significantly higher prevalence rates in rural areas compared to urban areas, with infection rates increasing with age but showing no significant sex-related differences [14]. Similarly, a study in Romania reported an overall seroprevalence of 41% among women of childbearing age, with higher rates observed in rural areas and among older age groups [15]. On the other hand, a Brazilian study revealed higher seroprevalence in urban areas compared to rural areas, suggesting that urbanization and local lifestyle factors may also contribute to exposure risk [16].

In North Africa, studies have highlighted the ongoing risk of toxoplasmosis among pregnant women. A study conducted in southern Algeria reported IgG and IgM seroprevalence rates of 13.6% and 0.88%, respectively, indicating that most infections were latent. The study also identified significant associations between infection, consumption of undercooked meat, seasonality, and a history of spontaneous abortion. It was noted that the majority of pregnant women remained seronegative and therefore at high risk of acquiring primary infection during pregnancy [17].

In Libya, studies have shown that *Toxoplasma gondii* infection is common, particularly among women of reproductive age as well as other high-risk groups. A study conducted in Alkhoms reported that 39% of pregnant women were IgG positive, with age, rural residence, and dietary habits identified as important risk factors [18]. In Tripoli, a higher prevalence of 51% was reported, highlighting the role of lifestyle and environmental factors, including cat ownership and urban versus rural living [19]. Smaller studies conducted in El-Beida and Sebha reported seroprevalence rates ranging from 27% to 37%, while a survey of blood donors in Tripoli found 36% IgG positivity, reflecting community-wide exposure [20-22]. Extending these findings to susceptible populations, a study on hemodialysis patients reported a high seroprevalence of 52%, with infection associated with educational and occupational status, blood transfusions, marital status, pregnancy-related complications, congenital disorders, and chronic kidney failure [23].

Overall, the reviewed studies demonstrate considerable geographic variation in the seroprevalence of *Toxoplasma gondii* infection among women, influenced by age, dietary habits, environmental exposure, and rural–urban differences. Despite these variations, a consistent finding across most studies is that a large proportion of women of reproductive age remain susceptible to infection. This underscores the need for preventive strategies, routine screening, and health education programs, particularly in regions with limited epidemiological data.

Materials and methods:

This descriptive cross-sectional study was conducted to assess seroprevalence of *Toxoplasma gondii* infection among women in Western Libya. A total of 362 participants who attended for serological testing for *Toxoplasma gondii* during the period from 2024 to 2025 were included. The age of patients was between 17 to 57 years old. Data were obtained from several laboratory records located in Al-Zawia and neighboring areas (Ibn Al-nafis, Ibn al-Rushd, Alpha, Alwiqaya, Surman AL markaziah, Al-hayah and Al-razi) during November 2024 to January 2025.

Demographic information, including age and residence was extracted from records. Data were entered and organized by demographic affiliation (sex, age, and place of residence) and analyzed using

Statistical Package for the Social Sciences (SPSS) software (version 26). Descriptive statistics including, frequencies and percentages were used to determine seroprevalence of *T. gondii* (IgG and IgM) antibodies among the study population. The chi-square test was applied to assess associations between seroprevalence and demographic variables, as well as variations according to the month of sample collection. A p-value of less than 0.05 was considered statistically significant.

Results:

The study included a sample of 362 women participants who attended for serological testing for *Toxoplasma gondii* from several medical laboratories from two regions (Al-Zawia and neighboring areas) during the period from 2024 to 2025 were included.

Descriptive Statistical Analysis

Age distribution of study participants: Table 1 presents the age structure of the study population. A total of 362 non-pregnant females were included in the analysis. The largest proportion of participants belonged to the reproductive age groups 20–30 years (43.6%) and 31–40 years (42.0%). Together, these two groups represented 85.6% of the total sample. Only a small fraction of participants were newborns (2.2%), while females older than 40 years accounted for 12.2% of the sample. This distribution is consistent with the study focus on women of reproductive age, who represent the most clinically relevant group for toxoplasmosis screening and prevention.

