

A Comparative Study of *Toxoplasma gondii* Infection: Urban versus Rural Areas in Duhok Province

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ABSTRACT

Background: Toxoplasmosis is a condition resulting from the protozoan parasite *Toxoplasma Gondii*, which can impact the health of humans and animals in various ways.

Aim: This study aimed to assess the seroprevalence of *T. Gondii* in females and to identify the risk factors associated with urban and rural areas within Duhok Province, Kurdistan region of Iraq.

Methods: In this study, 211 females of different ages attended medical laboratories in urban and rural areas of Duhok province from December 2023 to February 2024. Blood samples were used to detect specific anti-*Toxoplasma gondii* IgG and IgM antibodies using serological tests.

Results: In the current study, the total Seropositive toxoplasma antibodies IgG and IgM rate was 31.75% in urban and rural areas, with seropositivity of 3.79% in IgM and 27.96% in IgG. Urban seropositive of anti-*Toxoplasma* IgM and IgG was recorded in 1.58% and 23.01%, with rural seropositive of anti-*Toxoplasma* IgM and IgG in 7.05% and 35.29% respectively. Regarding the age groups, high seropositivity of IgM and IgG in urban areas was recorded in the age group of ≤ 20 years, whereas in rural areas, the high IgM and IgG seropositive were shown respectively in the age groups of 21-30 and 31-40 years.

Conclusion: Based on the study's findings, we can conclude that factors like stray cats, increased contact with contaminated soil, farming, caring for cattle or hens, dietary and culinary practices, and personal cleanliness are all responsible for the higher frequency of infection in rural areas.

Keywords: *Toxoplasma gondii*, seroprevalence, Toxoplasmosis, antibodies.

دراسة مقارنة لعدوى التوكسوبلازما جوندي: المناطق الحضرية والريفية في محافظة دهوك

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الخلاصة

الخلفية: داء المقوسات هو مرض ناتج عن الطفيلي الأولي *Toxoplasma gondii*، ويؤثر على صحة الإنسان والحيوان بطرق متعددة، وقد يُسبب مضاعفات صحية خطيرة في بعض الحالات.

الهدف من الدراسة: تهدف هذه الدراسة إلى تقييم معدل الانتشار المصلي لطفيلي *T. gondii* لدى الإناث، بالإضافة إلى تحديد عوامل الخطورة المرتبطة بالإصابة في المناطق الحضرية والريفية ضمن محافظة دهوك في إقليم كردستان العراق.

طرق البحث: شملت هذه الدراسة ٢١١ امرأة من أعمار مختلفة راجعن مختبرات طبية في المناطق الحضرية والريفية من محافظة دهوك خلال الفترة من كانون الأول/ديسمبر ٢٠٢٣ إلى شباط/فبراير ٢٠٢٤. تم جمع عينات دم لفحص الأجسام المضادة IgG و IgM الخاصة بطفيلي *Toxoplasma gondii* باستخدام الفحوصات المصلية.

النتائج: أظهرت النتائج أن معدل الإيجابية المصلية الكلي للأجسام المضادة IgG و IgM ضد *Toxoplasma gondii* بلغ ٣١.٧٥% في كلا المنطقتين الحضرية والريفية، حيث بلغت نسبة الإيجابية لـ IgM حوالي ٣.٧٩%، بينما كانت نسبة IgG نحو ٢٧.٩٦% في المناطق الحضرية، سُجّلت إيجابية الأجسام المضادة IgM و IgG بنسبة ١.٥٨% و ٢٣.٠١% على التوالي، بينما في المناطق الريفية سُجّلت بنسب أعلى بلغت ٧.٠٥% لـ IgM و ٣٥.٢٩% لـ IgG. وبالنسبة للفئات العمرية، فقد سُجّلت أعلى نسب إيجابية لـ IgG و IgM في المناطق الحضرية ضمن الفئة العمرية ≥ 20 سنة، في حين كانت النسب الأعلى في المناطق الريفية لدى الفئتين العمريتين ٢١-٣٠ سنة و ٣١-٤٠ سنة على التوالي.

الاستنتاجات: تشير نتائج الدراسة إلى أن هناك عوامل مثل وجود القطط الضالة، وزيادة التعرض للتربة الملوثة، وممارسة الزراعة، وتربية الأبقار أو الدواجن، والعادات الغذائية وأساليب الطهي، ومستوى النظافة الشخصية، كلها تلعب دوراً مهماً في زيادة معدل الإصابة بداء المقوسات في المناطق الريفية.

