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Sero-Evidence Status of *Toxoplasma gondii* Infection in Mazandaran Province, Northern Iran: First Population-Based Regional Registry Analysis

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ABSTRACT

Background: *Toxoplasma gondii* is one of the most common parasitic infections in humans and other vertebrates worldwide. Regional seroprevalence data are critical for targeted interventions. Weaimed to investigate serological evidence of *Toxoplasma* infection among patients referred to the Iranian National Registry Center for Toxoplasmosis (INRCT) at the Mazandaran University of Medical Sciences (MAZUMS).

Methods: In this retrospective (descriptive-analytical) study, all patients referred to the INRCT, constitute the study population (underlying diseases/status) throughout 2021-2025. All data including demographic and some related characteristics were collected into a questionnaire and registered at the INRCT in Imam Khomeini Hospital, Sari, northern Iran. The existence of anti-*Toxoplasma* antibodies (IgG) was explored using a commercially available ELISA kit (PishtazTeb, Iran), based on the manufacturer's protocol.

Results: Anti-*Toxoplasma* IgG were detected among 862/1691 patients (50.98%). The most positive anti-*Toxoplasma* antibodies were in infertile women and the least were in suicide. IgG seropositivity was more common in females (66.01%) than in males (33.99%) and in 31–40 yr old patients (33.41%) in urban populations (53.71%).

Conclusion: The findings highlight a high burden of *T. gondii* infection in northern Iran, with gender, age, and residency as key determinants. Targeted screening and preventive measures are recommended for high-risk groups, including women of reproductive age and immunocompromised populations.

Keywords: *Toxoplasma gondii*, Seroprevalence, IgG antibodies, Registry-based study, Iran, Epidemiology

Introduction

Toxoplasma gondii is a highly prevalent parasitic protozoan infecting human beings and other vertebrates throughout the world. It is an intracellular obligate parasite capable of causing chronic infection, which in immunocompetent hosts remains asymptomatic but is lethal in immunocompromised hosts and pregnant women, including congenital toxoplasmosis and ocular disease (1,2). The seroprevalence globally is extremely heterogeneous by geographical, environmental, and socio-economic determinants at an estimated global average of some 30%-40% within the general population and even reaching 55% within some at-risk populations such as pregnant women (3-5). The age is also a significant contributor to seroprevalence, and rates increase more by age and even beyond over 80% among elderly in some areas (5). Other risk factors are contact with contaminated soil or water, contact with cats (the definitive host), dietary practices, and climatic conditions that allow the survival of oocysts (2,5,6).

Serological techniques continue to be the "gold standard" in the diagnosis of *T. gondii* infection, mainly through the detection of characteristic IgG and IgM antibodies. IgG antibodies indicate past or latent infection, and IgM antibodies indicate recent or acute infection (1). Serologic diagnosis on proper assessment is not only important for epidemiologic surveillance but also for clinical management, especially in pregnant women and immunocompromised individuals whose reactivation or primary infection can have serious consequences. Prophylactic interventions, therapy, and follow-up in individual risk patterns rely on serologic data. Besides, seroprevalence surveys provide significant data to public health administrators in planning successful prevention and control strategies, e.g., environmental management education, food hygiene, and safe practice (6).

Regional seroprevalence data are critical for targeted interventions. We aimed at establishing the seroprevalence of infection with *T. gondii* among patients referred to the Iranian National Registry Center for Toxoplasmosis (INRCT). As the seroprevalence in Iran ranges from 33% to 45% in the general population and may be higher in some populations such as immunocompromised patients, local epidemiological patterns need to be familiar (2). The findings will better reflect the patterns of *T. gondii* infection in Iran and facilitate the determination of high-risk groups and guide targeted prevention, diagnosis, and treatment approaches within the national health system.

Methods

The research was a descriptive-analytical retrospective registry-based study that encompassed all patients who were referred to the Iranian National Registry Center for Toxoplasmosis (INRCT) in Imam Khomeini Hospital, Sari, northern Iran, during 2021-2025, and therefore constituted the whole study group. Participants in the study were patients with various underlying illnesses and clinical conditions to the study. Exhaustive data collection was conducted through a structured questionnaire to obtain demographic information alongside pertinent clinical and epidemiological characteristics.

All the collected data were documented and systematically kept in INRCT database, connected to MAZUMS, north of Iran. Serological testing for anti-*T. gondii* IgG antibody detection was performed by using a commercial ELISA kit (PishtazTeb, Iran). The test was performed precisely following the manufacturer's instruction in order to get accurate and reproducible results.

Ethical Approval

Ethical approval for this study was obtained from the Ethical Committees of Mazandaran University of Medical Sciences and Iranian National Registry Center for Toxoplasmosis in Imam Khomeini Hospital, Iran (IR.MAZUMS.REC.1399.8630).

