

Serological Profiles of *Toxoplasma gondii* among Women in Taraghin, Libya: Associated Factors, Reproductive Health Indicators and One Health Implications

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Abstract

Background: *Toxoplasma gondii* is a globally distributed zoonotic protozoan with particular relevance to women of reproductive age because primary maternal infection may result in congenital transmission. Contemporary Libyan data remain geographically fragmented, especially in the south. This study assessed anti-*T. gondii* IgG and IgM serological patterns among women attending a health facility in Taraghin, southern Libya, and examined associations with demographic, reproductive and behavioural variables.

Methods: A facility-based cross-sectional study analysed serum from 150 women attending Taraghin Health Centre between October and December 2023. Anti-*T. gondii* IgG and IgM were assessed using the ichroma™ Toxo IgG/IgM qualitative immunoassay (REF CFPC-112; Boditech, Republic of Korea) on the ichroma™ platform. Serological profiles were categorised as IgG-/IgM-, IgG+/IgM+, IgG+ only and IgM+ only. Pearson's chi-square test was used for multicategory comparisons, while Yates' continuity correction was applied to 2x2 analyses. Because several multicategory tables contained sparse cells, those findings were interpreted as exploratory. A secondary binary analysis compared any antibody positivity with double-seronegativity, and effect sizes were expressed using Cramér's V where appropriate.

Results: Overall, 56/150 women showed reactivity to at least one anti-*T. gondii* antibody class (37.3%; 95% CI 30.0–45.3%). The distribution was 62.7% IgG-/IgM-, 6.7% IgG+/IgM+, 8.0% IgG+ only and 22.6% IgM+ only. Any antibody positivity was higher among women reporting cat ownership (62.5%) than among non-owners (25.5%; $\chi^2=17.56$, $p<0.001$; Cramér's $V=0.34$). Antibody positivity also varied by marital/pregnancy category, age group, education and reported abortion-timing category; however, several of these comparisons were affected by small subgroup sizes and are best regarded as exploratory. Consumption of undercooked meat was not significantly associated with overall antibody positivity in the binary reanalysis ($p=0.268$).

Conclusions: Anti-*T. gondii* antibody reactivity was frequent among women attending the Taraghin health facility. Cat ownership showed the strongest observed behavioural association in the unadjusted analysis. The unusually high proportion of isolated IgM reactivity should not be interpreted as confirmed recent infection without confirmatory testing such as repeat serology, IgG avidity and/or molecular testing. The findings support integrated maternal-health education, food and water safety, responsible cat management, and strengthened laboratory confirmation within a One Health framework aligned with Sustainable Development Goals 3, 5 and 6.

Keywords: *Toxoplasma gondii*; toxoplasmosis; women; pregnancy; antibody reactivity; IgG; IgM; Libya; One Health; Sustainable Development Goals.

1. Introduction

Toxoplasma gondii is an obligate intracellular apicomplexan parasite with an exceptionally broad host range. Felids are the definitive hosts, shedding environmentally resistant oocysts, whereas humans and other warm-blooded animals serve as intermediate hosts in which tissue cysts may persist. Human infection is therefore embedded in a complex interface linking animal reservoirs, environmental contamination, food systems and human behaviour. This ecology makes toxoplasmosis a prototypical One Health problem rather than a narrowly clinical infection (Aguirre et al., 2019; Müller de Barros et al., 2022; İnci et al., 2023).

In immunocompetent adults, infection is frequently asymptomatic or self-limiting, yet its implications change substantially in pregnancy and immunosuppression. Maternal infection acquired during gestation can result in transplacental transmission and fetal disease, while the severity of congenital manifestations depends on the timing of transmission and other host–parasite factors. For this reason, the interpretation of serological results in women of reproductive age has direct clinical and public-health relevance (Robert-Gangneux and Dardé, 2012; Laboudi et al., 2021; Rabaan et al., 2023).