الكلمات المفتاحية: المقوسة الغوندية، الانتشار المصلي، داء المقوسات، الأجسام المضادة.

INTRODUCTION

Toxoplasma gondii, the parasite responsible for causing toxoplasmosis, is an obligate intracellular parasite that can affect a wide variety of warm-blooded animals, including humans^{1,2}. This parasite has a complex life cycle that involves different hosts, such as members of the feline family as definitive hosts and birds and livestock as intermediate hosts³. Toxoplasma gondii can be transmitted through various means, including consuming undercooked meat containing tissue cysts, ingesting oocysts from contaminated soil or water, organ transplants, and even through transmission from mother to fetus during pregnancy^{4,5}. Various risk factors are associated with Toxoplasma infection, including contact with cats, soil, unwashed raw vegetables, raw or undercooked meat consumption, and poor hand hygiene practices.

The risk of infection can increase, particularly in agricultural settings, due to exposure to contaminated soil⁶. Cats shedding oocysts in their feces play a crucial role in the transmission cycle of Toxoplasma by contaminating the environment. Consuming raw or undercooked meat, especially from infected animals, can also result in infection⁷.

Pregnant women are at risk of Toxoplasma infection, as it can have severe consequences for the fetus, including stillbirth, spontaneous abortion, or severe neurological disorders in the child⁸.

People at risk must take preventive measures, such as avoiding contact with potentially contaminated sources, practicing good hygiene, and ensuring proper food safety practices, which are essential in reducing the risk of Toxoplasma infection, especially for pregnant women⁹.

Serological tests, such as enzyme-linked immunosorbent assay (ELISA), are commonly used to detect Toxoplasma-specific antibodies in individuals, which helps in the diagnosis of acute or chronic infection phases¹⁰. Transmission of Toxoplasma gondii can be prevented by early detection and awareness of risk factors, which is crucial in reducing the associated health risks, particularly for vulnerable populations like Immuno-compromised people and pregnant women¹¹. Iraq, including Duhok Province, is considered endemic for Toxoplasma gondii infection, with previous studies reporting varying seroprevalence rates across different regions and populations^{12,13}.

However, there is limited information on the epidemiology of Toxoplasma gondii infection in urban and rural areas within Duhok Province specifically. Urban and rural areas differ in population density, living conditions, and environmental factors, which can influence the risk of exposure to Toxoplasma gondii.

This study aims to address this gap by conducting a comparative analysis of Toxoplasma gondii infection in urban and rural regions within Duhok Province by assessing the prevalence of the disease and risk factors associated with it in these areas.

MATERIAL AND METHODS

Study Setting

This cross-sectional study was conducted in Duhok Governorate, Kurdistan Region of Iraq, from December 2023 to February 2024.

Urban and rural areas were selected as the primary study sites because of their diverse environments, exposure to various factors, and significance in evaluating the prevalence of Toxoplasma gondii within the population. The research utilized a cross-sectional approach, enabling data gathering within a defined timeframe to establish the occurrence of T. gondii infection in females aged 1 to 50 in Duhok province (urban and rural areas of the City).

Sample Collection

During this period, 211 female patients attended laboratories in both urban and rural areas of Duhok province. Patients were categorized according to residency age group, and blood samples were collected for serological tests using the ELISA method.

Laboratory Analysis

Collected blood samples from patients were centrifuged, and after the sera separation, the samples were subjected to serological testing to identify anti-toxoplasma antibodies, IgG, and IgM antibodies. The Enzyme-Linked Immunosorbent Assay (ELISA) was employed as the preferred method for antibody detection, a commonly utilized and dependable technique for serological examinations. The ELISA kits used in the study for testing were applied according to the manufacturer's instructions as the coating step,

which began with the addition of *Toxoplasma* g. antigens to microtiter plates and other steps, which are blocking, sample Incubation, Detection, substrate addition, and measurement; in the final step (measurement), the microplate reader was used to measure color intensity to find the IgG and IgM antibody levels.

Statistical Analysis

In the current study, the statistical analysis of results was done using the SPSS 20.0 program, and to show the statistical difference between infected females of urban and rural areas, the chi-square test was used (significant P value <0.05).

Ethics Approval

The research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The Scientific/Ethics Committee of the College of Pharmacy, University of Duhok, reviewed and approved the research.

