



RESEARCH ARTICLE

Seroprevalence of *Toxoplasma gondii* Infection Among Women of Reproductive Age In Mukalla City, Hadhramout ,Yemen

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Abstract

Background: *Toxoplasmosis* is a globally distributed zoonotic infection caused by the protozoan parasite *Toxoplasma gondii*. The infection is of particular importance among women of reproductive age because of its potential implications for maternal and fetal health. This study aimed to determine the seroprevalence of *T. gondii* infection among women in Mukalla City, Hadhramout Governorate, Yemen, and to assess its relationship with selected demographic, reproductive, and hematological factors.

Methods: A cross-sectional study was conducted among 192 women aged 17–42 years who attended selected healthcare centers and hospitals in Mukalla City. Blood samples were collected and analyzed for anti-*T. gondii* IgG and IgM antibodies using an enzyme-linked immunosorbent assay (ELISA). A structured questionnaire was used to collect demographic, reproductive, and exposure-related information, including residence, occupation, cat contact, and abortion history. Hematological parameters were also recorded.

Results: Anti-*T. gondii* IgG antibodies were detected in 140 participants (72.9%), while anti-*T. gondii* IgM antibodies were detected in 40 participants (20.8%). Both IgG and IgM antibodies were detected in 12 participants (6.25%). A statistically significant association was observed between occupation and anti-*T. gondii* IgG seropositivity ($p = 0.002$), whereas no significant association was found between occupation and IgM seropositivity ($p = 0.814$). No statistically significant associations were observed between *T. gondii* seropositivity and residence or reported cat contact. Correlation analysis showed very weak positive correlations between age and IgG ($r = 0.029$) and IgM ($r = 0.008$), while weak negative correlations were observed between WBC counts, hemoglobin levels, abortion history, and anti-*T. gondii* antibody seropositivity.

Conclusion: The study demonstrated a high seroprevalence of *T. gondii* among women in Mukalla City, indicating substantial exposure to the parasite within the studied population. The findings highlight the importance of continued awareness and preventive measures against toxoplasmosis among women of reproductive age in Hadhramout Governorate.

Keywords: ELISA, Mukalla city, Toxoplasmosis, Seroprevalence

INTRODUCTION

Toxoplasmosis is a widespread zoonotic infection caused by *Toxoplasma gondii*, an obligate intracellular protozoan parasite that infects humans and a wide range of vertebrate hosts. Approximately one-third of the global population is estimated to have been exposed to *T. gondii*, with seroprevalence generally ranging from 30% to 60% in developing countries, particularly in tropical and subtropical regions¹⁻⁴. Cats and other felids are the definitive hosts of *T. gondii*, in which sexual reproduction occurs and environmentally resistant oocysts are excreted. Humans and other mammals and birds can act as intermediate hosts⁵.

Human infection can occur through several routes, including consumption of raw or undercooked meat containing tissue cysts (bradyzoites), ingestion of food or water contaminated with sporulated oocysts, and contact with contaminated environmental materials. Transmission may also occur through blood transfusion and organ transplantation from infected donors^{6,7}. In addition, consumption of unpasteurized milk and handling raw meat may represent potential sources of infection because of exposure to the rapidly multiplying tachyzoite stage⁸.

Following ingestion of *T. gondii* oocysts or tissue cysts, the parasite undergoes developmental stages in the host and can invade tissues. If the host immune response is insufficient, the rapidly multiplying tachyzoite stage may disseminate through the body and establish infection in different tissues⁹.

In immunocompetent individuals, toxoplasmosis is frequently asymptomatic or associated with mild, nonspecific clinical manifestations. However, primary infection during pregnancy is of particular concern because congenital transmission may result in serious consequences for the fetus and newborn, including spontaneous abortion, stillbirth, premature birth, and severe fetal or neonatal complications^{10,11}. Congenital toxoplasmosis may also be associated with neurological and ocular manifestations, including hydrocephalus, microcephaly, retinochoroiditis, and other severe clinical conditions¹². In immunocompromised individuals, toxoplasmosis may cause severe systemic manifestations, including encephalitis, myocarditis, and pneumonia¹². Severe ocular or congenital manifestations may also occur following reactivation of latent infection under certain immunosuppressive conditions¹³.