The global and regional epidemiology of toxoplasmosis is markedly heterogeneous. A recent meta-analysis of pregnant women in Africa estimated a pooled seroprevalence of 42.9%, with wide variation by country, diagnostic

method and subregion; cat ownership, raw meat consumption and raw vegetable consumption were significant pooled determinants (Gelaw et al., 2024). In the WHO Eastern Mediterranean Region, pooled seroprevalence among pregnant women was 36.5%, with substantial between-study heterogeneity and evidence linking exposure with reproductive outcomes such as abortion, miscarriage and stillbirth (Rabaan et al., 2023). Such heterogeneity reflects not only biological transmission but also differences in climate, food preparation, water safety, cat density, socioeconomic conditions, laboratory assays and case definitions.

North Africa illustrates this variability. In Rabat, Morocco, 43% of pregnant women were IgG seropositive and 3.9% were IgM positive; importantly, IgG avidity excluded recent infection in most women with combined IgG/IgM positivity, demonstrating why isolated antibody classes must be interpreted cautiously (Laboudi et al., 2021). A recent study from southern Algeria reported IgG and IgM seroprevalence of 13.6% and 0.89%, respectively, with associations involving spontaneous abortion history and undercooked meat exposure (Sebaa et al., 2024). These results reinforce the need for local data rather than extrapolation across neighbouring countries.

Libyan evidence remains limited and geographically dispersed. Historical surveys documented substantial exposure in Tripoli and Benghazi, but these studies pre-date contemporary diagnostic platforms and current changes in food systems and population movement. More recent work by Elammari et al. (2021) in El-Beida reported IgG and IgM seropositivity of 26.86% and 11.94%, respectively, among pregnant women, while a Benghazi study published in 2024 also documented ongoing toxoplasmosis among pregnant women (Elammari et al., 2021; Agelah, 2024). Southern Libya remains comparatively underrepresented in the published literature.

Beyond individual-level exposure, toxoplasmosis intersects with the Sustainable Development Agenda. Prevention of congenital and severe toxoplasmosis contributes to SDG 3 (good health and well-being), particularly maternal, neonatal and communicable-disease targets; health education and access to reproductive health information are relevant to SDG 5; and prevention of waterborne exposure aligns with SDG 6 on safe water and sanitation (United Nations, 2015). A One Health framing additionally recognises that effective control requires coordination among clinical services, veterinary and animal-health sectors, food-safety systems and environmental health programmes. Against this background, the present study aimed to characterise anti-*T. gondii* IgG and IgM patterns among women attending a health facility in Taraghin, southern Libya, and to examine associations with selected demographic, reproductive and behavioural variables. The findings were further interpreted within a contemporary One Health framework and in relation to relevant Sustainable Development Goals.

2. Materials and Methods

2.1 Study design, setting and participants

A facility-based cross-sectional study was conducted among women attending Taraghin Health Centre in southern Libya from October to December 2023. Participants were recruited by convenience sampling during routine attendance at the centre. The analytic sample comprised 150 women: 10 unmarried women, 79 married pregnant women and 61 married non-pregnant women.

2.2 Data collection

Demographic, reproductive and behavioural information was collected using a structured study questionnaire. Variables included marital/pregnancy category, age group, educational level, cat ownership, self-reported consumption of undercooked meat and reported abortion-timing category.

2.3 Specimen collection and serological testing

Approximately 5 mL of venous blood was collected from each participant. Serum was separated by centrifugation at 3,500 rpm for 5 minutes. Anti-*T. gondii* IgG and IgM antibodies were assessed using the ichroma™ Toxo IgG/IgM qualitative test (REF CFPC-112; Boditech, Republic of Korea), intended for detection of anti-Toxoplasma gondii IgG/IgM antibodies in human whole blood, serum or plasma, and read on the ichroma™ platform. According to the study procedure, 150 µL of detector diluent was transferred to the detector tube and mixed until the detector granules were fully dissolved; 5 µL of serum was then added and mixed thoroughly. After approximately 3 minutes, 75 µL of the reaction mixture was dispensed into the cartridge sample well, incubated for 12 minutes at room temperature or in the designated incubator, and the cartridge was inserted into the ichroma™ reader for interpretation. Results were interpreted on the ichroma™ platform according to the manufacturer's qualitative output.

