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A.M. ABDULLAH*, M.K. ABDULLAH, R.M. RASHEED,
A.J. AZKO, Y.I. YOUNIS, H.O. AHMAD, S.A. MAJEED

College of Pharmacy, University of Duhok, Iraq

* Author for correspondence; e-mail: arshadzanko@gmail.com

THE PREVALENCE OF *TOXOPLASMA GONDII* INFECTION IN DUHOK, KURDISTAN REGION, IRAQ

Toxoplasmosis is a parasitic infection, with widespread gestational and congenital transmission rates globally, consequently, it is regarded as a public health concern and an overlooked medical condition. Human infection occurs through various routes, including the ingestion of oocysts found in cat feces, consumption of raw or undercooked meat containing the parasite, and vertical transmission from an infected pregnant mother to her fetus. Objective. The aim of this study is to determine the prevalence of Toxoplasma gondii infection among individuals in various age groups and genders in Duhok City. Methods. In this research, 2251 individuals of various ages and genders visited the central laboratory in Duhok City, Kurdistan Region, Iraq, and peripheral blood samples were taken from individuals to identify specific anti-Toxoplasma gondii IgM and IgG antibodies using serological test (ELISA test). Results. Based on the findings of this study, it was observed that the prevalence of toxoplasmosis among females with infections detected in both IgM and IgG was 0.3 % and 20.6 %, respectively, and in males, the rate of infection with IgG was found to be 0.3 %, while no infections were detected with IgM. Also among female individuals, the study recorded a 0.3 % infection rate for toxoplasmosis, which encompassed both IgM and IgG cases. Conclusions. Based on this study, it can be concluded that Toxoplasma infection is more common in females than in males, chronic toxoplasmosis appears to be more prevalent than acute infection with the highest rate of acute infections was found in the age group of 21–40 years.

Keywords: toxoplasmosis, *Toxoplasma gondii*, parasites, ELISA.

Toxoplasmosis is a significant disease caused by an intracellular obligate parasite known as *Toxoplasma gondii*, which has a complex life cycle (Galvan-Ramirez et al., 2012; Saki et al., 2015). *T. gondii*, the causative agent of toxoplasmosis, is widespread globally, infecting both humans and

animals, and often leads to chronic infections in high percentage (Daryani et al., 2014; Dubey et al., 2014; Saadatnia & Golkar, 2012). This protozoan parasite infects both warm-blooded animals and humans, but the prevalence of infection is higher in humans than in animals (Nicolle & Manceaux,

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2009). The infective stage of this parasite is the oocyst stage, which is excreted in the feces of cats and can remain viable in the environment for approximately a year (Dubey, 1998; Frenkel et al., 1970). *T. gondii* infects individuals through the consumption of undercooked or raw contaminated meat, ingestion of the parasite's oocyst stage found in cat feces, and through transmission from infected pregnant women to their babies (Cook et al., 2000; Ducrocq et al., 2021; Jones et al., 2009). Precise information about the prevalence and impact of this parasite is of paramount importance for healthcare systems and for advancing our knowledge to prevent and efficiently manage the risks associated with this infection (Makiani et al., 2012). Serological tests, particularly ELISA tests, are widely employed and straightforward methods for detecting this parasite (Fallah et al., 2008; Golkar et al., 2007). The diagnosis of acute and chronic toxoplasmosis relies on the detection of both toxoplasma IgM and IgG antibodies, with these antibodies serving as important indicators for identifying this pathogen (Makiani et al., 2012; Petersen, 2007). During pregnancy, when women become infected with this parasite, there is a risk of transmitting the infection to the fetus vertically. This can result in fetal health issues, including conditions like microcephaly, hydrocephaly, chorioretinitis, cognitive impairments, vision problems, and even abortion (Daryani et al., 2014). The **aim** of this study is to assess the prevalence of toxoplasmosis among individuals of groups of different ages and genders in Duhok City.

Materials and Methods. Study area and sample collections. This research was conducted in the central laboratory of Duhok City, the Kurdistan region of Iraq. This laboratory serves patients from the health centers within the Duhok Governorate. The data collection period extended from January to December 2019. During this study, a total of 2251 individuals, of both genders, sought serodiagnostic testing for toxoplasmosis at the laboratory. They were categorized into three groups according to their age and gender.

Laboratory analyses. A 5mL peripheral blood sample was collected from each individual, and by blood centrifugation at 3000 rpm for 5 minutes, the sera were separated and then stored at 4 °C. The detection of anti-*Toxoplasma gondii* IgG and IgM antibodies was carried out using a commercial ELISA kit (Diagnostic Automation, Inc.) according to the manufacturer's instructions. All collected data on patient gender and age were tabulated. In this study, the Pearson chi-squared test was performed for statistical analysis.

