Investigation of Seropositivity of Anti-*Toxoplasma gondii* Antibodies and Possible Risk Factors in Pregnant Women with Diabetes at Risk

Diyabet Tanılı Riskli Gebelerde Anti-Toxoplasma gondii Antikorlarının Seropozitifliği ve Olası Risk Faktörlerinin Araştırılması

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ABSTRACT

Objective: Toxoplasmosis is a parasitic infection caused by *Toxoplasma gondii*. Immunocompromised individuals and pregnant women are at risk, with the latter group being susceptible to miscarriages. This study aimed to determine the seropositivity of *T. gondii* antibodies and potential risk factors in pregnant women diagnosed with diabetes mellitus.
Methods: The research was conducted at the Ankara City Hospital Perinatology Clinic between October 2021 and June 2022. The study included 277 pregnant women diagnosed with diabetes mellitus and 277 healthy pregnant women who had given birth. Retrospective analysis of anti-*T. gondii* immunoglobulin (Ig)G and IgM levels was performed for patients between January 2020 and February 2022. Participants were administered an informed consent form and a questionnaire. Data were analysed using SPSS 22.
Results: Among pregnant women with diabetes, IgG seropositivity was 18.4%, IgM was 0.0%, and IgG+IgM was 0.0%. In healthy pregnant women, IgG seropositivity was 12.3%, IgM was 0.4%, and IgG+IgM was 0.4%. Overall, seropositivity rates were 15.3% for IgG, 0.2% for IgM, and 0.2% for IgG+IgM. The difference between the two groups was statistically significant (p<0.05). Among pregnant women with diabetes, there was a significant statistical difference (p<0.05) in anti-*T. gondii* IgG seropositivity related to education, employment status, number of pregnancies and live births, history of toxoplasmosis diagnosis in children, previous toxoplasmosis diagnosis, hygiene, nutrition, and social habits. Among healthy pregnant women, significant statistical differences were found (p<0.05) in IgG seropositivity related to age, income, education level, number of pregnancies and live births, previous toxoplasmosis diagnosis, hygiene, nutrition, and social habits. No invasive interventions were performed on infants born to seropositive mothers, and perinatal data were not available.
Conclusion: The seroprevalence of toxoplasmosis in Ankara appears to be decreasing, but *T. gondii* infections continue to pose a public health concern and are significant in pregnant women with diabetes mellitus.
Keywords: *Toxoplasma gondii*, pregnant, diabetes mellitus, seropositive, risk factors

ÖZ

Amaç: Toxoplasmosis, *Toxoplasma gondii*'nin sebep olduğu paraziter bir enfeksiyondur. Bağışıklığı baskılanmış kişiler ve gebeler risk altında olup gebelerde düşüğe sebep olabilmektedir. Bu çalışma diyabet tanısı almış riskli gebelerde *T. gondii* antikorlarının seropozitifliğinin ve olası risk faktörlerinin belirlenebilmesi amacıyla yapılmıştır.
Yöntemler: Araştırma Ankara Şehir Hastanesi Perinatoloji Kliniği'nde Ekim 2021-Haziran 2022 tarihleri arasında yürütülmüştür. Çalışmanın materyalini, doğum yapmış, 277 diyabet tanısı almış gebe ile 277 sağlıklı gebe oluşturmuştur. Geriye dönük Ocak 2020-Şubat 2022 tarihleri arasındaki hastaların anti *T. gondii* immünoglobulin (Ig)G ve IgM değerlerine bakılmıştır. Katılımcılar bilgilendirildikten sonra anket bilgi formu uygulanmıştır. Elde edilen veriler SPSS 22 programına yüklenerek istatistiksel analizler yapılmıştır.
Bulgular: Çalışmada diyabet tanılı gebelerde IgG %18,4, IgM %0,0, IgG+IgM %0,0; sağlıklı gebelerde ise IgG %12,3, IgM %0,4, IgG+IgM %0,4 olarak tespit edilirken, genel toplamda IgG %15,3, IgM %0,2 ve IgG+IgM %0,2 oranında seropozitiflik tespit