Despite its clinical importance, prenatal screening for *T. gondii* infection is not consistently included in routine antenatal health services in all settings. Consequently, the number of women who remain susceptible to primary infection during pregnancy may be difficult to determine¹⁴. In addition, the possibility of transmission through blood transfusion to seronegative recipients emphasizes the importance of understanding the prevalence of *T. gondii* infection and considering appropriate screening strategies¹⁵.

Several diagnostic approaches are available for toxoplasmosis, including biological, serological, cultural, histopathological, and molecular methods¹⁶. Serological techniques are widely used because they allow the detection of specific antibodies against *T. gondii* with high sensitivity. Detection of anti-*T. gondii* IgG and IgM antibodies by enzyme-linked immunosorbent assay (ELISA),

together with IgG avidity testing when indicated, can provide useful serological information regarding previous exposure and the possible timing of infection¹⁷.

Several studies have investigated the seroprevalence of *T. gondii* among women in Yemen. However, the epidemiological characteristics of toxoplasmosis may vary between geographical areas because of differences in environmental, behavioral, socioeconomic, and healthcare-related factors. Therefore, local seroepidemiological investigations remain important for understanding the distribution of *T. gondii* infection and identifying factors that may be associated with seropositivity.

The current study aimed to investigate the seroprevalence of *T. gondii* infection among women in Mukalla City, Hadhramout Province, Yemen, using an enzyme-linked immunosorbent assay (ELISA), and to assess selected factors that may be associated with seropositivity, including age, occupation, residence, and contact with cats. In addition, the study examined hemoglobin (Hb) and white blood cell (WBC) counts and explored their relationships with anti-*T. gondii* IgG and IgM antibody findings.

METHODS

Study design

This cross-sectional study was conducted among purposively selected women attending hospitals and healthcare centers in Mukalla City, Hadhramout Province, Yemen, from March to September 2017.

Study population

The study included pregnant and non-pregnant women aged 17–42 years who attended the participating hospitals and healthcare centers.

Sample size

The required sample size was calculated using the Steven K. Thompson formula¹⁸:

$$n = \frac{N \cdot P(1-P)}{((N-1) \cdot (d^2 \div z^2)) + P(1-P)}$$

where:

n = The required sample size

N = The total population size

p = The estimated proportion of the population characteristic

d = The accepted margin of error

z = The standard normal value corresponding to the selected confidence level.

Based on an estimated study population of approximately 380–385 women and the specified sampling parameters ($p = 0.50$, $d = 0.05$, and $z = 1.96$), the calculated sample size was approximately 192 women.

Study area

The study was conducted in Mukalla City, Hadhramout Province, Yemen. Participants were recruited from two hospitals, Mukalla Hospital and University Hospital, and from healthcare centers, including Marie Stopes International Yemen (MSIY) and the Health Procreation Center, where Obstetrics and Gynecology clinics were available. Routine laboratory examinations were performed at the laboratories of the participating healthcare centers, while ELISA testing was performed at Al-Qodos Laboratory and the National Center for Public Health Laboratories.

Data collection:

Data collection was performed using a structured questionnaire and laboratory investigations. A structured questionnaire was designed to collect sociodemographic and behavioral information from the participants. The collected information included age, place of residence, occupation, pregnancy status and period, number of pregnancies, and number of abortions. Behavioral information, particularly contact with or breeding of cats, was also recorded based on information provided directly by the participants. The questionnaire data were subsequently considered together with the laboratory findings, including CBC and ELISA results.

Blood Sample Collection and Processing

Blood samples were collected from 192 women by medically trained staff using disposable 5-mL syringes. Each blood sample was divided into two portions. The first portion (2 mL) was transferred into a tube containing EDTA for hematological analysis, including determination of hemoglobin (Hb) and white blood cell (WBC) counts, using a Sysmex CBC analyzer.

