ORIGINAL RESEARCH ARTICLE

Investigation of anti-*Toxoplasma gondii* antibody seropositivity and possible risk factors in women with abortion or stillbirth history in Kars, Turkey

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Abstract

Toxoplasma gondii is a common protozoan parasite that can cause serious outcomes, especially during pregnancy, including miscarriage, stillbirth, preterm birth, and congenital abnormalities. This study was designed to determine the seroprevalence of *T. gondii* and explore associated risk factors among women with a history of abortion or stillbirth in Kars, Turkey. A total of 274 women were included -137 with a history of abortion or stillbirth, and 137 healthy controls. Participants completed a 26-item questionnaire assessing possible risk factors for infection. Serum samples were analysed using the micro-ELISA method. In the patient group, IgG and IgM seropositivity rates were 32.8% and 1.5%, respectively while in the control group, IgG and IgM were 35% and 0.7% respectively. Overall, the prevalences of IgG and IgM in the two groups were 33.9% and 1.1% respectively. The difference between the groups was not statistically significant ($p > 0.05$). Significant associations were found in the patient group between seropositivity and factors such as educational level, number of previous pregnancies, abortions, and preterm births, and the source of drinking water ($p < 0.05$). In the control group, income level, feeding cats in the garden, and consumption of raw milk were significantly associated with seropositivity ($p < 0.05$). However, no statistically significant association was found between *T. gondii* seropositivity and a history of abortion or stillbirth when compared with the control group. The findings also reveal a relatively high seroprevalence of *T. gondii* in the region and suggest that several sociodemographic and behavioral factors may contribute to exposure to the parasite. Therefore, public health interventions tailored to local hygiene and dietary habits are recommended. *(Afr J Reprod Health 2026; 30 [10]: 72-84).*

Keywords: *Toxoplasma gondii*, seroprevalence, abortus, stillbirth, risk factors

Résumé

Toxoplasma gondii est un parasite protozoaire largement répandu pouvant entraîner des issues graves, en particulier pendant la grossesse, notamment des fausses couches, des mortinaissances, des naissances prématurées et des anomalies congénitales. Cette étude a été conçue afin de déterminer la séroprévalence de *T. gondii* et d'explorer les facteurs de risque associés chez des femmes ayant des antécédents de fausse couche ou de mortinatalité à Kars, en Turquie. Au total, 274 femmes ont été incluses, dont 137 présentant des antécédents de fausse couche ou de mortinatalité et 137 témoins en bonne santé. Les participantes ont rempli un questionnaire de 26 items visant à évaluer les facteurs de risque potentiels d'infection. Les échantillons de sérum ont été analysés à l'aide de la méthode micro-ELISA. Dans le groupe de patientes, les taux de séropositivité des IgG et des IgM étaient respectivement de 32,8 % et 1,5 %, tandis que dans le groupe témoin, ils étaient de 35 % et 0,7 %. Globalement, la prévalence des IgG et des IgM dans les deux groupes était respectivement de 33,9 % et 1,1 %. Aucune différence statistiquement significative n'a été observée entre les groupes ($p > 0,05$). Dans le groupe de patientes, des associations significatives ont été observées entre la séropositivité et des facteurs tels que le niveau d'instruction, le nombre de grossesses antérieures, les fausses couches, les naissances prématurées et la source d'eau utilisée ($p < 0,05$). Dans le groupe témoin, le niveau de revenu, le fait de nourrir des chats dans le jardin et la consommation de lait cru étaient significativement associés à la séropositivité ($p < 0,05$). Toutefois, aucune association statistiquement significative n'a été mise en évidence entre la séropositivité à *T. gondii* et les antécédents de fausse couche ou de mortinatalité par rapport au groupe témoin. Les résultats révèlent également une séroprévalence relativement élevée de *T. gondii* dans la région et suggèrent que plusieurs facteurs sociodémographiques et comportementaux peuvent contribuer à l'exposition au parasite. Par conséquent, des interventions de santé publique adaptées aux habitudes locales d'hygiène et d'alimentation sont recommandées. *(Afr J Reprod Health 2026; 30 [10]: 72-84).*

Mots-clés: *Toxoplasma gondii,* séroprévalence, fausse couche, mortinatalité, facteurs de risque

Introduction

Toxoplasmosis is a disease caused by the protozoan parasite *Toxoplasma gondii*, which lives inside host cells. Most people with a healthy immune system who come into contact with this parasite do not show any symptoms or may experience mild, non-specific symptoms such as fever, headache, and muscle pain, which resemble the symptoms of infection with the flu virus.[1,2] Although approximately one-third of the global population is infected with *T. gondii*, most individuals remain asymptomatic, meaning the condition often goes undiagnosed and unnoticed. A significant concern arises when the infection occurs during pregnancy, as the parasites can pass through the placenta to the fetus, potentially leading to severe consequences such as miscarriage when a primary infection occurs.[3,4]

