

The Seroprevalence of *Toxoplasma gondii* Infection among Male Population in Zakho City, Duhok Province, Iraq

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Article History	Abstract
Received: 01 June 2023 Revised: 07 Aug 2023 Accepted: 27 Aug 2023	<i>Toxoplasmosis is a neglected foodborne disease, stands as the fourth most frequent cause of hospitalization and the second leading factor behind deaths among immunocompromised individuals and pregnant women who contract the disease at early pregnancy stage. The prevalence of toxoplasma infections among males in Zakho city has remained poorly examined. The current study's primary objective is to estimate the seroprevalence of Toxoplasma gondii (T. gondii) in males residing in Zakho city, Iraq. Data for analysis were gathered through serological tests and participant questionnaires. Among the 213 participants, 65 (30.52%) and 4 (1.88%) exhibited IgG and IgM anti-Toxoplasma gondii antibodies, respectively. The current investigation highlighted the prevalence of T. gondii infection within the general population of Zakho city, Iraq. However, the rate of seropositivity of anti-toxoplasma IgG, increased with age, but this increase was non-significant ($P > 0.05$). Also, higher but non-significant seroprevalence rates of toxoplasmosis IgG and IgM Abs were observed with other studied factors such as residence, contact with cats, occupation, marital status, and eating at restaurants. Indicating to the presence of poor relationships between toxoplasmosis and these demographic factors in males.</i>
CC License CC-BY-NC-SA 4.0	Keywords: Seroprevalence, Toxoplasmosis, Males

1. Introduction

Toxoplasmosis is a zoonotic infection cause by an intracellular protozoan parasite, *Toxoplasma gondii*. It has a worldwide distribution, but is usually asymptomatic in immunocompetent individuals. This infection is clinically significant in immunocompromised individuals or in pregnant women at early pregnancy stage (Mose *et al.*, 2020 and Milne *et al.*, 2020). Typically, this parasite is transmitted to humans through consuming food or water contaminated with sporulated oocysts or through the consumption of undercooked meat containing tissue cysts. Furthermore, other rare methods that lead in acquiring toxoplasmosis include, the introduction of infected blood or leukocytes, organ transplantation, and transmission via the placenta (Falah *et al.*, 2008 and Daryani *et al.*, 2014). In pregnant women, this opportunistic pathogen has the potential to result in complications such as abortion, stillbirth, congenital abnormalities, and in cases of immunocompromised individuals, severe illness and even death (Milne *et al.*, 2020). Furthermore, there has been previous speculation about the potential connection between latent *T. gondii* infections and persistent neurological and psychiatric conditions, predominantly schizophrenia and bipolar disorder (Fabiani *et al.*, 2015; Fuglewicz *et al.*, 2017 and Milne *et al.*, 2020). The occurrence of *T. gondii* differs among various societies based on their geographic location (Robert-Gangneux and Darde, 2012).

Serological and molecular investigations have been conducted globally, revealing that over 33% of the population carries antibodies against *T. gondii* (Bodaghi *et al.*, 2012; Villard *et al.*, 2016 and Yousefvand *et al.*, 2021). A considerable shortage of information exists concerning male

toxoplasmosis in Zakho city and its surrounding regions. The current study was undertaken to estimate the prevalence of toxoplasmosis among male population and to find if there is any correlation between the disease and some factors like age, gender, marital status, geographic region, and male toxoplasmosis within Zakho city and its neighboring areas through measuring the levels of IgG and IgM antibodies by ELISA method

2. Materials and Methods

Study Design

A cross-sectional study was carried out at Zakho Hospital During the period from May 2021 until April, 2022 by collecting a total of 213 blood samples from outpatient males aged 18 to 75 years visited Zakho hospital for various health issues.

Serological Test

From each participant after taking his consent, 5 ml of blood was collected using aseptic techniques into vacutainer tubes without anticoagulants. Subsequently, these samples were centrifuged at 3000 rpm for 5 minutes. The resulting serum, obtained through separation, was then transferred into Eppendorf tubes. These tubes were labeled with information corresponding to the study's questionnaire. The sera samples were then transported to the biology laboratory, University of Zakho and stored at a temperature of -20°C until the laboratory examination was conducted.