The second portion (3 mL) was transferred into a plain tube and allowed to stand for 30 minutes. Serum was then separated from the whole blood by centrifugation at 3000 rpm for 10 minutes at room temperature. The separated serum was collected, labeled, and stored at -20°C until serological analysis.

Serological testing for toxoplasmosis:

Serum samples were tested for anti-*Toxoplasma gondii* IgG and IgM antibodies using an enzyme-linked immunosorbent assay (ELISA) kit (Human Gesellschaft for Biochemical and Diagnostic, Max Planck, Germany). The assay was based on the reaction between antibodies in the serum samples and the corresponding *T. gondii* antigen in the wells of the test kit.

ELISA test for IgM:

For the detection of anti-*T. gondii* IgM antibodies, serum samples were diluted at a ratio of 1:100 by adding 10 μL of serum to 1 mL of the supplied diluent and mixing thoroughly for 5 seconds. A total of 500 mL of washing solution was prepared according to the test procedure. The enzyme conjugate was prepared as described in the test procedure.

Then, 100 μL of the cut-off control was added to the designated well of the toxoplasmosis kit, and 100 μL of each prepared sample was added to the corresponding wells. The contents were

mixed carefully for 5 seconds, covered, and incubated for 60 minutes at 37°C. The wells were then washed four times with washing solution and dried.

Next, 100 µL of enzyme conjugate was added to the appropriate wells except the cut-off control well. The plate was mixed, covered, and incubated for 30 minutes at 37°C. The wells were subsequently washed four times, and 100 µL of substrate solution (SUB) was added to the wells and incubated for 30 minutes at 17–25°C. Finally, 100 µL of stop solution was added to terminate the reaction, and the absorbance was read using an ELISA reader (Stat Fax).

ELISA Test for IgG:

For the detection of anti-*T. gondii* IgG antibodies, serum samples were diluted at a ratio of 1:100 by adding 10 µL of serum to 1.0 mL of the supplied diluent and mixing thoroughly for 5 seconds. The washing solution was prepared at a dilution of 1:20 by adding 25 mL of washing solution to 375 mL of distilled water, giving a total volume of 400 mL.

Then, 100 µL of the cut-off control was added to the designated well of the toxoplasmosis kit, followed by the addition of 100 µL of each prepared sample to the corresponding wells. The contents were mixed carefully for 5 seconds, covered, and incubated for 30 minutes at 37°C. The wells were subsequently washed four times with washing solution and dried.

Next, 100 µL of conjugate (CON) was added to the appropriate wells except the cut-off control well. The plate was mixed, covered, and incubated for 15 minutes at 37°C. The wells were then washed four times, followed by the addition of 100 µL of substrate solution (SUB) and incubation for 15 minutes at 17–25°C. Finally, 100 µL of stop solution was added to terminate the reaction, and the absorbance was read using an ELISA reader (Stat Fax).

Statistical Analysis:

The collected data were entered and analyzed using SPSS version 24 (Statistical Package for the Social Sciences). Cross-tabulation was performed for descriptive and analytical statistics. The chi-square test was used to assess associations between *T. gondii* seropositivity and selected study variables, while correlation analysis was used to examine relationships between the investigated variables. Statistical significance was considered at $p < 0.05$.

RESULT

Sample Demographic Characteristics

A total of 192 women were included in the study and tested for *Toxoplasma gondii* antibodies using the ELISA technique. The participants ranged in age from 17 to 42 years, with a mean age of 27.39 years. Regarding residence, 110 women (57.3%) were from rural areas, whereas 82 (42.7%) were from urban areas. Concerning contact with or breeding of cats, 24 women (12.5%) reported breeding cats, 138 (71.9%) reported no contact or breeding, and 30 (15.6%) reported occasional contact. Regarding occupation, the majority of participants were housewives (180;

93.8%), followed by teachers (7; 3.6%) and clerks (5; 2.6%). The demographic characteristics of the study population are presented in Table 1.

Table 1. Socio-demographic characteristics of the study population(N=192).