2.4 Definition of serological profiles

Four mutually exclusive profiles were analysed: IgG–/IgM– (double-seronegative), IgG+/IgM+ (dual reactivity), IgG+ only and IgM+ only. For secondary epidemiological comparisons, “any antibody positivity” was defined as positivity for IgG and/or IgM. This composite outcome was used to describe assay reactivity and should not be interpreted as a uniform marker of established infection. IgG positivity is compatible with previous exposure, whereas IgM positivity—particularly isolated IgM—was not treated as definitive evidence of acute primary infection because IgM can persist, produce false-positive or non-specific reactions, and may require confirmation using repeat serology, IgG avidity and/or molecular testing (Laboudi et al., 2021; Tork et al., 2025).

2.5 Statistical analysis

Data were analysed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA), with statistical significance set at $p < 0.05$. Descriptive results are presented as counts and percentages, and overall anti-*T. gondii* antibody positivity is reported with a Wilson 95% confidence interval. Pearson’s chi-square test was used for multicategory contingency tables, while Yates’ continuity correction was applied to 2×2 comparisons. For the secondary binary analysis, the four serological profiles were collapsed into double-seronegative versus any antibody positive, and Cramér’s V was used to describe association strength. Because several multicategory comparisons contained expected cell counts below 5, these analyses were interpreted as exploratory rather than confirmatory.

2.6 Ethical considerations

Institutional permission to conduct the study and collect blood samples from women attending Taraghin Health Centre was granted by the Faculty of Education, Fezzan University, Taraghin, Libya, through an official letter dated 6 August 2023 addressed to the Director of Taraghin Health Centre and signed by the Vice Dean for Scientific Affairs. Participant information was handled confidentially, and results are reported only in aggregate form. Consent was obtained from all participants before data collection and blood sampling.

3. Results

3.1 Overall serological profile

Among 150 women, 94 were negative for both IgG and IgM (62.7%), while 56 showed reactivity to at least one antibody class, yielding an overall anti-*T. gondii* antibody positivity of 37.3% (95% CI 30.0–45.3%). Ten participants (6.7%) showed combined IgG/IgM reactivity, 12 (8.0%) were IgG positive only and 34 (22.6%) were IgM positive only (Table 1; Figure 1). The predominance of isolated IgM reactivity is epidemiologically notable but requires confirmatory laboratory evaluation before being interpreted as recent infection.

Table 1. Distribution of anti-*Toxoplasma gondii* serological profiles (n=150).

Serological profile	n	%
IgG–/IgM–	94	62.7
IgG+/IgM+	10	6.7
IgG+ only	12	8.0
IgM+ only	34	22.6
Any antibody positivity	56	37.3