Table (1): Age distribution of the study population

Age groups (years)	N	%
0–1	8	2.2%
20–30	158	43.6%
31–40	152	42.0%
>40	44	12.2%
Total	362	100.0%

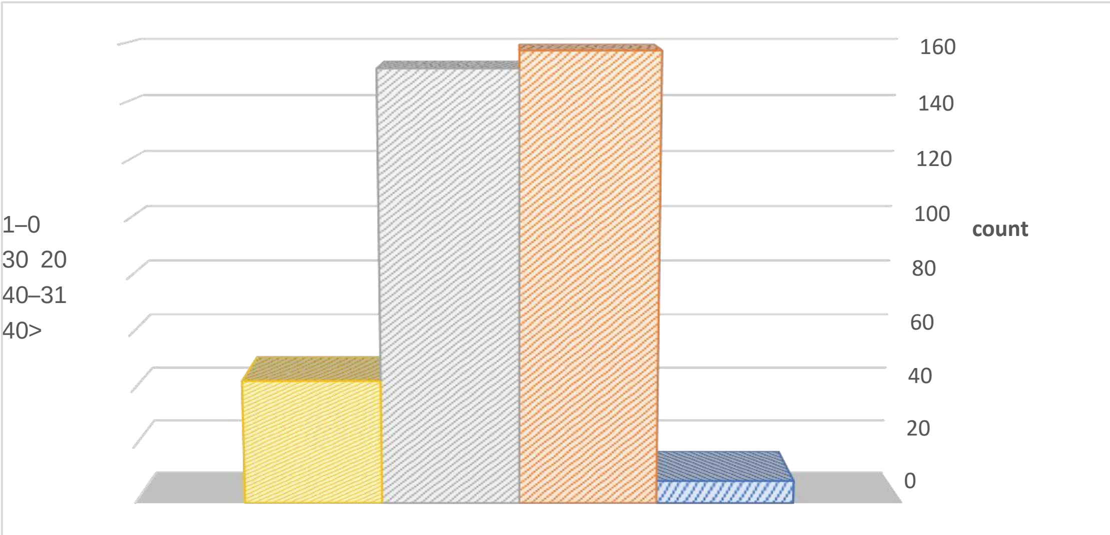

Figure (1): Frequency of age distribution

Geographic distribution of participants: The geographic distribution shows that 63.0% of the samples were obtained from laboratories in Surman and Sabratha, while 37.0% were collected from Al-Zawia. This reflects the higher availability of laboratory data from the Surman–Sabratha region. The unequal distribution between regions is acceptable because the analysis focuses on proportions rather than absolute numbers. The relatively large sample size from both regions allows a valid comparison of infection prevalence between the two geographic areas (Table 2).