Parameters	Category	Number(N)	Percentage
Occupation	Housewife	180	93.8%
	Teacher	7	3.6%
	Clerk	5	2.6%
Residence	Rural	110	57.3%
	Urban	82	42.7%
Breeding cats	Yes	24	12.5%
	No	138	71.9%
	Sometimes	30	15.6%

Overall Seroprevalence of *Toxoplasma gondii*

The overall seroprevalence of *T. gondii* infection among the 192 women was 72.9% (140/192) for anti-*T. gondii* IgG antibodies and 20.8% (40/192) for anti-*T. gondii* IgM antibodies. Co-detection of both anti-*T. gondii* IgG and IgM antibodies was observed in 12 women (6.25%). Thus, anti-*T. gondii* IgG seropositivity was substantially higher than anti-*T. gondii* IgM seropositivity in the study population. Four samples with an optical density (OD) value of 0.99 were classified as borderline/equivocal and were categorized under the negative/equivocal group according to the study classification (Table 2).

Table 2. Overall seroprevalence of *Toxoplasma gondii* among the studied women (N = 192).

Toxoplasmosis status	Positive, n	Percentage
Anti- <i>T. gondii</i> IgG	140	72.9%
Anti- <i>T. gondii</i> IgM*	40	20.8%
Anti- <i>T. gondii</i> IgG + IgM	12	6.25%

***Note:** Four borderline samples (OD = 0.99) were categorized as negative/equivocal.

Similarly, no statistically significant association was observed between anti-*T. gondii* IgG seropositivity and place of residence. The seropositivity rates among rural and urban participants did not differ significantly.

Effect of Some Factors on the Distribution of Toxoplasmosis Prevalence

The age of the studied women ranged from 17 to 42 years, with a mean age of 27.39 years. The total number of reported abortions among the participants was relatively low, with a mean of

0.88 abortions per woman. The number of pregnancies ranged from 0 to 12, with a mean of 3.01 pregnancies per woman. The mean values of white blood cell (WBC) counts and hemoglobin (Hb) levels were within the reported normal ranges.

The Relationship Between Anti-*T. gondii* IgG Seropositivity, Cat Contact, and Residence

No statistically significant association was observed between anti-*T. gondii* IgG seropositivity and reported cat contact ($p = 0.804$). Among women who reported no contact with cats, 92 of 138 (66.7%) were IgG-positive. Regarding residence, 94 of 110 rural women (85.5%) and 46 of 82 urban women (56.1%) were IgG-positive. The difference in IgG seropositivity according to residence was not statistically significant ($p = 0.321$). These findings are presented in Table 3.

Table 3. The distribution of chronic Toxoplasmosis(IgG) according to cat contact and residence :

Factor	Categories	(%) Positive [N]	(%) Negative [N]	Total
Residence	Rural	(85.5%) [94]	(14.5%) [16]	110
	Urban	(56.1%) [46]	(43.9%) [36]	82
Cat contact	Yes	(91.7%) [22]	(8.3%) [2]	24
	No	(66.7%) [92]	(33.3%) [46]	138
	Sometimes	(86.7%) [26]	(13.3%) [4]	30
(P value = 0.804)				

The Relationship Between Anti-*T. gondii* IgM Seropositivity and Cat Contact

No statistically significant association was observed between anti-*T. gondii* IgM seropositivity and reported cat contact ($\chi^2 = 2.451$, $p = 0.568$). Among women who reported cat contact, 9 of 24 (37.5%) were IgM-positive, compared with 25 of 138 (18.1%) among those who reported no cat contact and 6 of 30 (20.0%) among those reporting occasional contact. Table 4 shows acute *T. gondii* Infection According to Cat Contact

Table 4. The distribution of acute Toxoplasmosis (IgM) according to cat contact ($p = 0.568$).