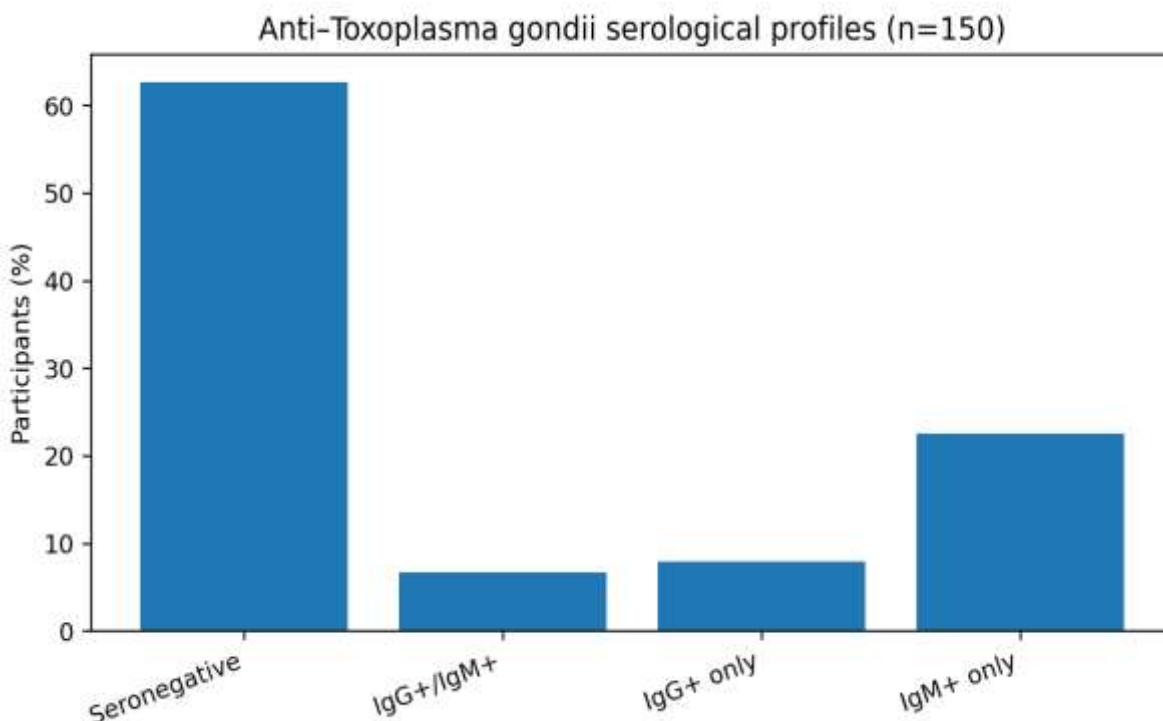


Figure 1. Distribution of anti-*T. gondii* serological profiles among study participants.

3.2 Participant category and antibody positivity

Any antibody positivity occurred in 2/10 unmarried women (20.0%), 40/79 married pregnant women (50.6%) and 14/61 married non-pregnant women (23.0%). The binary association was statistically significant ($\chi^2=12.65$, $df=2$, $p=0.0018$; Cramér's $V=0.29$). In the four-profile serological analysis, the corresponding chi-square statistic was 19.68 ($df=6$, $p=0.003$), although sparse expected counts limit the reliability of the asymptotic p-value (Figure 2A).

Table 2. Any anti-*T. gondii* antibody positivity by participant category.

Participant category	N	Seronegative n (%)	Any antibody positive n (%)
Unmarried	10	8 (80.0)	2 (20.0)
Married pregnant	79	39 (49.4)	40 (50.6)
Married non-pregnant	61	47 (77.0)	14 (23.0)

3.3 Cat ownership

Cat ownership showed the strongest observed behavioural association in the unadjusted dataset. Among 48 women reporting cat ownership, 30 (62.5%; 95% CI 48.4–74.8%) were antibody positive compared with 26/102 non-owners (25.5%; 95% CI 18.0–34.7%). The binary association was significant ($\chi^2=17.56$, $p<0.001$; Cramér's $V=0.34$). In the four-category serological analysis, χ^2 was 35.18 ($p<0.001$). Because the analysis was unadjusted, this finding should not be interpreted as an independent causal effect (Figure 2C).

Table 3. Anti-*T. gondii* antibody positivity according to cat ownership.

Cat ownership	n	Seronegative n (%)	Any antibody positive n (%)
No	102	76 (74.5)	26 (25.5)
Yes	48	18 (37.5)	30 (62.5)

3.4 Age group

Antibody positivity varied markedly across age groups: 10.5% at 18–27 years, 58.8% at 28–37 years, 10.9% at 38–47 years and 100% among the eight women aged ≥ 48 years. The binary chi-square test was significant ($\chi^2=49.10$, $df=3$, $p<0.001$; Cramér's $V=0.57$). The extreme value in the oldest category should be interpreted cautiously because only eight women were included, and the non-monotonic pattern suggests possible confounding or sampling effects (Figure 2B).

Table 4. Any anti-T. gondii antibody positivity by age group.