T. gondii is a source of infection in humans through the consumption of undercooked meat and meat products. Additionally, it can be transmitted via various other routes, including the ingestion of inadequately washed vegetables and fruits, as well as drinking water contaminated with oocysts from cat feces that have entered the environment.[5] The impact of *T. gondii* infection on women is minimal or non-existent up to three months before conception. However, exposure to this infectious agent during pregnancy, particularly in the first trimester, can lead to serious complications. Although the probability of transplacental transmission of the parasite is low during the first three months of embryogenesis, the clinical symptoms in the fetus are quite severe. In newborns, toxoplasmosis may cause complications such as hydrocephalus, microcephaly, intracranial calcifications, retinochoroiditis, strabismus, blindness, epilepsy, psychomotor and intellectual disabilities, as well as petechiae and anemia due to thrombocytopenia. In contrast, exposure to the agent during the last trimester generally results in the birth of asymptomatic infants.[6,7]

The age of the population, their educational level, the region in which they reside, and their dietary habits influence the prevalence of toxoplasmosis. Due to these factors, the global seroprevalence of toxoplasmosis is estimated to range from 10% to 80%.[8] For this reason, the objective of this study was to determine the *T. gondii* seroprevalence and identify potential epidemiological risk factors in women with a history of miscarriage, stillbirth, or pregnancy-related complications

Methods

Design, sample and setting

This was a comparative-descriptive study conducted between September 2018 and June 2019 in the Obstetrics and Gynecology Clinic of Kars Harakani State Hospital, in Turkey.

The study population consisted of women presenting to the Obstetrics and Gynecology Polyclinic with a history of miscarriage or stillbirth, along with a control group of healthy pregnant women. Healthy women were recruited as controls from the same hospital during the study period, and the control group was age-matched with the patient group to ensure comparability between the groups. According to data obtained from the Kars Provincial Health Directorate, the number of women who experienced miscarriage in 2017–2018 was 117, and the number of stillbirths was 20. The aim of the study was to reach the entire population. Therefore, the sample consisted of 137 women with a history of miscarriage or stillbirth and 137 healthy women who applied to the polyclinic and agreed to participate in the study, totalling 274 participants.

Independent variables: risk of miscarriage or stillbirth, sociodemographic characteristics, pregnancy-related information, and questions aimed at identifying possible risk factors affecting *Toxoplasma*.

Dependent variable: *T. gondii*

Data collection

Data collection tools included a "Survey Information Form" consisting of 26 questions developed by the researcher, and an "Informed Consent Form" signed by participants to provide written consent. The survey information form consisted of three main structured sections aimed at identifying personal sociodemographic characteristics, pregnancy-related information, and potential risk factors affecting toxoplasmosis. Data were collected through face-to-face interviews. The data collection process took approximately 15-20 minutes.

Personal sociodemographic characteristics: Age, place of residence, occupation, income, and education level.

Pregnancy-related information: Gestational week, number of pregnancies, history of stillbirth/premature/miscarriage, health status of surviving children, health status of the pregnant woman.

Questions regarding the investigation of possible risk factors for Toxoplasma: Keeping a cat at home or in the garden, working with soil such as in gardens/fields, source of water consumption, habit of eating raw or undercooked milk/eggs/meat and meat products (sausage, salami; raw meatballs, etc.), consumption of unwashed fruits/vegetables, hygiene habits such as attention to the cleanliness of kitchen utensils.

Sample collection and serological analysis: Following completion of the questionnaire, blood samples obtained from the participants during routine clinical examinations were initially used for standard laboratory analyses and subsequently utilized for the purposes of the present study. No additional invasive procedures were performed on the participants for this research. Serum samples were separated and transferred into 2 mL Eppendorf tubes using single-use manual pipettes. The labelled serum samples were stored in a deep freezer at −20 °C at the Medical Parasitology Laboratory, Faculty of Medicine, Kafkas University, until analysis, in order to prevent any potential decline in antibody titers.Serum samples were analyzed for anti-*T. gondii* IgM and IgG antibodies using the micro-ELISA method with commercially available kits manufactured by Diapro (Milan, Italy). All assays were performed in accordance with the manufacturer's instructions, and the kits were stored at +4 °C until use.