edilmiştir. İki grup arasındaki fark istatistiki olarak anlamlı bulunmuştur (p<0,05). Diyabet tanılı gebelerde; eğitim, çalışma durumu, gebelik ve canlı doğum sayısı, çocuklarında hastalık olma durumu, daha önce toxoplasmosis tanısı alma, hijyen, beslenme ve sosyal alışkanlıkları; sağlıklı gebelerde ise yaş, gelir, eğitim durumu, gebelik ve canlı doğum sayısı, daha önce toxoplasmosis tanısı alma, hijyen, beslenme ve sosyal alışkanlıkları ile anti-*T.gondii* IgG seropozitifliği arasında istatistiki fark anlamlı bulunmuştur (p<0,05). Seropozitif gebelerin bebeklerine herhangi bir invaziv girişim uygulanmamıştır. Dolayısıyla perinatal veriler bulunmamaktadır.

Sonuç: Ankara ilinde toxoplasmosis seropozitifliğinin giderek azaldığı, ancak *T. gondii* enfeksiyonlarının hala halk sağlığı sorunu olmaya devam ettiği ve diyabet tanılı riskli gebelerde önemli olduğu belirlenmiştir.

Anahtar Kelimeler: *Toxoplasma gondii*, gebe, diabetes mellitus, seropozitif, risk faktörleri

INTRODUCTION

Toxoplasma gondii is a eukaryotic parasite with a broad host spectrum, causing a parasitic infection seen in many living organisms (1,2). Approximately one-third of the world's population is exposed to this parasite. Cats are the definitive hosts. It has an obligate or facultative heteroxenous life cycle. It can infect all warm-blooded creatures, including humans (mammals, birds, etc.) (1,3). When acute toxoplasmosis occurs in a pregnant mother, resulting in fetal infection, congenital toxoplasmosis can occur, posing a risk (4,5). Toxoplasmosis, one of the protozoal infections, is seen at a high rate during pregnancy and has been reported to sometimes lead to fetal death (6). Chronic toxoplasmosis is considered a potential risk factor for type 2 diabetes mellitus (T2DM), as it is believed that *T. gondii* directly invades and destroys pancreatic β-cells, potentially triggering pancreatitis and, more importantly, diabetes (7). Particularly, researchers have highlighted that the protozoan parasite *T. gondii* might influence the risk and development of T2DM, potentially inducing low-grade inflammation (8). There is a belief that a possible relationship between toxoplasmosis and diabetes could shed light on the complex pathogenesis of diabetes and lead to significant clinical outcomes. Indeed, it has been suggested that toxoplasmosis increases susceptibility to becoming a diabetic and, conversely, that diabetic patients are more vulnerable to opportunistic infections such as *T. gondii* (7).

Acute toxoplasmosis contracted during pregnancy can be lethal for the fetus, and due to its high reported incidence, it is believed that this parasite may lay the groundwork for the development of diabetes. There is also a consideration that there is a connection between the two conditions. Reduced cellular immunity in pregnant women and diabetic patients may increase the susceptibility to infection. Therefore, despite studies on diabetic patients in Türkiye, there has been a lack of research specifically focusing on pregnant women diagnosed with diabetes. This study was conducted with the aim of determining the seropositivity of *T. gondii* antibodies in pregnant women diagnosed with diabetes at risk and identifying potential risk factors that could affect its epidemiology. In Türkiye, despite studies involving diabetic patients, no research has been found to focus on pregnant women diagnosed with diabetes. Hence, this study is aimed at investigating the seropositivity of *T. gondii* antibodies and identifying possible risk factors that could impact the epidemiology of the infection among pregnant women diagnosed with diabetes. It's important to consider the potential implications of such research, as acute toxoplasmosis in pregnant women and its relationship to diabetes could have significant health implications for both the mothers and their unborn children.