Results. The study involved the analysis of 2251 individuals who visited the central laboratory of Duhok City, the Kurdistan Region of Iraq. These individuals were divided into different age groups and in both genders, as shown in Table 1. The seropositivity rates for anti-*Toxoplasma* IgM and IgG in females were 0.3 % and 20.6 %, respectively (Table 1). In males, there was no detection of anti-*Toxoplasma* IgM, and the seropositivity rate for anti-*Toxoplasma* IgG was 0.3 %. When considering both gender and age groups, the highest seropositivity for anti-*Toxoplasma* IgM among females was observed in the age group of 21–40 years, with a rate of 0.4 %, and the highest percentage of anti-*Toxoplasma* IgG in females was found in the age group > 40, with a seropositivity rate of 35.9 %. Conversely, the lowest seropositivity rates for anti-*Toxoplasma* IgM among females were observed in both age groups of ≤ 20 and the age group >40 (with no infections), while the age group of ≤ 20 had a 6.3 % seropositivity rate for anti-*Toxoplasma* IgG. Among male individuals, the highest infection rate for anti-*Toxoplasma* IgG was observed in the age group >40, with a rate of 0.4%. There were no infections detected for anti-*Toxoplasma* IgM in males. Conversely, the lowest seropositivity rates for anti-*Toxoplasma* IgG among males were found in the age group of 21–40, with a rate of 0.3 %.

A total of 0.30 % of infections were recorded among females in the age group of 21–40, with seropositivity for both anti-*Toxoplasma* IgG and

Table 1. Prevalence of anti-Toxoplasma IgM and IgG in Duhok City

| Individual age group | Total examined | (IgM) | | (IgG) | | IgG) + (IgM) | |
|----------------------|----------------|-------|--------|-------|--------|--------------|--------|
| | | Male | Female | Male | Female | Male | Female |
| ≤ 20 | 32 | 0 | 0 | 0 | 6.3% | 0 | 0 |
| 21—40 | 1966 | 0 | 0.4% | 0.3% | 18.9% | 0 | 0.3% |
| > 40 | 253 | 0 | 0 | 0.4% | 35.9% | 0 | 0 |
| Total | 2251 | 0 | 0.3% | 0.3% | 20.6% | 0 | 0.3% |
| <i>P</i> < 0.00001 | | | | | | | |

Pearson Chi-squared test was performed for statistical analysis

IgM. Statistical analysis revealed a significant difference in the infection rates among different age groups for toxoplasmosis, with $P < 0.00001$.

Discussion. This research represents a crucial seroprevalence study conducted in Duhok City, the Kurdistan Region of Iraq, aimed at investigating toxoplasmosis infection rates among individuals of different groups, including males and females of various ages. Such research is especially important for women, particularly pregnant women, as toxoplasmosis can have serious consequences if contracted during pregnancy, potentially leading to fetal infection and significant health risks for both the mother and fetus. These studies help raise awareness about the importance of diagnosis, prevention, and proper management of toxoplasmosis to protect the health of vulnerable people, including pregnant women. The global variation in toxoplasmosis prevalence across different age groups has been documented extensively. The findings of this study underscore the significance of community-based seroepidemiological research in assessing infection rates caused by *T. gondii*. It was observed that the rates of infection in females were higher compared to males, and the total seropositivity rates were 20.6 % for IgG and 0.3% for IgM, approaching those reported in Almadinah governorate, Saudia (Imam et al., 2016), and lower than those in other studies in Baghdad and Cali, Colombia (Mohammed, 2011; Rosso et al., 2008). The samples in this study were collected

from the central laboratory of the Duhok City governorate, which encompasses samples from the surrounding rural areas. The information from the laboratory staff and archive records suggests that the rate of seropositivity was higher in individuals residing in rural areas and semi-rural cities. This observation aligns with the findings from previous studies conducted in other countries (Macpherson, 2005). The higher rate of seropositivity among individuals living in rural areas and semi-rural cities could be attributed to their closer contact with cats, which increases their exposure to sporulated oocysts. This exposure often occurs through the ingestion of oocysts that contaminate soil, such as during farming activities, or through the consumption of undercooked meat contaminated with oocysts. Additionally, the lower level of education among women regarding the risk factors for this infection also plays a significant role in contributing to the higher rates of toxoplasmosis in those areas. In our study, it was observed that the age group with the highest rate of toxoplasmosis infection was age group 2. This is likely because this age group represents the reproductive age, and women within this age range tend to be more active and have greater exposure to products or activities that could lead to infection, which was in concordance with the records in Saudi Arabia, Iran, and the Kurdistan Region of Iraq. The lower seropositivity in age group 1 can be attributed to several factors, first, there may have been fewer

examinations conducted for individuals in this age group; additionally, they might be less active and have limited contact with products or activities that could lead to toxoplasmosis infection. Furthermore, the unequal degrees of exposure to oocysts of *T. gondii* among individuals in different age groups are likely the primary suspected reason for the variation in infection rates across the age groups.