Data analysis

Data obtained from the questionnaire, together with the laboratory results, were entered into the Statistical Package for the Social Sciences (IBM SPSS Statistics, version 20). Descriptive statistics were calculated and expressed as mean, number (n), and percentage (%), as appropriate for the variables. Associations between categorical variables were assessed using the chi-square (χ^2) test. When more than 20% of the expected cell frequencies were less than five, Fisher's exact chi-square test was applied. Seropositivity rates were presented with 95% confidence intervals (95% CI). A significance level of 5% was used for all statistical analyses, and a p value < 0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with ethical standards and was approved by the Non-Interventional Clinical Research Ethics Committee of Kafkas University Faculty of Medicine (Approval date: 14 March 2018; Approval number: 80576354-050-99/51).

Results

None of the 274 women included in the study had a chronic illness. The women had not previously undergone blood transfusions. All of the women stated that they had never been diagnosed with toxoplasmosis and were not aware of the infection. The distribution of the antibodies among the women in the two groups is presented in Table 1.

As shown in Table 1, anti-*T. gondii* IgG seropositivity was detected in 33.9% of all women participating in the study, while anti-*T. gondii* IgM seropositivity was found in 1.1%. Concurrent seropositivity for both IgM and IgG antibodies against *T. gondii* was observed in 0.4% of the participants. No statistically significant difference was detected between the groups in terms of antibody presence (P > 0.05).

When anti-*T. gondii* IgG seropositivity was evaluated according to sociodemographic characteristics, a generally similar distribution across age groups was observed in both groups. However, in the 15–19 age group, the seropositivity rate was higher in the patient group (60.0%) compared with the control group (44.4%), whereas in the 30–34 age group, seropositivity was higher in the control group (57.1%) than in the patient group (38.9%).

With respect to the place of residence, higher seropositivity rates were observed among women living in rural areas compared with those living in urban areas in both groups. In terms of income status, higher seropositivity rates were detected among women with good income levels in both groups. According to educational level, the

Table 1: Seroprevalence of *T. gondii* in women in both groups

Groups		Group 1 (n=137) n (%)	Group 2 (n=137) n (%)	Total (N=274) n (%)
IgG	**Positive**	45(32.8)	48(35.0)	**93(33.9)**
	Negative	92(67.2)	89(65.0)	**181(66.1)**
IgM	**Positive**	2(1.5)	1(0.7%)	**3(1.1)**
	Negative	135(98.5)	136(99.3)	**271(98.9)**
IgG + IgM	**Positive**	0(0.0)	1(0.7%)	**1(0.4)**
	Negative	137(100.0)	136(99.3)	**273(99.6)**
Total		**137 (50.0)**	**137 (50.0)**	**274(100.0)**

***Group 1:** Women with a history of miscarriage, miscarriage or stillbirth
Group 2: Control Group: healthy pregnant women)

Table 2: Seroprevalence of anti-*T. gondii* IgG by sociodemographic characteristics of both groups

Groups		Group 1		Group 2		Total (N=274)	P	X^2
		n	Positive n (%)	n	Positive n (%)	n (%)		
	15-19 Age	5	**3 (60.0)**	9	4 (44.4)	**7 (50.0)**	1.000	0.311
	20-24 Age	26	10 (38.5)	27	10 (37.0)	20 (37.7)	0.915	0.011
	25-29 Age	48	12 (25.0)	53	16 (30.2)	28 (27.7)	0.561	0.338
Age	**30-34 Age**	36	14 (38.9)	28	**16 (57.1)**	30 (46.9)	0.147	2.107
	35 Age and above	22	6 (27.3)	20	7 (35.0)	13 (31.0)	0.293	0.588
Place of residence	**Rural**	47	**16 (34.0)**	38	**15 (39.5)**	**31/ (36.5)**	0.605	0.268
	Urban	90	29 (32.2)	99	33 (33.3)	62 (32.8)	0.871	0.026
Income status	**Good**	102	**35 (34.3)**	35	18 (51,4)	53 (38,7)	0,073	3,218
	Medium	24	8 (33.3)	64	14 (21.9)	22 (25.0)	0.269	1.222
	Low	11	2 (18.2)	38	16 (42.1)	18 (36.7)	0.151	2.101
	Illiterate	13	4 (30.8)	8	2 (25.0)	6 (28.6)	0.782	0.081
Educational background	**Primary education**	54	17 (31.5)	84	26 (31.0)	43 (31.2)	0.948	0.004
	High school	60	19 (31.7)	37	**18 (48.6)**	37 (38.1)	0.096	2.797
	University and above	10	**5 (50.0)**	8	2 (25.0)	**7 (38.9)**	0.293	1.169
Working status	**Yes**	25	7 (28.0)	21	**8 (38.1)**	15 (32.6)	0.467	0.529
	No	112	**38 (33.9)**	116	40 (34.5)	**78 (34.2)**	0.930	0.008
TOTAL		**137**	**45 (32.8)**	**137**	**48(35.0)**	**93(33.9)**	**0.702**	**0.146**

highest seropositivity was observed among women with university-level education or above in the patient group (50.0%), while in the control group, the highest rate was found among high school graduates (48.6%). Regarding employment status, the seropositivity rate among employed women in the control group (38.1%) was higher than that among unemployed women in the patient group (33.9%). However, no statistically significant differences were identified between the groups for any of the sociodemographic variables ($p > 0.05$), (Table 2).