METHODS

The research was conducted at the Ankara City Hospital Department of Obstetrics and Perinatology between October 2021 and June 2022. A total of 277 pregnant women with diabetes who gave birth in the hospital, had anti-*T. gondii* immunoglobulin (Ig)G and IgM values, and were diagnosed with 7.2% (n=20) type-1 diabetes mellitus (T1DM), 19.5% (n=54) type-2 diabetes mellitus (T2DM), and 73.3% (n=203) gestational diabetes mellitus (GDM) constituted the patient group, while 277 healthy pregnant women without chronic disease constituted the control group. None of the women in the control group had been diagnosed with gestational diabetes and were not using insulin. Afterward, a "questionnaire information form" consisting of 26 questions and an "informed consent form" were administered and obtained from the participants. *Toxoplasma* IgG and IgM values were recorded by checking the system.

Statistical Analysis

The participants' responses to the questionnaire and laboratory results were then entered into the Statistical Package for Social Sciences (SPSS) program. Descriptive statistics such as mean (mean), count (n), and percentage (%) were used to present the data for the variables. To determine the relationship between categorical variables, the chi-square (χ^2) test was employed. In cases where the frequency was less than 5, Fisher's Exact chi-square test was applied. Seropositivity values were presented with a 95% confidence interval (95% CI) and a significance level of p<0.05 was considered statistically significant.

Ethical Statement

While the study was receiving ethics committee approval, the necessary permission was obtained by applying to the Ministry of Health Provincial Health Directorate Ankara City Hospital No. 2 Clinical Research Ethics Committee (protocol number: E2-21-948, date: 27.10.2021).

For the research, the necessary institutional permission was obtained by applying to Ankara Governorship Provincial Health Directorate Ankara City Hospital Gynecology Hospital Chief Physician (date: 14.10.2021).

RESULTS

The research compared the demographic characteristics and pregnancy histories of diabetic and healthy pregnant women. Among diabetic pregnant women, the highest percentage (38.3%) was in the age group of 35 and above, whereas among healthy pregnant women, the highest percentage (37.9%) was in the age range of 25-29. Both groups had the highest proportion of urban residents, with percentages of 90.6% and 88.8% for diabetic and healthy pregnant women, respectively. Furthermore, both groups had a significant proportion (46.6% for diabetic and 44.4% for

Table 1. Seropositivity of *T. gondii* antibodies in diabetic and healthy pregnant women (n=554)

Groups		Diabetic n/(%)	Healthy n/(%)	Total n/(%)	p	χ²
IgG	**Positive**	**51 (18.4)**	**34 (12.3)**	**85 (15.3)**	**0.045**	**4.016**
	Negative	226 (81.6)	243 (87.7)	469 (84.7)		
IgM	**Positive**	0 (0.0)	**1 (0.4)**	**1 (0.2)**	1.000	1.002
	Negative	277 (100.0)	276 (99.6)	553 (99.8)		
IgG + IgM	**Positive**	0 (0.0)	1 (0.4)	**1 (0.2)**	1.000	1.002
	Negative	277 (100.0)	276 (99.6)	553 (99.8)		
Total		**277 (50.0)**	**277 (50.0)**	**554 (100.0)**		
Ig: Immunoglobulin						

healthy pregnant women) with a high school education level. Regarding pregnancy histories, the number of pregnancies and live births ranged from 1 to 3 in both groups. However, the rates of miscarriage and premature birth were higher in diabetic pregnant women compared to healthy pregnant women. These findings suggest that diabetes may have a potential impact on pregnancy outcomes.

According to the study, anti-*T. gondii* IgG seropositivity was detected in 18.4% of diabetic pregnant women (according to diabetes types; 5.0% T1DM, 13.0% T2DM and 21.2% GDM) and 12.3% of healthy pregnant women, resulting in an overall IgG seropositivity rate of 15.3%. The difference in anti-*T. gondii* IgG seropositivity between diabetic and healthy pregnant women was statistically significant (p<0.05) (Table 1).