Age group (years)	N	Seronegative n (%)	Any antibody positive n (%)
18–27	19	17 (89.5)	2 (10.5)
28–37	68	28 (41.2)	40 (58.8)
38–47	55	49 (89.1)	6 (10.9)
≥ 48	8	0 (0.0)	8 (100.0)

3.5 Reported abortion-timing category

The questionnaire recorded women according to a reported abortion-timing category. Antibody positivity was 5.3% for the first-trimester category, 97.0% for the second-trimester category, 88.9% for the third-trimester category and 20.0% among those reporting no abortion. The binary association was large ($\chi^2=86.08$, $df=3$, $p<0.001$; Cramér's $V=0.76$), but this result should be treated as exploratory. The available study documentation does not establish the chronology of seroconversion relative to pregnancy loss, and the cross-sectional design cannot determine whether *T. gondii* caused any reported abortion. Small cell sizes, recall error, clustering of participant characteristics and residual confounding may also have contributed to the extreme percentages.

Table 5. Anti-T. gondii antibody positivity according to reported abortion-timing category.

Reported abortion timing	n	Sero-negative n (%)	Any antibody positive n (%)
First trimester	38	36 (94.7)	2 (5.3)
Second trimester	33	1 (3.0)	32 (97.0)
Third trimester	9	1 (11.1)	8 (88.9)
No reported abortion	70	56 (80.0)	14 (20.0)

3.6 Undercooked meat consumption

Among 47 women reporting consumption of undercooked meat, 14 (29.8%) were antibody positive, compared with 42/103 (40.8%) among those who did not report this exposure. The binary association was not statistically significant ($\chi^2=1.23$, $p=0.268$; Cramér's $V=0.09$). The four-profile serological analysis likewise showed no significant association ($\chi^2=5.27$, $p=0.153$). This finding should not be interpreted as evidence that undercooked meat is unimportant in toxoplasmosis transmission; rather, exposure measurement, sample size, meat type and preparation practices may have limited detection of an association (Figure 2C).

Table 6. Anti-T. gondii antibody positivity according to reported consumption of undercooked meat.

Undercooked meat	N	Sero-negative n (%)	Any antibody positive n (%)
No	103	61 (59.2)	42 (40.8)
Yes	47	33 (70.2)	14 (29.8)

3.7 Educational level

Antibody positivity varied substantially by educational category: 0/5 among women recorded as illiterate, 2/33 (6.1%) at primary level, 40/42 (95.2%) at intermediate level and 14/70 (20.0%) among university-educated women. The binary association was statistically significant ($\chi^2=85.96$, $df=3$, $p<0.001$; Cramér's $V=0.76$). However, the highly non-monotonic pattern and small size of some strata make an independent effect of education implausible to infer from these unadjusted data. This pattern should therefore be regarded as exploratory and potentially influenced by age, participant category, data structure or other unmeasured confounders (Figure 2D).

Table 7. Anti-*T. gondii* antibody positivity according to educational level.

Education	N	Sero-negative n (%)	Any antibody positive n (%)
Illiterate	5	5 (100.0)	0 (0.0)
Primary	33	31 (93.9)	2 (6.1)
Intermediate	42	2 (4.8)	40 (95.2)
University	70	56 (80.0)	14 (20.0)

4. Discussion

This study provides facility-based seroepidemiological data on *T. gondii* among women in Taraghin, southern Libya, a setting for which contemporary published evidence is scarce. The principal finding was an overall anti-*T. gondii* antibody positivity of 37.3%, indicating that more than one-third of the sampled women showed IgG and/or IgM reactivity. This composite measure is not directly equivalent to IgG-defined prior exposure because 22.6% of participants had isolated IgM reactivity. Nevertheless, the overall proportion is numerically close to the 36.5% pooled seroprevalence reported for pregnant women across the WHO Eastern Mediterranean Region, although direct comparison must remain cautious because the present sample included both pregnant and non-pregnant women, used a different diagnostic platform and included isolated IgM reactivity in the composite outcome (Rabaan et al., 2023). The estimate is also below the 42.9% pooled seroprevalence reported for pregnant women across Africa (Gelaw et al., 2024), but those meta-analytic estimates should not be treated as directly comparable prevalence measures.