As shown in Table 3, when the number of pregnancies is compared between women with a history of miscarriage, stillbirth, or preterm delivery and healthy women, the frequency of seropositive cases showed a generally similar distribution. In terms of gestational age, seropositivity rates were comparable between the two groups at 6–12 weeks of gestation, whereas among women at ≥33 weeks of gestation, anti-*T. gondii* IgG seroprevalence was higher in the patient group compared to the control group. Seropositivity rates were similar in both groups among women without a history of stillbirth or preterm delivery. Among women without a history of miscarriage, no seropositive cases were observed in the patient group, while a seropositivity rate of 35.0% was detected in the control group. Statistical analysis of Table 3 indicated no significant differences between the groups for any of the parameters evaluated ($p > 0.05$).

Table 3: Anti-*T. gondii* IgG seroprevalence according to pregnancy status in both groups

Groups		Group 1 n	Positive n (%)	Group 2 n	Positive n (%)	Total (N=274) n (%)	*P*	X^2
Number of pregnancies	**1-3**	118	40(33.9)	121	44(36.4)	84(35.1)	0.690	0.159
	4-6	18	4(22.2)	16	4(25.0)	20(58.8)	1.000	0.036
	7-9	1	**1(100.0)**	0	-	**1(100.0)**	-	-
Pregnancy week	**0**	103	31(30.4)	0	-	31(30.4)	-	-
	6-12	27	11(40.7)	29	12(41.4)	23(41.1)	0.961	0.002
	13-19	3	1(33.3)	29	6(20.7)	7(21.9)	0.620	0.254
	20-26	0	-	22	8(36.4)	8(36.4)	-	-
	27-32	2	-	28	11(39.3)	11(39.3)	0.273	1.241
	+33	2	**2(100.0)**	29	11(37.9)	**13(41.9)**	0.091	2.960
Number of miscarriages	**0**	3	-	137	48(35.0)	**48(35.0)**	0.208	1.599
	1-3	134	**45(33.6)**	0	-	45(33.6)	-	-
Number of stillbirths	**0**	125	40(32.0)	137	48(35.0)	88(33.6)	0.603	0.270
	1-3	12	**5(41.7)**	0	-	**5(41.7)**	-	-
Number of premature births	**0**	119	38(31.9)	137	48(35.0)	86(33.6)	0.600	0.275
	1-3	18	**7(38.9)**	0	-	**7(38.9)**	-	-
TOTAL		**137**	**45 (32.8)**	**137**	**48(35.0)**	**93(33.9)**	**0.702**	**0.146**

Table 4: Anti-*T. gondii* IgG seroprevalence in both groups by potential social, nutritional, and hygiene-related risk factors