In this study, when the comparison was made in terms of anti-*T. gondii* IgM seropositivity, it was determined that a total of 1 (one) pregnant woman showed seropositivity (0.4%). The avidity test of this pregnant woman, who was among the healthy pregnant women, was negative. In addition, when compared according to socio-demographic characteristics, possible risk factors such as social, nutritional, hygiene habits, pregnancy status, blood transfusion and previous diagnosis of toxoplasmosis, no statistically significant difference was observed between the groups in terms of IgM seropositivity (p>0.05).

In Table 2, potential risk factors that could lead to toxoplasmosis in diabetic and healthy pregnant women are presented. These risk factors include socio-demographic characteristics, pregnancy history, social, dietary, and hygiene habits, and statistically significant findings are shared (p<0.05).

In healthy pregnant women, a significant relationship has been detected between age groups and income levels with anti-*T. gondii* IgG seropositivity. It was determined that low-income healthy pregnant women have a higher risk group with a rate of 28.6% (p<0.05).

In the diabetic group, according to educational status, illiterate and primary school graduate pregnant women were found to be 2.22 times more at risk compared to high school and university graduates (odds ratio=2.22, 95% CI: 1.200-4.108, p<0.05). In the same group, 44.4% of pregnant women who indicated that they had a chronic illness in their living children were found to be anti-*T. gondii* IgG seropositive (p<0.05).

When both groups were compared in terms of anti-*T. gondii* IgG seropositivity, although the majority answered positively to questions about potential risk factors, it was determined that a higher rate of seropositivity was found in diabetic diagnosed

pregnant women and the difference between the groups was statistically significant (p<0.05) (Table 3).

DISCUSSION

According to scientific assessments, it is estimated that the number of diabetic patients will reach 522 million by the year 2030 (9). Recent research has suggested a potential relationship between infectious agents such as *Helicobacter pylori*, Coxsackie B4 virus, and diabetes. Similarly, *T. gondii* has been proposed as a possible cause for diabetes (10). Indeed, there are indications of an indirect relationship between toxoplasmosis and specific types of diabetes (7,9-11). A study examining the potential relationship between latent toxoplasmosis and blood glucose levels found that pregnant women with toxoplasmosis had significantly higher blood glucose levels during oral glucose tolerance testing (OGTT). Elevated glucose levels and increased GDM incidence could lead to significant clinical effects such as metabolic syndrome and T2DM development in women infected with *T. gondii* (11).

Diabetes, a metabolic disorder, has a widespread distribution, especially among individuals with high-calorie diets. While insulin deficiency is associated with type 1 diabetes mellitus (T1DM), improper response to insulin in target cells is known as T2DM, resulting in hyperglycaemia. Genetic factors, autoimmune processes, and environmental factors have been suggested as causes (7). *T. gondii* can infect and replicate in any nucleated cell, including pancreatic cells. Insulin, a hormone secreted by the pancreas, plays a role in regulating blood sugar. Theoretically, toxoplasmosis could play a role in the development of T1DM (9). In fact, Nassief Beshay et al. (9) reported that anti-*Toxoplasma* IgG seropositivity was 86.4% in T1DM, 66.7% in T2DM, and 60.0% in the control group. The difference was statistically significant compared to the control group, with T1DM patients having a 4.2 times higher seroprevalence. In a study conducted in China, as diabetes prevalence increased, *T. gondii* seroprevalence was found to be 16.5% in T1DM, 23.5% in T2DM, and 21.3% in GDM patients. Each type of DM patients had significantly higher *T. gondii* seroprevalence compared to control subjects (10). Another study in China found significantly higher rates of anti-*T. gondii* IgG seropositivity in GDM women compared to non-GDM women, but no statistically significant difference was found in terms of anti-*T. gondii* IgM (12). Similarly, in a study conducted in Trabzon, Türkiye, the seroprevalence of *T. gondii* was found to be significantly higher in diabetic individuals compared to non-diabetic individuals (13).