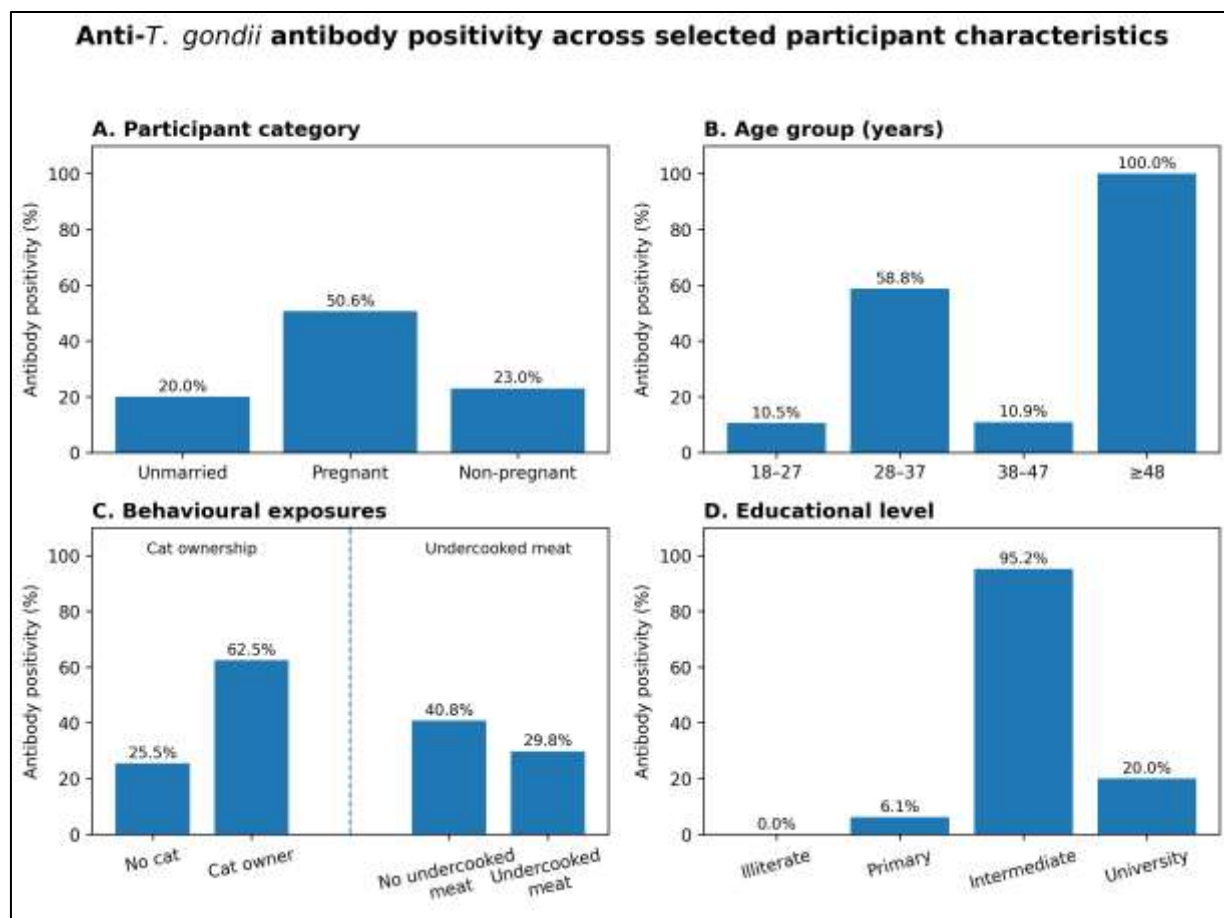


Figure 2. Anti-*T. gondii* antibody positivity across selected participant characteristics: (A) participant/pregnancy category; (B) age group; (C) behavioural exposures (cat ownership and undercooked-meat consumption); and (D)

educational level. Percentages are unadjusted and should be interpreted descriptively, particularly for sparse categories.

The Libyan context is characterised by substantial geographic variability. Elammari et al. (2021) reported IgG positivity of 26.86% and IgM positivity of 11.94% among pregnant women in El-Beida. Historical studies in Tripoli and Benghazi have reported higher exposure estimates, whereas more recent regional studies elsewhere in North Africa have ranged from 13.6% IgG seropositivity in southern Algeria to 43% in Rabat, Morocco (Khadre and El-Nageh, 1987; Kassem and Morsy, 1991; Elammari et al., 2021; Laboudi et al., 2021; Sebaa et al., 2024). Such differences are plausible given variation in climate, cat density, rural–urban exposure, food traditions, water sources and diagnostic methods. The present data therefore provide a useful estimate for women attending a health facility in Taraghin, southern Libya, but they should not be generalised to the national population.