Groups		Group 1 n	Positive n (%)	Group 2 n	Positive n (%)	Total (N=%) n (%)	*P*	X^2
Feeding cats at home	**Yes**	28	**10(35.7)**	16	**9(56.2)**	**19(43.2)**	0.186	1.750
	No	109	35(32.1)	121	39(32.2)	74(32.2)	0.984	0.000
Feeding cats in the garden*	**Yes**	49	13(26.5)	38	**19(50.0)**	**32(36.8)**	**0.024**	5.070
	No	88	**32(36.4)**	99	29(29.3)	61(32.6)	0.303	1.060
Engage in gardening or field work	**Yes**	34	9(26.5)	32	**15(46.9)**	**24(36.4)**	0.085	2.966
	No	103	**36(35.0)**	105	33(31.4)	69(33.2)	0.590	0.291
Eating unwashed fruits/vegetables	**Yes**	50	16(32.0)	49	17(34.7)	33(33.3%)	0.776	0.081
	No	87	**29(33.3)**	88	**31(35.2)**	**60(34.3)**	0.792	0.070
Eating raw or undercooked meat (salami. sausage. raw meatballs. etc.)	**Yes**	21	**8(38.1)**	6	2(33.3)	**10(37.0)**	0.834	0.045
	No	116	37(31.9)	131	**46(35.1)**	83(33.6)	0.593	0.286
Eating raw or undercooked eggs	**Yes**	5	**3(60.0)**	25	**10(40.0)**	**13(43.3)**	0.418	0.679
	No	132	42(31.8)	112	38(33.9)	80(32.8)	0.726	0.122
Do not drink raw milk*	**Yes**	8	0 (0.0)	79	**30(38.0)**	**30(34.5)**	**0.047**	4.637
	No	129	**45(34.9)**	58	18(31.0)	63(33.7)	0.606	0.265
Water supply	**Faucet**	103	29(28.2)	114	42(36.8)	71(32.7)	0.173	1.855
	Ready Bottle	33	**16(48.5)**	19	4(21.1)	20(38.5)	0.050	3.834
	Well	1	-	4	**2(50.0)**	**2(40.0)**	0.414	0.833
Washing your hands before and after cooking	**Yes**	132	**44(33.3)**	137	**48(35.0)**	**92(34.2)**	0.768	0.087
	No	5	1(20.0)	0	-	1(20.0)	-	-
Importance is given to the cleanliness of kitchen utensils that come into contact with undercooked or raw meat products.	**Yes**	131	43(32.8)	88	28(31.8)	**71(44.7)**	0.876	0.024
	No	6	**2(33.3)**	49	**20(40.8)**	22(40.0)	1.000	0.125
Importance is given to the cleaning of kitchen utensils that come into contact with unwashed fruits/vegetables.	**Yes**	137	45(32.8)	77	26(33.8)	71(33.2)	0.891	0.019
	No	0	-	60	22(36.7)	**22(36.7)**	-	-
Total		**137**	**45 (32.8)**	**137**	**48(35.0)**	**93(33.9)**	**0.702**	**0.146**

When the anti-*T. gondii* IgG seropositivity was statistically compared between the two groups of female participants in the study, a significant relationship was found only among women who kept cats in the garden based on their social habits (OR = 0.361, 95% CI: 0.147–0.886, $p<0.05$). Regarding dietary habits, significance was observed only among those who consumed raw milk ($p<0.05$). No statistically significant difference was found between the groups based on hygiene habits ($p> 0.05$), (Table 4).

When compared with the anti-*T. gondii* IgM seropositivity among the female participants, a total of three women were found to be seropositive (1.1%). Of these women, two were in Group 1, which were women with histories of miscarriage, stillbirth, or pregnancy loss, while the other woman was found in Group 2, the control group of healthy women without pregnancy losses. When the seropositive cases were compared according to their sociodemographic characteristics and potential risk factors, including social, dietary, and hygiene habits, no statistically significant difference was found between the groups regarding IgM seropositivity ($p>0.05$). However, when compared by pregnancy status, the results show that seropositivity was significantly higher in the patient group (33.3%) as compared to the control group (1.4%) of women who had not experienced a miscarriage. A statistically significant difference was observed between the two groups ($p<0.05$). The patient group was found to be 68 times (OR=68.000, 95% CI: 3.053–1514.797) more at risk compared to the control group.

Discussion

Studies conducted on women with a history of abortion worldwide have indicated[9,10-14] that maternal acute toxoplasmosis during pregnancy is one of the factors that increase the likelihood of spontaneous abortion.[15,16] Additionally, a genotyping study conducted in Tehran has demonstrated that *Toxoplasma* genotype III is predominant in women who have experienced miscarriage.[17]In Turkey, IgG seropositivity in women with a history of abortion, stillbirth, or premature birth ranges from 37% to 84%.[18,19] Studies conducted in various regions have reported high prevalences of IgG in women with a history of abortion.[20-24] The seropositivity rates observed in these studies vary depending on factors such as geographic region, lifestyle differences, dietary habits, socioeconomic conditions, age groups, and employment status.[25,26]

In studies conducted in Kars province, IgG seroprevalence among women of reproductive age was found to be 36.5% between 2008 and 2013,[27] 20.3% in pregnant women in 2015,[28] and 44.8% in pregnant women in 2019.[29]

Additionally, a three-year evaluation conducted between 2020 and 2022 found IgG seroprevalence of 19.4% and IgM seroprevalence of 0.5% in women of reproductive age.[30] Given the widespread practice of animal husbandry in the Kars region, residents are frequently exposed to animals and animal products, increasing the potential risk of *Toxoplasma* transmission. As a result, there is a need for further research on *Toxoplasma* in humans. In the present study, we found IgG seropositivity of 32.8%, IgM seropositivity of 1.5%, and IgG+IgM seropositivity of 0.0% in the patient group, while in the control group, IgG was 35.0%, IgM was 0.7%, and IgG+IgM was 0.7%. Overall, the total seropositivity rates were 33.9% for IgG, 1.1% for IgM, and 0.4% for IgG+IgM. The findings of this study are consistent with the national and provincial seroprevalence results.