Table (2): Geographic distribution of Participants

Region	N	%
Al-Zawia	134	37.0%
Surman + Sabratha	228	63.0%
Total	362	100.0%

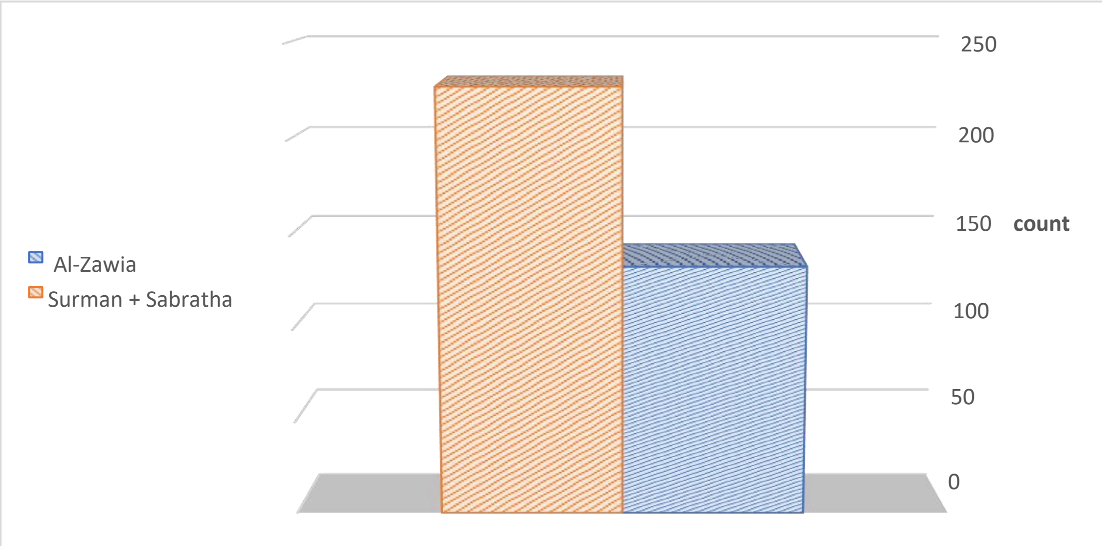

Figure (2): Frequency of geographic distribution

Serological results

Serological results by age groups: Table 3 summarizes the serological profile of *Toxoplasma gondii* infection across different age groups. The overall prevalence of infection (IgG and/or IgM positivity) was 30.4%. The highest infection rate was observed in the 31–40-year age group (41.4%), followed by the 20–30-year group (29.7%). Lower prevalence was found in females older than 40 years (27.3%) and in newborns (12.5%). A critical observation is that no cases of isolated IgM positivity were detected. All IgM-positive results were accompanied by IgG antibodies, indicating past infection with possible reactivation rather than new acute primary infection. This finding suggests that recent active toxoplasmosis was not common in the study population.

Table (3): Serological results by age groups

Age groups	Total N	IgG+ only	IgG+ & IgM+	Fully negative	Infection rate (%)
0–1	8	1	0	7	12.5%
20–30	158	42	5	111	29.7%
31–40	152	57	6	83	41.4%
>40	44	10	1	32	27.3%
Total	362	110	12	240	30.4%