Table 2. Anti-*T. gondii* IgG seropositivity according to potential risk factors in diabetic and healthy pregnant women

Survey questions		Diabetic pregnant women			Healthy pregnant women		
		n	IgG positive n/(%)	p	n	IgG positive n/(%)	p
Educational level	Illiterate-primary education	103	**27 (26.2)**	0.010	100	18 (18.0)	0.029
	High school and beyond	174	24 (13.8)		177	16 (9.0)	
Number of pregnancies	1-3	186	28 (15.1)	0.039	222	21 (9.5)	0.004
	4-6+	91	**23 (25.3)**		55	13 (23.6)	
Number of live births	1-3	247	41 (16.6)	0.026	261	28 (10.7)	0.002
	4-6+	30	**10 (33.3)**		16	6 (37.5)	
	No	259	43 (16.6)				
Contact with cats	Yes	17	**7 (41.2)**	0.012	25	12 (48.0)	0.000
	No	260	44 (16.9)		252	22 (8.7)	
Feeding cats at home	Yes	11	**6 (54.5)**	0.002	3	2 (66.7)	0.041
	No	266	45 (16.9)		274	32 (11.7)	
Feeding cats in the garden	Yes	31	**12 (38.7)**	0.002	19	11 (57.9)	0.000
	No	246	39 (15.9)		258	23 (8.9)	
Engaging in garden or field work	Yes	30	**13 (43.3)**	0.000	15	10 (66.7)	0.000
	No	247	38 (15.4)		262	24 (9.2)	
Consumption of unwashed fruits and vegetables	Yes	18	**7 (38.9)**	0.020	16	7 (43.8)	0.000
	No	259	44 (17.0)		261	27 (10.3)	
Consumption of raw or undercooked meat	Yes	15	**6 (40.0)**	0.027	6	4 (66.7)	0.02
	No	262	45 (17.2)		271	30 (11.1)	
Consumption of raw or undercooked meat	Yes	66	**24 (36.4)**	0.000	63	19 (30.2)	0.000
	No	211	27 (12.8)		214	15 (7.0)	
Consumption of raw milk	Yes	4	**4 (100.0)**	0.001	3	2 (66.7)	0.041
	No	273	47 (17.2)		274	32 (11.7)	
Consumption of processed foods in their raw form	Yes	126	**37 (29.4)**	0.000	92	21 (22.8)	0.000
	No	151	14 (9.3)		185	13 (7.0)	
Do not use the knife used for cutting raw meat to also cut cooked meat or raw fruits/vegetables intended for consumption	Yes	127	**34 (26.7)**	0.001	116	24 (20.7)	0.000
	No	150	17 (11.3)		161	10 (6.2)	
Grand total		**277**	**51 (18.4)**		**277**	**34 (12.3)**	

Ig: Immunoglobulin

Toxoplasmosis studies conducted in diabetic individuals have also yielded contradictory results. Indeed, a study in Iran found anti-*T. gondii* IgG seropositivity rates of 69.0% in T1DM, 63.0% in T2DM, and 59.0% in the control group. However, no statistically significant differences were observed in terms of toxoplasmosis among the studied groups (14). A study in Durango, Mexico, concluded that there was no serological evidence of a relationship between *T. gondii* infection and diabetes. Similarly, despite limitations such as a small number of studies, a systematic analysis by Majidiani et al. (7) suggested that chronic toxoplasmosis could

be a potential risk factor for T2DM. However, using a random-effects model, no statistically significant relationship between *T. gondii* and T1DM was found. Similarly, a study conducted in Sivas, Türkiye, found that anti-*T. gondii* seropositivity rates were 40.5% in diabetic patients and 38.2% in healthy individuals in the control group, and *Toxoplasma* IgM was negative in both groups. Consequently, there was no statistically significant relationship reported in terms of *Toxoplasma* IgG seropositivity between the groups (15). Another study in Egypt investigated different types of diabetic vascular complications and glycosylated haemoglobin

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Table 3. Comparison of anti-*T. gondii* IgG seropositivity in diabetic and healthy pregnant women according to possible risk factors