Results

Overall, 1,691 individuals were recruited into the study, of whom 862 (50.98%) were seropositive for *T. gondii* IgG antibodies and 829 (49.02%) were seronegative (Table 1). The female gender was the most common gender among the study population (60.08%). Seroprevalence of *T. gondii* IgG was significantly higher among females (66.01% of positives) compared to males (33.99% of positives), and gender and seropositivity were found to have a statistically significant relationship (*P*=0.023). Participants were divided into four age groups. The greatest percentage of seropositive participants was in the 31–41 yr age group (33.41%), followed by ≥50 yr (24.36%), ≤30 yr (24.48%), and 41–50 yr (17.75%). There was a significant positive correlation between *T. gondii* IgG seropositivity and age group (*P*=0.041). 51.09% of the population belonged to urban residents, and 53.71% of the seropositive infection was detected in them compared to 46.29% in rural residents. The urban and rural populations were statistically different from each other regarding seropositivity (*P*=0.012). The infertile females were the most frequent seropositive attendees (39.68%), followed by blood donors (17.40%), rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE) (13.46%), opioid addicts (12.64%), hypothyroid patients (9.51%), and previous suicide (7.31%). Highest seroprevalence of *T. gondii* IgG was in opioid addicts and childless women. There was statistical significance between disease/status groups and seropositivity (*P*=0.034).

Table 1: Demographic characteristics and anti-*Toxoplasma* specific IgG antibody results of patients referred to the toxoplasmosis registry

Characteristics	***Overall (%)***	***T. gondii IgG Positive (%)***	***T. gondii IgG Negative (%)***	***P-value***
Gender				
Male	675 (39.92)	293 (33.99)	382 (46.08)	0.023
Female	1016 (60.08)	569 (66.01)	447 (53.92)	
Age groupe (yr)				
≤30	436 (25.78)	211 (24.48)	225 (27.14)	0.041
31–41	571 (33.77)	288 (33.41)	283 (34.14)	
41–50	301 (17.80)	153 (17.75)	148 (17.85)	
> 50	383 (22.65)	210 (24.36)	173 (20.87)	
Residential place				
Urban	864 (51.09)	463 (53.71)	401 (48.37)	0.012
Rural	827 (48.91)	399 (46.29)	428 (51.63)	
Disease/Status				
Opioid	139 (8.22)	109 (12.64)	30 (3.62)	0.034
Suicide	147 (8.69)	63 (7.31)	84 (10.13)	
Blood donors	462 (27.32)	150 (17.40)	312 (37.64)	
Infertile women	520 (30.75)	342 (39.68)	178 (21.47)	
RA and SLE	305 (18.04)	116 (13.46)	189 (22.80)	
Hypothyroidism	118 (6.98)	82 (9.51)	36 (4.34)	
Total	1691 (100)	862 (50.98)	829 (49.02)	

RA: rheumatoid arthritis
SLE: systemic lupus erythematosus

Discussion

In the current study, a *T. gondii* IgG seroprevalence of approximately 51% was observed, which was greater in females, adults aged 31-41 yr, and urban residents. The findings are in line with other recent international and regional research that has documented high heterogeneity of seroprevalence by geography, population, and exposure. A meta-analysis of 138 reports among pregnant women globally reported a global seroprevalence of 36.6%, ranging from a high of 52.8% in South America and 46.8% in Africa to a low of 29.4% in Asia and 24.6% in Europe (7,8). The variation in seroprevalence between the studied regions is mainly due to a combination of socioeconomic factors, weather conditions, and local or culturally specific behaviors that influence exposure risk. Exposure risk is mainly the result of dietary habits, hygiene, and animal contact. Therefore, it is possible to see very different infection rates in populations of similar environmental exposures for reasons dependent on their behaviors (7). Seroprevalence in this study was moderately high but within the rate seen in populations of similar socioeconomic and climatic characteristics.

Gender variation noted in this study, where female subjects reported a much higher seroprevalence, agrees with a number of studies. For example, a Turkish case-comparison study of over 42,000 samples revealed significantly elevated IgG and IgM positivity in females compared to males, ascribing the same to gender-specific risk exposures and possibly hormonal or immunological factors (9). Similarly, Palestinian females reported a 27.9% IgG seroprevalence where sex differences were due to behavioral and cultural exposures (10).

The variation in seroprevalence based on gender may result from a complex interaction of biological factors and socio-cultural factors that likely directly influence immune mechanisms, and the epidemiology of exposure to parasitic infections of domestic animals, itself ordered by socially prescribed gender roles. For example, women are more likely to participate in domestic activities that entail contact with raw meat or soil, thus increasing their probability of exposure to parasitic infections. Addressing biological and sociocultural complexities is important for development of gender-focused public health responses (11). Gender must be considered with due thought in toxoplasmosis epidemiology.