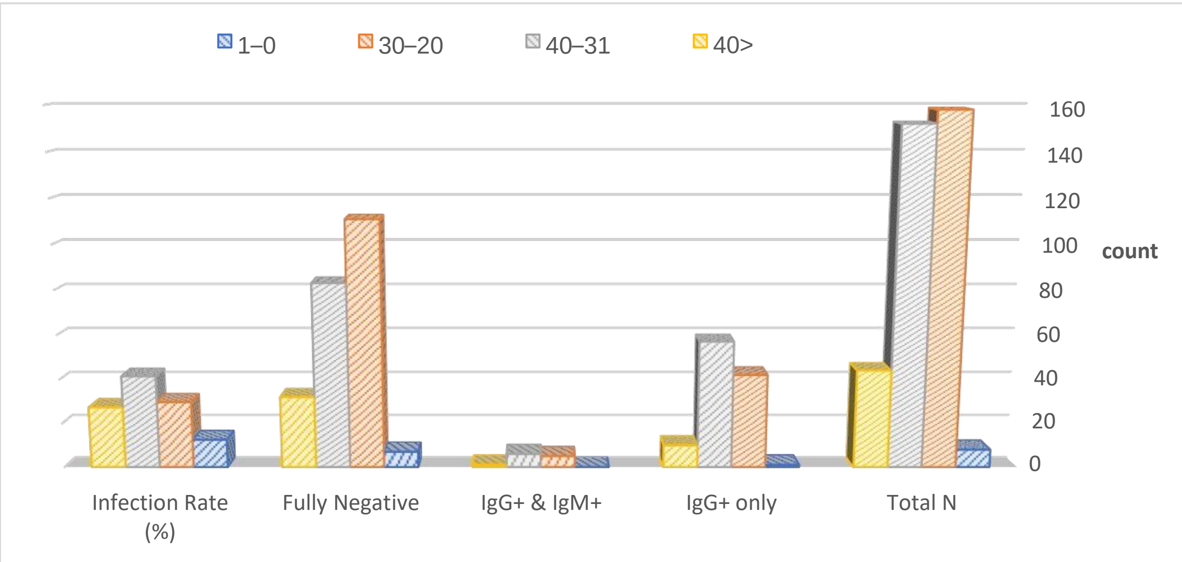

Figure (3): Frequency of serological profile

Infection rate by region

Table 4 compares the prevalence of *Toxoplasma gondii* infection between the two geographic regions. The infection rate was higher in Surman and Sabratha (34.2%) compared to Al-Zawia (23.9%). Although this difference appears notable from a descriptive perspective, statistical testing is required to determine whether it represents a true epidemiological difference or is due to random variation. Further inferential analysis is therefore presented in the following tables.

Table (4): Infection rate by region

Region	Positive	Negative	Infection rate
Al-Zawia	35	99	23.9%
Surman + Sabratha	87	141	34.2%
Total	122	240	30.4%

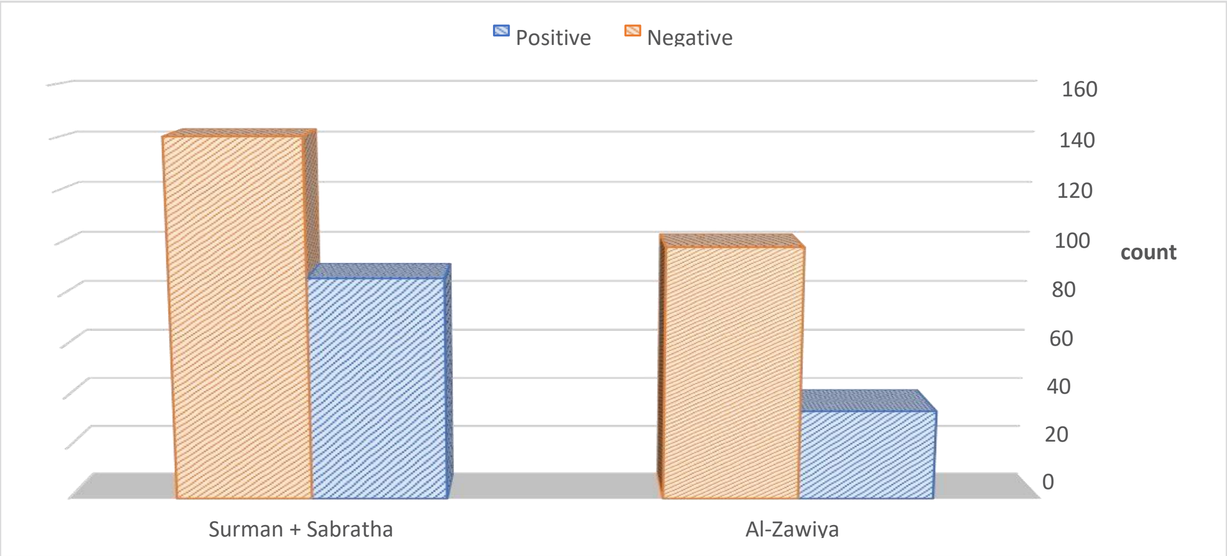

Figure (4): Compares the prevalence between regions

Inferential statistical analysis

Association between age and infection

Chi-square test for age groups vs infection: The chi-square test was applied to evaluate the relationship between age group and infection status. The obtained value ($\chi^2 = 4.12$, df = 3, p = 0.25) indicates no statistically significant association between age and the presence of Toxoplasma antibodies (Table 5). Despite the descriptive observation that the 31–40 age group had the highest prevalence, the difference among age groups was not strong enough to reach statistical significance. Therefore, age cannot be considered a confirmed risk factor in this dataset.