Cat contact	(%) Positive N	(%) Negative N	Total	Chi-Square(χ^2)
Yes	(37.5%) [9]	(62.5%) [15]	24	2.451
No	(18.1%) [25]	(81.9%) [113]	138	
Sometimes	(20%) [6]	(80%) [24]	30	
Total	(20.8%) [40]	(79.2%) [152]	192	
(P value = 0.568)				

The Relationship Between Anti-*T. gondii* IgM Seropositivity and Residence

No statistically significant association was found between anti-*T. gondii* IgM seropositivity and place of residence ($\chi^2 = 0.941$, $p = 0.669$). Anti-*T. gondii* IgM seropositivity was observed in 26 of 110 rural women (23.6%) and 14 of 82 urban women (17.1%). Table 5 shows the distribution of anti-*T. gondii* IgM seropositivity according to residence

Table 5. The distribution of acute Toxoplasmosis (IgM) according to residence ($P = 0.669$).

Residence	(%)Positive N	(%)Negative N	Total	Chi-Square (X ²)
Rural	(23.6%) [26]	(76.4%) [84]	110	0.941
Urban	(17.1%) [14]	(82.9%)[68]	82	
Total	(20.8%) [40]	(79.2%) [152]	192	
<i>(P value = 0.669)</i>				

The Relationship Between Anti-*T. gondii* IgM Seropositivity and Occupation

No statistically significant association was observed between anti-*T. gondii* IgM seropositivity and occupation ($\chi^2 = 0.412$, $p = 0.814$). Anti-*T. gondii* IgM seropositivity was observed in 38 of 180 housewives (21.1%), 1 of 7 teachers (14.3%), and 1 of 5 clerks (20.0%). The anti-*T. gondii* IgM seropositivity according to occupation is shown in Table 6.

Table 6. The distribution of acute Toxoplasmosis (IgM) by occupation.

Occupation	(%)Positive N	(%) Negative N	P-value	Chi-Square(X^2)
Housewife	(21.1%) [38]	(78.9%) [142]	0.814	0.412
Teacher	(14.3%) [1]	(85.7%)[6]		
Clerk	(20%) [1]	(80%)[4]		
Total	(20.8%) [40]	(79.2%)152		
	192	192		

The Relationship Between Anti-*T. gondii* IgG Seropositivity and Occupation

A statistically significant association was observed between anti-*T. gondii* IgG seropositivity and occupation ($\chi^2 = 14.538$, $p = 0.002$). Among housewives, 130 of 180 (72.2%) were IgG-positive, compared with 6 of 7 teachers (85.7%) and 4 of 5 clerks (80.0%). Housewives accounted for 130 of the 140 IgG-positive women (92.9%). The anti-*T. gondii* IgG Seropositivity according to occupation is shown in Table 7.

Table 7. The distribution of chronic Toxoplasmosis(IgG) according to occupation.

Occupation	(%)Positive N	(%)Negative N	Total	P-value	Chi-Square(X ²)
Housewife	(72.2%) [130]	(27.8%) [50]	180	0.002	14.538
Teacher	(85.7%) [6]	(14.3%) [1]	7		
Clerk	(80%) [4]	(20%) [1]	5		
Total	(72.2%) [140]	(27.1%) [52]	192		

Correlation Analysis

Correlation analysis was performed to assess the relationships between selected demographic, hematological, and reproductive variables and anti-*Toxoplasma gondii* IgG and IgM seropositivity. A very weak positive correlation was observed between age and anti-*T. gondii* IgG ($r = 0.029$) and IgM ($r = 0.008$). Weak negative correlations were observed between WBC counts and IgG ($r = -0.082$) and IgM ($r = -0.072$). Similarly, weak negative correlations were observed between hemoglobin levels and IgG ($r = -0.036$) and IgM ($r = -0.037$). The number of reported abortions showed very weak negative correlations with IgG ($r = -0.011$) and IgM ($r = -0.009$).

DISCUSSION

Distribution of the Study Population According to Demographic Parameters

In the present study, housewives represented the largest proportion of participants (180/192, 93.8%), followed by teachers (7/192, 3.6%) and clerks (5/192, 2.6%). This distribution was comparable to that reported by Kadir et al.¹⁹ in Iraq, where housewives accounted for 93.7% (299/319) of the study participants, followed by women officials (6.25%, 20/319). The predominance of housewives in the present study may reflect the demographic characteristics of the women attending the selected healthcare facilities rather than an occupation-specific risk of *T. gondii* infection.