A particularly important feature of the present dataset is the high proportion of isolated IgM positivity (22.6%). This is considerably higher than pooled IgM estimates in recent regional meta-analyses and higher than many contemporary antenatal studies. IgM antibodies can persist for months, and false-positive or non-specific IgM reactions are well recognised; therefore, isolated IgM reactivity cannot by itself establish acute primary toxoplasmosis. In Morocco, Laboudi et al. (2021) showed that IgG avidity excluded recent infection in 83% of IgG/IgM-positive pregnant women. A recent systematic review likewise concluded that combining IgM with IgG avidity and additional serological markers improves diagnostic classification (Tork et al., 2025). For Taraghin, confirmatory algorithms should therefore be prioritised before clinical decisions are based on IgM alone.

Cat ownership showed the strongest observed behavioural association in the unadjusted analysis. Antibody positivity among cat owners was more than twice that observed among non-owners (62.5% versus 25.5%), with a moderate effect size. This direction is consistent with the African meta-analysis, where cat ownership increased the pooled odds of seropositivity (Gelaw et al., 2024), and with recent studies in which cat contact was associated with infection (Kassie et al., 2024). However, the present analysis was not adjusted for age, pregnancy status, education or other covariates, so cat ownership cannot be interpreted as an independent causal factor. The pathway should also not be oversimplified: infection is not acquired merely by touching a cat, but through exposure to oocysts shed by infected felids and contaminating soil, water, litter or food. Public-health messaging should therefore emphasise litter hygiene, handwashing, environmental sanitation and safe management of cat faeces rather than indiscriminate avoidance or removal of cats. (Figure 2C).

The absence of an association between undercooked meat consumption and antibody positivity in this sample contrasts with pooled evidence showing raw or undercooked meat as a recurrent risk factor in Africa and elsewhere (Gelaw et al., 2024; Kassie et al., 2024). Several explanations are plausible. The questionnaire variable may not have captured frequency, meat species, degree of cooking or cross-contamination during preparation. Exposure through contaminated vegetables, soil or water may also dominate in some settings. Non-differential misclassification of dietary exposure could bias the association towards the null. Accordingly, the present null finding should be interpreted as study-specific rather than as evidence against meat-borne transmission.

Age-related patterns were highly uneven. The highest antibody positivity occurred in the ≥ 48 -year category, but that stratum contained only eight women, making the 100% estimate imprecise. The 28–37-year group also showed comparatively high positivity (58.8%). Increasing cumulative exposure with age is biologically plausible and has been observed in some studies, but the sharp fall in the 38–47-year group argues against a simple age-gradient interpretation and suggests that sampling structure, pregnancy status, education or other covariates may have shaped the pattern. A larger study with continuous age and multivariable logistic regression would be more informative than isolated age-group comparisons.

The strong unadjusted association between reported abortion-timing category and antibody positivity requires especially cautious interpretation. Toxoplasma infection during pregnancy is a recognised cause of adverse fetal outcomes, and systematic reviews in the Eastern Mediterranean have documented associations between serological positivity and histories of abortion or miscarriage (Rabaan et al., 2023). Nevertheless, the present study is cross-sectional, the available questionnaire documentation does not establish the timing of maternal infection relative to pregnancy loss, and confirmatory diagnostic data were not available. The study therefore cannot attribute individual abortions to toxoplasmosis. The extreme positivity observed in second- and third-trimester categories may also

reflect small cell sizes, recall bias, clustering of participant characteristics, coding structure or residual confounding. This result should be treated as hypothesis-generating and independently verified in a prospectively designed study. Educational level was statistically associated with antibody status, but the pattern was not ordinal: the intermediate group had exceptionally high positivity while both primary and university groups were much lower. This inconsistency argues against a simple dose–response interpretation and raises the possibility of residual confounding, sampling structure or coding effects. Recent knowledge-attitude-practice work from Morocco has shown that education can influence awareness of toxoplasmosis and testing, but educational attainment should not be assumed to translate directly into lower biological exposure without measuring specific behaviours and access to information (Atif et al., 2025). The educational finding in the present study should therefore be considered exploratory.