Increased age in the seroprevalence is confirmed and well-supported here with the highest prevalence occurring in the 31–41 age bracket. This trend is consistent with international data linking cumulative exposure by ages as one of the primary causative agents of seropositivity (9,12). As an example, meta-analysis of Iranian populations yielded seroprevalence by age, rising seroprevalence with rising age and a reflection of prolonged risk for infection by exposure through environment or consumption. Urban-rural inequality in the present study, with greater rate among urban residents, is juxtaposed to some classical assumptions regarding the elevated risk of rural populations due to contact with soil and exposure to animals. Nevertheless, recent studies suggest that pet ownership, changes in food habit, and urbanization can enhance urban risk, as noted in Iran and Turkey (12).

The trend of increased incidence of infection in urban localities may be indicative of revised epidemiological patterns in relation to lifestyle changes. Urban dwellers tend to acquire more pets but particularly cats which are the definitive hosts for *T. gondii*. Urban dwellers may also be consuming processed or undercooked foods which lead to the associated risks of infection. There may be increased transmission due to urban environmental contamination and composition of population through high

density. Urban living is no longer being classified as low risk as a rural resident (11).

Correlation of *T. gondii* seropositivity with specific clinical groups, e.g., women with infertility, autoimmune disease patients, opioid drug users, hypothyroid or suicide history, corresponds well with recent data attributing toxoplasmosis to diverse health outcomes. Toxoplasmosis has been associated with infertility in certain research, possibly through chronic inflammation or immunomodulation. The parasite's ability to induce prolonged immune activation or dysregulation may contribute to reproductive complications and other chronic conditions. Such immunopathological effects extend the clinical significance of toxoplasmosis beyond acute infection, and it is worthwhile to explore the parasite's potential in systemic diseases (13).

Similarly, increased seroprevalence among opioid addicts and autoimmune disease sufferers may result from immunosuppression or behavioral risk factors. Immunocompromised individuals, including those with substance use disorders, are more susceptible to opportunistic infections like toxoplasmosis. Behavioral factors may contribute to compromised immune function with poor hygienic practices, food consumption risk, and higher exposures to contaminated environments, and therefore responsiveness to opportunities, raising the importance of screening and prevention to these populations (14). Linking toxoplasmosis with neuropsychiatric disease, such as suicidality, has been a goal of meta-analyses, and subclinical infection may be a cause of mental disease (15).

There is growing evidence to suggest that latent *T. gondii* infection might disrupt neurotransmitter systems or induce mild neuroinflammation, which might underlie psychiatric symptoms such as depression and suicidal ideation. These observations underscore the need to consider infectious causes in mental health studies and clinical practice (16).

Temporal trends in the Turkish retrospective study revealed the positivity rate of *T. gondii* IgG and IgM to have significantly decreased between 2016 and 2023, perhaps as a result of increased hygienic habits with the COVID-19 pandemic aftermath (8). This declining seroprevalence trend over the past few years has been seen in other worldwide meta-analyses and indicates that public health education and campaigns can be reducing transmission. The persistent high seroprevalence in certain groups still testifies to the need for ongoing surveillance and targeted prevention (7).

Environmental and behavioral risk factors continue to be of greatest concern in toxoplasmosis epidemiology understanding. Factors determining the risk of infection cited by the literature include cat ownership, raw meat handling, contact with soil having contaminated soil, and socioeconomic status (17). Socioeconomic level and education influence individual behavior such as habits of food preparation and hygiene, which have a direct impact on exposure risk. Cultural values also decide contact patterns with the environment and animals as infectious sources. All these complex factors are the reason why infection levels can be quite heterogeneous even among groups of individuals who live in similar climatic zones (18).

Education level and cultural habits are the determining factors for exposure and explain regional variation in the presence of a similar climate. These assertions are supported by this study's results, demonstrating the intricate nature of *T. gondii* transmission. Additionally, a bibliometric assessment of international publications related to toxoplasmosis found a continuous rise in the number of scientific papers published over the decades, which suggests a greater scientific interest and advances in better global understanding of the epidemiology, clinical consequences,

and prevention characteristics of toxoplasmosis (19).

Limitations

The study's retrospective design and reliance on registry data might introduce selection bias. Future studies should include prospective cohorts and molecular diagnostics to refine risk assessments.

Conclusion

This registry-based study revealed a *T. gondii* IgG seroprevalence of 50.98% in northern Iran, aligning with global trends but underscoring regional heterogeneity. The higher prevalence among females, adults aged 31–41 yr, and urban residents suggests behavioral or environmental exposure disparities. Notably, infertile women and opioid addicts exhibited elevated seropositivity, implicating *T. gondii* in broader health outcomes such as reproductive health and mental health. As a whole, our study provides critical baseline data for policymakers to mitigate *T. gondii* transmission in northern Iran, emphasizing the need for integrative health strategies.

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Conflict of interest

The authors declare that there is no conflict of interests.

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