Table (5): Chi-square test for age groups vs infection

Variable	χ^2	df	p-value
Age × infection	4.12	3	0.25

Trend analysis across age groups

Mantel–Haenszel trend test: To further explore whether infection increases progressively with age, a Mantel–Haenszel test for linear trend was performed. The result ($\chi^2 = 2.01$, p = 0.156) shows that there is no significant linear trend of increasing infection with advancing age. This confirms that the variations observed between age groups are irregular and do not follow a systematic pattern (Table 6).

Table (6): Mantel–Haenszel trend test

Test	Statistic	p-value
Mantel–Haenszel χ^2	2.01	0.156

Association between region and infection

Chi-square test for region vs infection: This analysis assessed whether geographic location was associated with infection status. The chi-square result ($\chi^2 = 2.75$, df = 1, p = 0.097) shows that the difference in prevalence between regions did not reach statistical significance at the conventional 0.05 level. Although Surman and Sabratha had a higher prevalence, the p-value suggests that this difference could be due to chance as represented in Table 7.

Table (7): Chi-square test for region vs infection

Variable	χ^2	df	p-value
Region × Infection	2.75	1	0.097

Odds Ratio Estimation

Odds ratio for infection by region: An odds ratio was calculated to estimate the magnitude of association between region and infection. Females from Surman and Sabratha had 1.64 times higher odds of infection compared to those from Al-Zawia. However, the 95% confidence interval (0.94–2.85) included the value 1, and the p-value was 0.097. Therefore, this increased risk is not statistically significant, and no firm conclusion about geographic risk can be made as shown in Table 8.

Table (8): Odds Ratio for Infection by Region

Comparison	OR	95% CI	p-value
Surman, Sabratha vs Al-Zawia	1.64	0.94–2.85	0.097

Logistic Regression Analysis

Multivariate logistic regression model: A multivariate logistic regression model was constructed to evaluate the independent effect of age and region on infection status as illustrated in Table 9. None of the predictors reached statistical significance: Age groups showed elevated odds ratios but with wide confidence intervals and non-significant p-values. Region also showed a trend toward higher risk but remained non-significant (p = 0.10). These results indicate that, within this dataset, no demographic variable independently predicted infection.

Table (9): Multivariate logistic regression model

Predictor	OR	95% CI	p-value
Age 20–30	2.5	0.3–21	0.38
Age 31–40	4.8	0.6–36	0.12
Age >40	2.2	0.2–19	0.45
Region	1.7	0.9–3.3	0.10

Confidence intervals for prevalence

Confidence intervals for serological outcomes: Table 10 presents the precision of prevalence estimates using 95% confidence intervals:IgG positivity: 30.4% (95% CI: 25.8–35.0), IgM positivity: 3.3% (95% CI: 1.5–5.7), fully negative: 66.3% (95% CI: 61.7–71.0). The relatively narrow confidence intervals demonstrate good reliability of the prevalence estimates due to the adequate sample size.

Table (10): 95% Confidence intervals for serological outcomes

Outcome	N	Prevalence (%)	95% CI
IgG positive	110	30.4	25.8–35.0
IgM positive	12	3.3	1.5–5.7
Fully negative	240	66.3	61.7–71.0

Temporal analysis

Year-to-year comparison: The prevalence of infection was compared between the two study years: 2024: 32.1%, 2025: 28.9%. The Z-test for two proportions (p = 0.52) indicated no significant difference between the two years. This suggests that the epidemiological situation remained stable over the study period as demonstrated in Table 11.

Table (11): Year-to-year comparison

Year	Total tested	Positive	Prevalence	Z-test	p-value
2024	190	61	32.1 %	0.63	0.52
2025	172	61	28.9 %		

Monthly variability analysis: Monthly prevalence rates were analyzed to detect possible seasonal variation. The Kruskal–Wallis test (p = 0.60) showed no statistically significant differences between months. This indicates that infection rates were relatively consistent throughout the year and that no clear seasonal pattern was present as shown in Table 12.