Groups		n	Diabetic Positive n/(%)	n	Healthy Positive n/(%)	Total	p	χ²
Cat contact	No	260	44 (16.9)	252	22 (8.7)	66 (12.9)	**0.006**	**7.650**
Feeding stray cats in the garden	No	246	39 (15.9)	258	23 (8.9)	62 (12.3)	**0.018**	**5.620**
Working in garden and field	No	247	38 (15.4)	262	24 (9.2)	62 (12.2)	**0.032**	**4.605**
Drinking water source	Purifier	67	13 (19.4)	66	3 (4.6)	16 (12.0)	**0.014**	**6.935**
Consumption of unwashed fruits and vegetables	No	259	44 (17.0)	261	27 (10.3)	71 (13.7)	**0.027**	**4.867**
Consumption of raw or undercooked meat	No	262	45 (17.2)	271	30 (11.1)	75 (14.1)	**0.043**	**4.107**
Consumption of raw or undercooked eggs	No	211	27 (12.8)	214	15 (7.0)	42 (9.9)	**0.046**	**3.995**
Handwashing before and after cooking	Yes	270	**50 (18.5)**	275	**34 (12.4)**	84 (15.4)	**0.047**	**3.959**
Total		**277**	**51 (18.4)**	**277**	**34 (12.3)**	**85 (15.6)**	0.45	4.016

Ig: Immunoglobulin

(HbA1c) levels, yet no significant relationship between *T. gondii* infection and diabetes was identified. Despite the high prevalence of anti-*T. gondii* IgG among diabetic patients, the researchers concluded that there was no association with diabetic complications and glycaemic control (16).

In this study, anti-*T. gondii* IgG seropositivity was determined to be 18.4% in pregnant women diagnosed with diabetes, while it was found to be 12.3% in healthy pregnant women. The difference between the groups is statistically significant (p<0.05). In the study, *T. gondii* IgG seropositivity rates were 5.0% in pregnant women diagnosed with T1DM, 13.0% in pregnant women diagnosed with T2DM, and 21.2% in pregnant women diagnosed with GDM. However, no statistically significant differences were observed in terms of anti-*T. gondii* IgG seropositivity between pregestational and gestational diabetes types or between insulin-using and non-insulin-using pregnant women (p>0.05).

In a cross-sectional study conducted on subjects with T1DM and T2DM referred to diabetes centres in Iraq, it has been reported that *T. gondii* seropositive diabetic individuals have a higher likelihood of being obese compared to seronegative diabetic individuals (8). In a study conducted in Korea, *T. gondii* IgG seropositive cases were found to have a higher seroprevalence in terms of various diseases in order of frequency, including malignant neoplasms, diabetes mellitus (DM), arthritis, chronic hepatitis B, chronic kidney diseases, schizophrenia, and acute lymphadenitis, compared to the control group. Furthermore, the study suggested that individuals with weakened immune systems due to chemotherapy-related drugs, as well as cancer, chronic hepatitis, or metabolic disorders related to diabetes, might have a higher risk of contracting infectious diseases such as toxoplasmosis. The potential association of *T. gondii* seropositivity with neoplasms, DM, and other chronic infections has been highlighted (17).

When looking at studies conducted on pregnant women in Ankara, Güngör et al. (18) conducted research involving 245 participants using the Sabin Feldman and ELISA methods, reporting a *T. gondii* IgG seropositivity rate of 41.6%. In a study by Saraçoğlu and Şahin (19), involving 231 pregnant women, a *T. gondii* IgG seropositivity

rate of 38.1% was reported. In a study conducted by Oral (20) on healthy pregnant women, a *T. gondii* IgG seropositivity rate of 27.4% was reported. In this study conducted at Ankara City Hospital Women's Health and Birth Tower, a total of 554 pregnant women showed a *T. gondii* IgG positivity rate of 15.9%. When examining all these studies conducted in Ankara, it can be observed that *T. gondii* seropositivity is decreasing gradually. This decline may be explained by factors predominant in Ankara, where urbanization is prominent, such as reduced contact with soil, decreased engagement in gardening and farming, a lower presence of stray cats, increased education levels, and greater awareness over the years. Similarly, in Fas, when studies conducted in 2007, 2014, and 2021 are compared, a decrease in *T. gondii* IgG seroprevalence is reported, with rates of 51.0%, 47.0%, and 43.0% respectively in the studied regions (21).