The transmission dynamics of *T. gondii* differ between rural and urban areas.[31] In rural areas, seroprevalence is higher due to inadequate hygiene, soil and animal contact, and consumption of unpasteurized water/milk.[32] This finding is supported by both national and international studies.[33-37] Similarly, in the present study, the seroprevalence rate was found to be higher in rural areas; however, no statistically significant difference was observed between the patient and control groups ($p>0.05$). This result may be attributed to environmental factors commonly observed in rural areas, including suboptimal hygiene conditions, frequent contact with soil, consumption of raw milk, and water obtained from wells. Additionally, it suggests that the risk of infection is influenced not only by the place of residence but also by socio-cultural habits.

Studies investigating the relationship between income level and toxoplasmosis have generally reported higher seropositivity among women with low income;[36,37] however, similar seropositivity levels have also been observed in the

high-income group.[38] The subjective assessment of income level complicates the precise determination of this risk factor.[36] In this study, the highest IgG seropositivity was observed in healthy women with a high-income level (51.4%), while IgM seropositivity was found in the patient group with a middle-income level. A significant relationship was found between income level and IgG in the healthy group ($p<0.05$), but no statistical difference was detected between income level and seropositivity overall ($p>0.05$). Due to the lack of an objective assessment of income level, this relationship requires further detailed investigation.

The relationship between educational level and *T. gondii* seropositivity has been reported variably. Some studies have shown higher seropositivity among illiterate women,[36,37] while others reported elevated rates in women with high school or higher education.[39,40] Additionally, some research indicates that seropositivity decreases with increasing educational attainment.[41,42] In the present study, IgG seropositivity was highest among university-educated women in the patient group (50.0%) and among high school graduates in the control group (48.6%). IgM seropositivity was observed in 15.4% of illiterate women, with no statistically significant difference between groups (p>0.05). Higher seropositivity in more educated individuals may be associated with increased consumption of ready-to-eat or raw foods, dining out, and exposure to novel cuisines, whereas elevated rates in less educated women may reflect inadequate hygiene, lower socioeconomic status, and rural residence.

Studies both worldwide and in Turkey have reported higher seropositivity among housewives, which has been attributed to traditional domestic roles, increased contact with pets, handling raw meat during food preparation, tasting undercooked meat, contact with raw fruits and vegetables, and, in some rural areas, involvement in gardening or agricultural activities[31,43,44]. Consistent with these findings, in the present study, the highest IgG seropositivity in the patient group was observed among housewives (33.9%). In contrast, seroprevalence was higher among employed women in the control group (38.1%). IgM seropositivity was elevated among non-working women in both groups. Comparison between the groups revealed no statistically significant difference according to employment status (p>0.05).

In the literature, studies show a negative correlation between the number of pregnancies and seropositivity, indicating that as the number of pregnancies increases, the seropositivity of the infection decreases.[12] However, there are also studies suggesting that seropositivity increases as the number of pregnancies rises.[44,45] Additionally, some studies have stated that there is no relationship between seropositivity and the number of pregnancies.[26,46] In this study, the high IgG (58.8%) and IgM (11.1%) seroprevalence was observed in women with 4 to 6 pregnancies. One of our patients had 8 pregnancies, and the highest IgG seropositivity (100.0%) was observed in this patient. In comparison to the referenced studies, this study also showed a proportional increase in seropositivity with the increase in the number of pregnancies; however, when pregnancy numbers were compared between groups, no statistically significant relationship was found ($p>0.05$).

According to studies, the risk of congenital infection is low in the early stages of pregnancy, while the risk of IgG transmission increases with the progression of pregnancy, reaching 6% at the 13th week, 40% at the 26th week, and 72% at the 36th week. In congenital toxoplasmosis, the risk of disease development varies according to the week of pregnancy during maternal IgM seroconversion (61% at the 13th week, 25% at the 26th week, and 9% at the 36th week).[47] As a result, it has been concluded that the frequency of transmission from mother to fetus is inversely proportional to the severity of congenital disease.[1,48] In our study, the highest IgG seropositivity was observed in women in the patient group at +33 weeks of pregnancy (100.0%). This trend was maintained in healthy women between 27-32 weeks of gestation (39.3%). IgM seropositivity was high in both groups during the 6-12 weeks of pregnancy, but it was higher in the patient group compared to the control group. However, no statistically significant difference was found when comparing the two groups (p>0.05).