Table (12): Monthly variability analysis

Statistic	Value
Mean monthly rate	18.1%
Standard deviation	5.6
Kruskal–Wallis p-value	0.60

Sensitivity analysis

Effect of excluding newborn group: To ensure that the small newborn subgroup did not influence the overall findings, a sensitivity analysis was conducted by excluding this group. After exclusion, the prevalence increased slightly from 30.4% to 34.2%, but the overall conclusions remained unchanged. This demonstrates that the main results of the study are stable and robust as depicted in Table 13.

Table (13): Effect of excluding newborn group

Indicator	Before exclusion	After exclusion
Total sample	362	354
Prevalence	30.4%	34.2%

Discussion:

The present study provides an epidemiological overview of *Toxoplasma gondii* infection among non-pregnant females in Western Libya. The overall seroprevalence was 30.4% during the period 2024-2025, meaning that approximately one-third of the sample was infected with the parasite, reflecting a significant epidemic presence in the community. This prevalence is consistent with findings reported in several studies, where seroprevalence rates ranged between 25% and 50% [4, 25]**.**

The highest infection rate was observed in the 31–40 age groups (41.4%). Medically, this could be explained by the accumulation of exposure opportunities, as older individuals are more susceptible to infection from sources such as dampness, pollution, contaminated water, or poor nutrition. However, these differences between age groups were not statistically significant, indicating that age is not a defining factor in this sample. This aligns with previous studies in Saudi Arabia [12] and [10, 13] suggests that age is a partially influential factor, with older age groups successfully managing the infection.

The difference is attributed to variations in food consumption, such as the consumption of undercooked meat or meat distributed to cats, whereas in Libya, exposure rates may be similar across age groups. However, the absence of a statistically significant association between age and infection (p = 0.25) indicates that, within this population, age alone is not a strong independent predictor. Similar findings were reported by studies conducted in North Africa, where age-related differences were observed descriptively but lacked statistical significance [24].

Geographically, the incidence was highest in Surman and Sabratha (34.2%) compared to Zawia (23.9%). Although the OR (1.64) indicated a slightly higher risk in Surman and Sabratha, the result did not reach statistical significance (p=0.097), Multiple logistic regression (p=0.10) confirmed these findings, suggesting that environmental factors and lifestyles in these areas are sufficiently similar that location does not produce a significant epidemiological difference. This contrasts with the findings in the Philippines [14] and Romania [15], where there is no higher prevalence in rural areas compared to urban areas.

In Libya, however, the local environment in the studied cities appears to be similar in terms of exposure sources (cat ownership, meat consumption), which explains the lack of overall difference.The results indicated that 98 out of 110 positive cases were positive for IgG only, suggesting a previous infection that had conferred immunity. No positive IgM antibodies were observed; all positive IgM results (3.3%) were associated with IgG antibodies.

This immunophenotype suggests an early infection during the study period, and the observed IgM levels may support the likelihood of latent or chronic infection rather than new infection. This finding is agreement with the early study, where most cases were positive for high-grade IgG, leading to more conclusive results than recent ones [11]. A study in Algeria Sebaa et al. [17] also found that most patients had recent latent infections, which aligns with our findings.

The study has several limitations. First, the study confined to a specific geographic area (western Libya). Second, study used of a single diagnostic method (serology only). Third, study was limited to a restricted population (non-pregnant women only) and limited study period (2024-2025).

Conclusion:

The present study demonstrated that *Toxoplasma gondii* infection is relatively common among non-pregnant females, with a seroprevalence of 30.4%. Although higher infection rates were observed in certain age groups and regions, no statistically significant associations were identified. The infection pattern appears stable over time, with no evidence of seasonal variation. The predominance of IgG positivity indicates that most infections are chronic or previously acquired rather than recent. Overall, the findings highlight the endemic nature of toxoplasmosis in the study population and highlight the need for continuous surveillance and preventive strategies. Overall, the study needs increase awareness among regarding transmission of toxoplasmosis particularly through undercooked meat and contaminated food or water, promote proper cooking of meat, washing vegetables and safe food handling practices, regular routine screening programs especially for women of reproductive to detect and monitor infection status and stables a national database to follow infection rates and their changes over time.

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