RESULTS

This study recorded two hundred and eleven patients (211) from several areas and laboratories of Duhok governorate. Individuals were divided into several age groups, as shown in table (1), (2) & (3).

Table (1): Demographic characteristics of the study participants.

Characteristic	Urban Area	Rural Area	Total
Age groups			
≤ 20	12	13	25
21-30	51	37	88
31-40	48	17	65
41-50	15	18	33
Location			
Urban areas	126		
Rural areas		85	

The total seropositivity percentage of anti-*Toxoplasma* IgM and IgG was 31.75%. Anti-*Toxoplasma* IgM and IgG were recorded at 3.79% and 27.96%, respectively, in urban and rural areas (Table 2).

Table (2): Seroprevalence of anti-*Toxoplasma* IgM and IgG in Urban and Rural areas of Duhok Province.

Areas	Total examined	IgM %	IgG %	IgG) % + (IgM	P- Value
Urban areas	126	2 (1.58%)	(23.01%) 29	(3.17%) 4	0.19
Rural areas	85	(%7.05) 6	(35.29%) 30	(3.52%) 3	
Total	211	8 (3.79%)	59 (27.96%)	7 (3.31%)	

On comparing urban and rural areas, anti-*Toxoplasma* IgM was shown in the Rural areas with a rate of %7.05 and 1.58% in urban areas, and the rate of anti-*Toxoplasma* IgG in Rural areas was recorded in 35.29% and 23.01% in urban areas. The total rate of IgG + IgM seropositivity was shown at 3.31% in both urban and rural areas, with 3.17% in urban and 3.52% in rural areas, and the records showed non-significant differences in anti-*Toxoplasma* IgM and IgG seropositivity when we compared the urban and rural areas (P- value 0.19). As shown in Table 3, the anti-*Toxoplasma* IgM seroprevalence in urban areas was recorded in 1.58% with a higher percentage in age group ≤ 20 years (8.33%) and no infection in age groups of 31-40 and 41-50 years.

Table (3): Seroprevalence of anti-*Toxoplasma* IgM and IgG in Urban areas of Duhok Province.

Age group	Total examined	IgM %	IgG %	IgG) % + (IgM	P- Value
≤ 20	12	(8.33%) 1	(58.33%) 7	(8.33%) 1	0.64
21-30	51	(1.96%) 1	(17.64%) 9	(5.88%) 3	
31-40	48	0	(25%) 12	0	
41-50	15	0	(6.66%) 1	0	
Total	126	(1.58%) 2	(23.01%) 29	(3.17%) 4	

The anti-*Toxoplasma* IgG seropositive in urban areas was recorded at 23.01%, and the highest anti-*Toxoplasma* IgG seropositive was shown in the ≤ 20 years age group with 58.33%, and the lowest rate was shown with 6.66% in 41-50 years age group. The results showed non-significant differences in urban areas when we compared the seropositive of anti-*Toxoplasma* IgM and IgG (P-value 0.64).

Table (4): Seroprevalence of anti-Toxoplasma IgM and IgG in Rural areas of Duhok Province.

Age group	Total examined	IgM %	IgG %	IgG) % + (IgM	P- Value
≤ 20	13	(7.69%) 1	(61.53%) 8	(7.69%) 1	0.66
21-30	37	(8.10%) 3	(16.21%) 6	(5.40%) 2	
31-40	17	(11.76%) 2	(70.58%) 12	0	
41-50	18	0	(22.22%) 4	0	
Total	85	(7.05%) 6	(35.29%) 30	(3.52%) 3	

In rural areas, the anti-Toxoplasma IgM and IgG seropositive (Table 4.) showed that the highest percentage of IgM and IgG were recorded in the age group of 31-40 with 11.76% and 70.58% of infection in both IgM and IgG respectively, and lowest infection rates in age group of 41-50 with no anti-Toxoplasma IgM detection and the incidence of 22.22% in anti-Toxoplasma IgG. These results show non-significant differences between Seroprevalence of anti-Toxoplasma IgM and IgG in rural areas (P- value 0.66).