Regarding residence, 110 participants (57.3%) were from rural areas, whereas 82 (42.7%) were from urban areas. This distribution differed from reports from Aden and Saudi Arabia by Muqbil and Alqubati²⁰ and Aqeely et al.²¹, respectively. The higher representation of rural women in the present study may be related to the use of hospitals and healthcare centers in Mukalla by women from surrounding rural areas, possibly because of better transportation facilities, relatively lower costs, and the limited availability of comparable healthcare facilities in some rural areas of Hadhramout.

Distribution of *T. gondii* Seroprevalence

The present study demonstrated a high seroprevalence of anti-*T. gondii* IgG antibodies (72.9%) and anti-*T. gondii* IgM antibodies (20.8%) among the 192 women studied. The IgG seroprevalence was higher than that reported among women in Sana'a, Yemen, where Al-Nahari²²

reported IgG and IgM seroprevalence rates of 41.90% and 11.88%, respectively. It was also higher than the rates reported by Alkadasi et al.²³ in Ibb, Yemen, where IgG and IgM seropositivity were 13% and 4%, respectively. Similarly, the present IgG and IgM rates were higher than those reported in Aden by Muqbil and Alqubatii²⁰, who reported seropositivity rates of 31% for IgG and 14% for IgM.

In contrast, the IgG seroprevalence observed in the present study was lower than the 84.44% reported by Al-Taie²⁴, while the IgM seroprevalence was comparable to the 18.2% reported in Venezuela by Diaz-Suarez and Estevez²⁵. The IgG prevalence was also broadly comparable to the 75% reported in Brazil by Coelho²⁶.

The present findings also differed from the prevalence reported in other countries. Previous studies cited in the original manuscript reported IgG seroprevalence rates of 20.0%, 38.9%, and 37.1% in Saudi Arabia, Sudan, and Libya, respectively, while the corresponding IgM rates were 6.2%, 12.9%, and 3.57%.^{27–29} The relatively high seroprevalence observed in Mukalla may reflect differences in lifestyle, socioeconomic conditions, environmental and climatic factors, healthcare access, residence, age, and educational characteristics between populations³⁰.

The substantially higher prevalence of IgG than IgM in the present study is consistent with the persistence of IgG antibodies following previous exposure to *T. gondii*, whereas IgM is generally associated with a more recent immune response³¹.

Relationship Between Anti-*T. gondii* Seropositivity and Occupation

In the present study, occupation was significantly associated with anti-*T. gondii* IgG seropositivity ($p = 0.002$), whereas no statistically significant association was observed between occupation and anti-*T. gondii* IgM seropositivity ($p = 0.814$). Housewives constituted the largest occupational group in the study population (180/192, 93.8%) and accounted for 130 of the 140 IgG-positive women (92.9%). However, this high proportion should be interpreted in relation to the predominance of housewives in the study population rather than as evidence that being a housewife itself increases the risk of infection. The higher IgG seropositivity observed among housewives is consistent with the findings of Kadir et al.¹⁹, who reported a higher prevalence among housewives than among other occupational groups. No statistically significant association was observed between reported cat contact or cat breeding and anti-*T. gondii* IgG or IgM seropositivity in the present study. Among the IgG-positive women, 92 (65.7%) reported no cat contact, 22 (15.7%) reported breeding cats, and 26 (18.6%) reported occasional contact. These findings are consistent with previous studies conducted in Aden²⁰, Ibb²³, and Taiz³². The absence of a significant association between cat contact and seropositivity suggests that direct contact with cats may not have been the predominant identifiable exposure factor in this study population. In the Hadhramout context, other possible routes of exposure may include contact with domestic animals, farming activities, consumption of unpasteurized milk, undercooked meat, contaminated soil, and inadequately washed vegetables.^{33–35}