4.1 One Health interpretation

The findings are best interpreted through a One Health lens. Human exposure in Taraghin potentially arises from an interconnected system in which felids contaminate the environment with oocysts; livestock and other intermediate hosts may harbour tissue cysts; water and fresh produce can act as vehicles; and household practices determine the final probability of exposure. Modern reviews emphasise that effective toxoplasmosis control requires coordination across human medicine, veterinary services, environmental health, food safety and public education (Müller de Barros et al., 2022; İnci et al., 2023). For southern Libya, practical priorities include safer cat-litter handling, control of environmental faecal contamination, food hygiene, safe meat preparation, protection of drinking-water sources and targeted education for women before and during pregnancy.

4.2 Sustainable Development Goals

This study has direct relevance to the 2030 Agenda. Prevention and accurate diagnosis of maternal toxoplasmosis contribute to SDG 3 by supporting maternal and newborn health and reducing the burden of communicable disease. Providing women with accessible, evidence-based reproductive health information is consistent with SDG 5, particularly universal access to sexual and reproductive health information and services. Because *T. gondii* oocysts can contaminate water and food, improved water quality, sanitation and hygiene link the control agenda to SDG 6. The One Health framing additionally promotes cross-sector partnerships that are consistent with SDG 17 (United Nations, 2015).

4.3 Strengths and limitations

A strength of this study is the inclusion of a comparatively understudied southern Libyan population and the simultaneous evaluation of IgG and IgM serological profiles alongside several behavioural and reproductive variables. Reporting confidence intervals, binary antibody positivity and effect-size estimates provides a clearer epidemiological interpretation of the observed patterns. Several limitations should nevertheless be acknowledged. The facility-based convenience sample limits population-level generalisability, and the modest sample size produced small subgroups and sparse contingency tables. In addition, exposures such as meat consumption and cat ownership were self-reported and were not quantified in detail.

5. Conclusions

Anti-*T. gondii* antibody reactivity was common among women attending the Taraghin health facility, with 37.3% showing IgG and/or IgM positivity. Because isolated IgM reactivity accounted for a substantial proportion of positive results, this composite measure should not be interpreted as a uniform estimate of established infection. Cat ownership showed substantially higher antibody positivity in the unadjusted analysis, whereas undercooked meat consumption was not associated in this dataset. Strong statistical patterns were also observed for age, participant category, educational level and reported abortion timing, but several were influenced by small strata, non-monotonic distributions and unresolved confounding and should therefore be regarded as hypothesis-generating. The high frequency of isolated IgM reactivity is a major clinical and methodological signal: IgM positivity should be confirmed with repeat serology, IgG avidity and/or PCR when clinically indicated, particularly in pregnancy. Integrated maternal-health education, environmental and food-safety interventions, responsible cat management and improved laboratory confirmation are warranted within a One Health approach.

6. Implications for practice and future research

For clinical practice, women with IgM reactivity—particularly during pregnancy—would benefit from a locally standardised confirmatory pathway incorporating repeat serology and IgG avidity where available, with PCR used

according to clinical indications and gestational timing. Antenatal and preconception education should emphasise safe handling of cat litter and soil, hand hygiene, thorough washing of fresh produce, safe water and adequate cooking of meat. Future research should use larger multicentre samples, more detailed exposure measurement and multivariable analysis, and should extend beyond human serology to relevant veterinary and environmental interfaces such as cats, livestock, soil and water. Strengthened diagnostic quality assurance and cross-sector surveillance would improve comparability across Libyan laboratories and support One Health contributions to SDGs 3, 5 and 6.

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Consent to participate: Consent was obtained from all participants before data collection and blood sampling.

Conflict of interest: The authors declare no conflict of interest.

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