Data regarding the rate of miscarriage and congenital diseases caused by *T. gondii* are very limited. However, numerous studies have demonstrated that toxoplasmosis is a significant contributor to miscarriage, yielding critical findings.[10,24,35,39,49] In addition to studies regarding

women's abortion histories and causes of infertility[43], there are also studies focused on women who have experienced stillbirths or given birth to infants with congenital anomalies.[22,50,51] Although less common, some studies examine both miscarriage and stillbirth occurring together.[52] Since *T. gondii* can be transmitted from mother to fetus via the placenta, causing permanent sequelae in newborns, the focus of research has shifted to the newborns themselves. Studies have shown that in cases of active maternal toxoplasmosis, congenital infection is also observed in newborns.[53] In our study, we found seroprevalence of 33.6% IgG and 0.7% IgM in women who had miscarried, 41.7% IgG and 8.3% IgM in women who had stillbirths, and 38.9% IgG and 11.1% IgM in women who had preterm births. No comparison could be made with the control group, as these parameters were not present. However, when comparing women who had not miscarried in both the patient and control groups, IgG and IgM seropositivity were found to be higher, with a statistically significant difference in terms of IgM (p<0.05). It was determined that the patient group had 68 times (OR=68.000, 95% CI: 3.053-1514.797) higher IgM seropositivity compared to the control group. The fact that the majority of women with high seropositivity lived in rural areas, kept cats at home or in their gardens, and had other potential risk factors may provide an adequate explanation for this elevated rate. This suggests that further investigation of this situation using molecular and other advanced diagnostic methods is necessary.

The cat, being the only known definitive host of *T. gondii*, plays a significant role in the transmission of the infection. Several studies have shown that close contact with cats and cleaning of items that have been in contact with cats can increase seropositivity.[32,54] It has even been suggested that living with cats increases the risk of infection by five times.[55] However, there are also studies in which no relationship between *T. gondii* seropositivity and cats has been identified.[18,36,37,56] In our region, the seroprevalence in household cats is reported to be 65%, which is attributed to the fact that most of the cats were previously stray and later taken into homes.[57] In another study conducted in Kars, a seroprevalence of 44.1% in cats was reported[58]. In the present study, the highest IgG seropositivity was found among women in the control group who kept cats at home (56.2%). Similarly, the group of women who kept cats in their gardens exhibited the highest seropositivity (50.0%), and this difference was statistically significant (p<0.05). When comparing the patient and control groups, no significant difference was found regarding keeping cats at home (p>0.05); however, a significant difference was observed regarding keeping cats in the garden (p<0.05).

In our region, livestock breeding and agriculture are common sources of livelihood, and during the summer months, people often move to highland pastures, resulting in frequent contact with soil, water, and animals. Previous studies have identified soil contact as a significant risk factor for *T. gondii* infection,[56,59] although some studies have found no significant association.[36] Research involving women with a history of abortion also reported soil contact as an important risk factor.[60] In the present study, IgG seropositivity among women in the patient group who reported no involvement in gardening or agricultural activities was 35.0%, whereas in the control group, women engaged in gardening or fieldwork exhibited higher seropositivity (56.2%). IgM seropositivity in the patient group was relatively elevated (5.2%). These findings suggest a strong association between *T. gondii* infection and soil contact, indicating that women may become infected through direct contact with contaminated soil. Furthermore, several studies have reported that the consumption of unwashed fruits and vegetables increases the risk of *T. gondii* infection.[32,61,62] Accordingly, in our survey, among women in both groups who answered “no” to the question “Do you consume unwashed fruits or vegetables?”, IgG seropositivity was 34.3% and IgM seropositivity was 3.0%, with no statistically significant difference observed between the groups (p>0.05).

Studies have suggested that consuming raw or undercooked meat, as well as raw eggs or milk, can increase the risk of infection.[44,63,64] Literature reports have identified live parasites in eggs that were boiled for less than five minutes or fried for three minutes.[65] Additionally, a study conducted on pregnant women in Portugal and Angola found that women in Angola who consumed raw milk had a higher seroprevalence. This was attributed to factors such as the widespread sale of milk and dairy products on the streets, misunderstandings about pasteurized products among participants, and poor hygienic conditions in the country.[64] In

Turkey, a study in Ankara found a *Toxoplasma* IgG seroprevalence of 41.7% in pregnant women who consumed raw milk and dairy products, such as cream-fresh cheese; however, this finding was not statistically significant.[44]