DISCUSSION

This study was conducted to determine the seroprevalence of *Toxoplasma gondii* infection in Urban and Rural areas of Duhok Governorate. The results of this study showed that the seropositivity of anti-Toxoplasma IgG and IgM were 27.96% and 3.79%, respectively, with 3.31% being both IgG and IgM positive together, yielding a total of 31.75% seropositivity overall for both IgM and IgG. Toxoplasmosis, although one of the most common infections in humans, its prevalence varies widely from one country to another (from less than 10% to over 90%) and often between different communities in the same region ^{7,14}. When comparing current results with those of findings of Salih et al., 2020 in Duhok city ¹⁵, it shows that the overall percentage of seropositivity of the anti- T.

gondii antibodies and seropositivity of IgG in our study is higher. Still, the seropositivity of IgM in our results is lower. The highest seropositivity of IgM (urban areas) and IgG (rural areas) of the current study were shown in the age group of ≤ 20 and 31-40 years, which agrees with the results of Sultan and Mero 2021 in Duhok province ¹⁶.

Younger individuals are more susceptible to toxoplasma infection than older ones due to their high activity in outdoor agricultural work with soil and more contact with sources of Oocysts ^{17,18}. A study in Northern Iran, where an outbreak of toxoplasmosis occurred, yielded a total prevalence of IgG and IgM of 43.2%, a rate higher than that of 31.75%. This can be attributed to factors such as sample size, duration of sample collection (555 samples, compared to 211 samples of our study), and the fact that the population here isn't too keen on seeking healthcare facilities readily ¹⁹.

When our results were analyzed by place of residence, it was observed that the prevalence in rural areas was higher as compared to Urban areas, which contradicts the results of Morais et al., 2021 ²⁰, in which the rural areas (63.1%) was lower than that in the urban areas (81.3%). Also, in studies carried out in some tropical countries such as Sri Lanka and Burkina Faso, a higher seroprevalence was observed in urban areas, which can be due to factors such as poverty, overpopulation, and inadequate water supply/purification systems ^{21,22}. Another study in Iran showed that the seropositivity of anti-Toxoplasma IgG was 32.95% ²³, compared to Duhok's 27.96%, since Iran neighbors Kurdistan, it possesses a similar climate and environment. The appropriate condition for oocyst sporulation and environmental survival is essential in the infection rate and disease burden. Kurdistan has seasonal variations, so the weather varies in the provinces of this country. Studies have shown that cold and hot climates have a low prevalence of *Toxoplasma* infection. In contrast, wet and mild temperatures have high prevalence, which explains the difference in infection rates between our region and places such as Brazil and Sri Lanka ^{24,25}. In 2013, stray/feral cats were captured in Iraq as part of the US Army Zoonotic Disease Surveillance Program, and blood samples were collected from 207 cats, mainly in Baghdad but also in Kurdistan and western parts of Iraq, to determine the prevalence of *Toxoplasma* infections.

Seroprevalence of *Toxoplasma* was 30.4% among the stray cats, and since people in rural areas have more contact with dirt and stray animals, their risk of infection is higher than those residing in urban areas, which have less contact with dirt, stray animals, and also vaccinate their pets ²⁶.

Thus it becomes apparent that toxoplasmosis prevalence is influenced by several factors which are the number and presence of cats, socioeconomic conditions (with lower prevalence in developed countries compared to underdeveloped ones), environmental conditions (oocysts lose their virulence when frozen or dried, and therefore

higher prevalence is observed in areas with warm and humid climate), Diet and cooking habits (more contact with raw meat increases risk of infection) and Personal hygiene, which are the main factors that increase the toxoplasmosis infection in rural areas, as compared to that in urban^{14,27}. In this study, we can mention several points that are limiting, such as time restriction, participant number, and limited geographic area.

CONCLUSIONS

The total seropositivity rates of anti-Toxoplasma IgM and IgG in this study were recorded at 31.75%. Higher seropositivity of anti-Toxoplasma IgM (7.05%) and IgG (35.29%) was recorded in Rural areas as compared with urban areas anti-Toxoplasma IgM (1.58%) and anti-Toxoplasma IgG (23.01%) seropositivity. Regarding the individual ages, the current study shows the higher seropositivity of IgM and IgG in the age group of 31-40 in rural areas.

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Authorship Contribution Statement

The study's conception and design were carried out by AMA. Fieldwork contributions came from AAM and JWF. HHA, with MJA, analyzed the data. The initial draft of the paper was written by AMA, BYB, and AAM, with all authors participating in discussions about the results and contributing to the final version of the manuscript.

Declaration Of Competing Interest

There are no conflicts of interest associated with this work.

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Data Availability

All the data utilized in this study are accessible.

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