In some studies, it has been observed that *T. gondii* seroprevalence increases proportionally with age, and this is attributed to the elevated exposure to *Toxoplasma* with aging (22). Indeed, the reason for the increase in quantitative titers with age is thought to be the higher likelihood of an individual coming into contact with one of the routes of transmission. Many studies support this phenomenon (13,17,19,21,23-26). In a study conducted in Muş, while no significant difference was found between age and *Toxoplasma* IgM seropositivity, a linearly significant increase in *Toxoplasma* IgG seropositivity with age was observed. Researchers attributed this to the higher risk of encountering the pathogen as age progresses in an area where contact with both large and small livestock is common (27). Additionally, it has been reported that there is no significant relationship between age increase and infection (28-32). In this current study, while no statistical significance was found between seropositivity and age in pregnant women diagnosed with diabetes, a significant relationship was observed in healthy pregnant women (p<0.05).

Researches revealing the relationship between the number of pregnancies and anti-*Toxoplasma* IgG seropositivity have been encountered (20,33,34). While two studies conducted at different times found no relationship between the number of pregnancies and anti-*Toxoplasma* IgG seropositivity (33,34), another study reported a proportional increase in *Toxoplasma* IgG seropositivity

with an increasing number of pregnancies (20). In this study, it was determined that as the number of pregnancies and live births increased, the proportional increase in anti-*Toxoplasma* seropositivity was significant (p<0.05). Education level has contributed to awareness in many diseases and has also added the skill of being conscious about toxoplasmosis. There are studies indicating an inverse relationship between education level and seropositivity. Changes in lifestyle related to development, hygiene measures, and higher education levels can contribute to reducing the prevalence of infection (13,20,21). In this study, when the education levels of pregnant women diagnosed with diabetes and healthy pregnant women were categorized as "illiterate, primary education, secondary education, university and above", it was observed that as education levels increased in both groups, *T. gondii* IgG seroprevalence rates decreased, and a significant relationship was found (p<0.05). This suggests that educated pregnant women act more consciously, and the increase in knowledge of personal hygiene could explain the lower incidence of infection.

The final host of the disease, cats, are known to play a significant role in the spread of toxoplasmosis. Regions with a high cat population and activities involving contact with cats or cat litter have been found to be significantly associated with *T. gondii* seropositivity (5,28,35). It has been reported that both *Toxoplasma* IgG and IgM seropositivity are higher in individuals with pet animals (36,37). A study conducted in Ethiopia found that living with pet cats increased the infection rate by five times by *T. gondii* (38). A study in China reported that keeping cats at home was a significant risk factor for diabetes patients (10). Another study found a significant association between feeding cats in the garden and seropositivity (31). A seroprevalence study conducted in Kars, Türkiye, found that although pregnant women who had cats at home or in the garden had higher seropositivity rates, there was no statistically significant relationship (26). In this study, a significant relationship was observed between anti-*Toxoplasma* IgG seropositivity and keeping cats at home and in the garden, as well as contact with cats (p<0.05).

CONCLUSION

This study has once again highlighted potential risk factors for toxoplasmosis in both pregnant women with diabetes and healthy pregnant women. Pregnant women who are in contact with cats, which is one of the most important potential risk factors for transmission, may be less likely to transmit the disease if their cats are treated with internal parasite medication every three months. Increasing awareness and knowledge could play a pivotal role in disease control. Educational sessions during prenatal classes and regular follow-ups at healthcare centres could offer informative insights about toxoplasmosis and its associated risk factors. Displaying informative posters in relevant centres could effectively raise awareness. Moreover, nationwide screening programs should be implemented to ensure broader coverage and prevention of congenital toxoplasmosis, ultimately contributing to the overall health of the population. The development and implementation of preventive and control programs for the disease are both cost-effective and feasible. This study could serve as a guide for future research and control policies among pregnant women diagnosed with diabetes.

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