Conversely, a study conducted in Aydın found no increase in *Toxoplasma* seroprevalence related to the consumption of milk and dairy products.[66] Furthermore, a study in Trabzon involving individuals aged 20 and above found no relationship between raw milk consumption and toxoplasmosis seropositivity.[37] The researcher suggested that this may be due to the limited consumption of goat milk in the country. In the present study, when comparing women in the patient group with women in the control group, a significant relationship was found between raw milk consumption and IgG seropositivity ($p<0.05$). However, no significant difference was observed between the groups regarding the consumption of raw eggs ($p>0.05$).*T. gondii* oocysts are resistant to conventional disinfection methods.[67] Experimental methods have been developed to detect these oocysts in environmental water sources, particularly to prevent waterborne outbreaks.[51,68]

T. gondii outbreak cases have been reported globally due to the consumption of unfiltered water.[69] Research has highlighted that the methods of drinking water supply can influence infection rates. Studies indicate that drinking sources such as tap water[59], and spring water[70] are associated with a higher risk of infection. In Kilis, it was noted that *Toxoplasma* seroprevalence increased among individuals consuming tap and well water; however, no statistically significant relationship was found between the two.[36] In the present study, the highest IgG seroprevalence (50.0%) and IgM seroprevalence (100.0%) were observed in the control group that used well water. While this factor was significant in the patient group ($p<0.05$), there was no significant difference found between the two groups overall ($p>0.05$). These findings align with the results of the study by Demiroğlu.[36]

Consumption of undercooked or raw meat, as well as inadequate cleaning of kitchen utensils that come into contact with these foods, are important risk factors for *T. gondii* infection. High seropositivity has been reported among individuals handling raw meat, particularly pregnant women.[71,72] Accordingly, adherence to hygiene practices and proper cleaning of kitchen utensils exposed to raw or undercooked meat and unwashed fruits or vegetables is strongly recommended.[44,56] In the present study, IgG seropositivity was 44.7% among women who reported paying attention to cleaning utensils used for raw or undercooked meat, while IgM seropositivity was 16.7% among those who did not. Similarly, in women who neglected cleaning utensils exposed to unwashed fruits or vegetables, IgG seropositivity in the control group was 40.8%, and IgM seropositivity in the patient group was 16.7%, representing the highest rates observed.

Poor hygiene practices, limited knowledge of hygiene, and insufficient handwashing have been identified as major contributors to *T. gondii* infection in several studies.[59,73,74] Furthermore, the recent influx of refugees into the country has further compromised hygiene conditions, contributing to increased exposure and infection risk[75].

In this study, the participating women reported adhering to hygiene practices. However, despite their self-reported compliance, *T. gondii* seroprevalence was found to be high. This elevated seroprevalence suggests that their hygiene practices may not be effectively implemented, highlighting the need to critically assess and understand women's perceptions and behaviours regarding hygiens.

Strengths and limitations

This study included women with a history of abortion or stillbirth and matched healthy controls, allowing for direct comparison of anti-*T. gondii* IgG and IgM seroprevalence. Detailed sociodemographic, obstetric, and behavioral data were collected using a structured questionnaire, and serum samples were analyzed using a standardized micro-ELISA method. Furthermore, this is the first comparative study of these groups in Kars, Turkey, and all patients recorded within one year were included, enhancing the representativeness of the sample. The study provides valuable region-specific data, particularly given the absence of a national screening program or specific public health policy for *T. gondii* in Turkey, highlighting its importance for public health. Limitations include the single-center and comparative-descriptive design, which restricts the generalizability of the findings, precludes causal inference, and the

potential for recall bias due to self-reported data. Despite these limitations, the study identifies key risk factors and supports the need for targeted public health interventions, as well as informing strategies to improve maternal and child health policies in the region.

Conclusion and recommendations

In conclusion, although *T. gondii* remains an important public health concern, this study did not demonstrate a significant association between seropositivity and a history of abortion or stillbirth. However, IgM seropositivity was found to be higher in the patient group, which may indicate recent exposure to the infection. In addition, several behavioral and environmental factors were identified as potential risk factors, highlighting the need for increased public awareness and preventive strategies.While considerable research has already been conducted on the seroprevalence of toxoplasmosis, regular surveillance studies remain important. Performing confirmatory tests in cases of abortion may contribute to a better understanding of the relationship between *T. gondii* infection and adverse pregnancy outcomes. Furthermore, more comprehensive studies evaluating all potential risk factors are needed to better predict the risk of congenital toxoplasmosis. In this context, increasing awareness and providing education on preventive measures would be beneficial for public health.

Availability of data and materials

The data setsused and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

N.M.- designed the research study. B.K., N.M.- performed the research. B.K.- collected and processed data. B.K., N.M.- analyzed and interpreted the data. B.K., N.M.- conducted a literatüre search. B.K., N.M.- wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors readand approved the final manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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