Conclusions. Based on the findings of the current study, some conclusions can be drawn: toxoplasma infection is more prevalent among females compared to males; chronic infection with toxoplasmosis (indicated by IgG antibodies) is more common than acute infection (indicated by IgM antibodies); the highest rate of acute toxoplasmosis infection (IgM) was observed in the age group of 21—40 years.

Recommendations. Based on the data from this study, it is advisable to consider the following recommendations: regular serological examinations, particularly for women before and during pregnancy to detect and manage toxoplasmosis infection. This can help in providing timely intervention and guidance for pregnant women to minimize the risk of transmitting the infection to the fetus. Awareness and education programs should be implemented to inform individuals, especially pregnant women, about the precautions they should take to avoid contact with sources of *T. gondii* infection, such as stray cats, litter boxes, and soil. Further research, particularly molecular studies, is warranted to identify and characterize different strains of *T. gondii*.

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Ethical approval. The study was carried out in compliance with ethical principles rooted in the Declaration of Helsinki. It underwent a thorough evaluation and received approval from the Scientific/Ethics Committee of the College of Pharmacy at the University of Duhok City. (Reference No. 642).

Author contributions. The study's conception and design were carried out by Arshad M. Abdullah and Muhamad K. Abdullah. Fieldwork contributions came from Ahmad J. Azko and Younis I. Younis. Arshad M. Abdullah with Sarmad A. Majeed analyzed the data. The initial draft of the paper was written by Arshad M. Abdullah, Hashim O. Ahmad, and Raad M. Rasheed, with all authors participating in discussions about the results and contributing to the final version of the manuscript.

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Consent to participate. Ethical considerations were taken into account, and no names or personal information of individuals were utilized in this study.

Conflict of interest. The authors declare they have no conflicts of interest related to this research.

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А.М. Абдулла, М.Х. Абдулла, Р.М. Рашид, А.Д. Азко, Ю.І. Юніс, Х.О. Ахмад, С.А. Маджид

Фармацевтичний коледж, Університет Духока, Ірак

ПОШИРЕНІСТЬ ІНФЕКЦІЇ *TOXOPLASMA GONDII* В ДУХОКУ, КУРДИСТАН, ІРАК

Токсоплазмоз — це паразитарна інфекція, яка широко розповсюджена у світі, має високий ризик передачі під час вагітності та несе глобальну небезпеку, враховуючи високі ризики вроджених вад розвитку. Тому вона вважається проблемою громадського здоров'я та медичною загрозою, якій не приділяється належної уваги. Зараження людини відбувається різними шляхами, в тому числі шляхом заковтування ооцисти, що знаходиться в котячих фекаліях, споживання сирого або недовареного м'яса, що містить паразита, і вертикальної передачі від інфікованої вагітної матері до плоду. **Мета.** Метою цього дослідження є визначення поширеності інвазії *T. gondii* серед осіб різних вікових груп та статі в місті Духок. **Методи.** У цьому дослідженні залучено 2251 особу різного віку та статі в місті Духок, Курдистан, Ірак, у них були відібрані зразки периферичної крові для визначення специфічних антитіл до *T. gondii* IgM та IgG за допомогою серологічного тесту (ELISA). **Результати.** За результатами проведеного дослідження було виявлено, що поширеність токсоплазмозу серед осіб жіночої статі, у яких було виявлено IgM і IgG, становила 0,3 % та 20,6 %, а серед осіб чоловічої статі рівень IgG становив 0,3 %, тоді як IgM не було виявлено у жодному випадку. Також серед осіб жіночої статі зафіксовано 0,3 % інфікованості токсоплазмозом, що охоплює випадки інфікування як IgM, так і IgG. **Висновки.** На основі цього дослідження можна зробити висновок, що токсоплазмозова інфекція частіше зустрічається у жінок, ніж у чоловіків. Хронічний токсоплазмоз виявляється більш поширеним, ніж гостра інфекція, причому найвищий рівень гострої інфекції виявлено у віковій групі 21—40 років.

Ключові слова: токсоплазмоз, *Toxoplasma gondii*, паразити, ІФА.