Relationship Between Anti-*T. gondii* Seropositivity and Age

The present study showed a very weak positive correlation between age and anti-*T. gondii* IgG ($r = 0.029$) and IgM ($r = 0.008$) seropositivity. Although the direction of the correlations was positive, the strength of the observed relationships was very weak. Previous studies cited in the original manuscript reported an increase in *T. gondii* seropositivity with age, consistent with the findings reported by Alkadasi et al.²³ and other studies.^{35,36} Longer cumulative exposure to potential sources of infection may contribute to increased seropositivity with advancing age, as previously suggested.^{37–39}

Relationship Between Anti-*T. gondii* Seropositivity and Residence

No statistically significant association was observed between residence and anti-*T. gondii* IgG or IgM seropositivity in the present study. Although the proportion of seropositive women was higher among participants from rural areas, the difference between rural and urban residents was not statistically significant. This finding is consistent with the study reported by Al-Adlan⁴⁰ but differs from the findings of Sroka et al.⁴¹. The lack of a significant difference between rural and urban residents may be related to similarities in food habits and potential exposure to sources of *T. gondii* infection in both settings. The present findings also indicate that exposure to the parasite may occur in both rural and urban environments rather than being restricted to rural areas. Previous findings reported by Muqbil and Alqubatii²⁰ and Kadir et al.¹⁹ also showed relatively high seroprevalence among women living in rural or suburban areas.

Relationship Between Anti-*T. gondii* Seropositivity and Hematological Parameters

The present study showed weak negative correlations between WBC counts and anti-*T. gondii* IgG ($r = -0.082$) and IgM ($r = -0.072$) seropositivity. Similarly, weak negative correlations were observed between hemoglobin levels and IgG ($r = -0.036$) and IgM ($r = -0.037$). The mean WBC count was 8479.09 cells/ μ L, which was within the reported normal range. White blood cells play an important role in innate and adaptive immune responses against infectious agents, including bacteria, viruses, and parasites⁴². *T. gondii* is an obligate intracellular protozoan that can persist within host tissues⁴³. The original study proposed that the observed inverse relationships might be related to the parasite's persistence within host cells and interactions with host immune responses⁴⁴. However, given the weak correlation coefficients observed in the present study, these findings should be interpreted cautiously and should not be considered evidence of a causal effect of *T. gondii* infection on WBC counts. The observed weak inverse relationship between hemoglobin levels and antibody seropositivity is consistent with the findings reported by Al-Aboudi⁴⁵, who observed decreased hemoglobin levels among individuals infected with parasites.

Relationship Between Abortion History and Anti-*T. gondii* Seropositivity

The present study showed very weak negative correlations between the number of reported abortions and anti-*T. gondii* IgG ($r = -0.011$) and IgM ($r = -0.009$) seropositivity. The mean number of reported abortions was 0.88 per woman, with a maximum reported number of seven abortions. These findings did not indicate an apparent relationship between the number of abortions and *T. gondii* seropositivity in the studied population.

This finding is consistent with Kadir et al.¹⁹, who reported no relationship between the number of abortions and *T. gondii* seropositivity.

CONCLUSION

The present study demonstrated a high seroprevalence of *Toxoplasma gondii* among women in Mukalla City, Hadhramout, Yemen, with anti-*T. gondii* IgG detected in 72.9%, and IgM detected in 20.8% of the study participants. Co-detection of both IgG and IgM antibodies was observed in 6.25% of participants. These findings confirm substantial exposure to *T. gondii* within the studied population. Occupation was significantly associated with anti-*T. gondii* IgG seropositivity, whereas no significant association was observed between IgM seropositivity and occupation. No statistically significant associations were found between *T. gondii* seropositivity and residence or reported cat contact. Correlation analysis showed very weak relationships between age, hematological parameters, abortion history, and anti-*T. gondii* antibody seropositivity. The high IgG seroprevalence observed in this study highlights the importance of continued awareness and preventive measures against *T. gondii* infection among women of reproductive age in Mukalla. Further studies involving larger populations and additional diagnostic approaches are recommended to characterize better the epidemiology and potential risk factors of toxoplasmosis in Hadhramout Governorate.

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