These samples were tested for anti-*Toxoplasma* IgG and IgM using ELISA kits (DRG International Instruments, GmbH, Germany) according to the instructions provided with this kit.

Analysis of Data

The collected data were analyzed using GraphPad Prism software (Version 9.0.2, 2021). P value less than 0.05 was considered statistically significant. To compare the seroprevalence values in relation to the subjects' characteristics, the Chi-square tests were used.

3. Results and Discussion

Out of the 213 males included in the study, 30.52% (65/213) tested positive for IgG antibodies, and 1.88% (4/213) tested positive for IgM antibodies (table 1). As regard to age, the highest rate (41.94%) for anti-*Toxoplasma* IgG Abs was exhibited among the age group > 56 years, whereas the age group of 18-35 exhibited the highest rate (3.03%) for anti-*Toxoplasma* IgM Abs (Table2). Statistical analysis revealed non-significant differences among different age groups for both IgG ($P < 0.09$) and IgM ($P < 0.71$) seropositive samples.

Table 1: Seropositive percentage of IgG and IgM *Toxoplasma* infection among males in Zakho city

Gender	No. of tested Samples	IgG +		IgM +	
		No.	%	No.	%
Male	213	65	30.52	4	1.88

Regarding the area of residence, a higher percentage of IgG and IgM positive samples were observed among individuals living in urban areas compared to those living in suburban areas (39.47% vs 28.57%) for IgG and (2.63% vs 1.71%) for IgM. However, non-significant differences were found between the two areas for both IgG ($P < 0.24$) and IgM ($P < 0.54$) positive samples.

Regarding other parameters, non-significant association was observed between contact with cats, occupation, marital status and eating outside home for both types of antibodies as indicated in table 2.

Table 2: Seroprevalence of *Toxoplasma* infection among individuals in Zakho according to sociodemographic characteristics

Variables	Tested n	IgG +			IgM +		
		Positive n	%	P Value	Positive n	%	P Value
Age group							
18-25	66	20	30.30	0.09	2	3.03	0.71

26-35	38	5	13.16		1	2.63	
36-45	41	14	34.15		0	0.00	
46-55	37	13	35.14		1	2.70	
>56	31	13	41.94		0	0.00	
Residence							
City	38	15	39.47	0.24	1	2.63	0.54
Cityside	175	50	28.57		3	1.71	
Contact with cats							
Yes	37	15	40.54	0.17	0	0.00	>0.99
No	176	50	28.41		4	2.27	
Occupation							
Employed	108	32	29.63	0.88	2	1.85	>0.99
Unemployed	105	33	31.43		2	1.90	
Marital Status							
Unmarried	69	23	33.33	0.53	3	0.69	0.1
Married	144	42	29.17		1	4.35	
Restaurants Meals							
Yes	142	44	30.99	0.87	4	2.82	0.3
No	71	21	29.58		0	0.00	

The study findings revealed that the overall prevalence of anti-Toxoplasma IgG and IgM was 31.88%, with 30% classified as chronic cases (IgG) and 1.88% as acute cases (IgM).

The outcomes of this study are close to the findings of Mahmood *et al.* (2013), who reported rates of 30.25% for IgG and 2.5% for IgM Abs among male blood donors at the National Blood Transfusion Center in Baghdad. On the other hand, Noori (2021) In Al-Najaf Province, reported slightly higher rates for both antibodies types among males which were 33.7%, and 5%, respectively. While Bahhaj *et al.* (2017) in northwestern Iran reported a higher rate of 38.66% for IgG and a lower rate of 1.03% for IgM.

A lower rate for IgG Abs and a higher rate for IgM Abs were reported among males in Duhok province by Salih *et al.* (2020) which were 20.75% for IgG and 4.72% for IgM. These discrepancies in toxoplasmosis seroprevalence could stem from variations in geographical location, living conditions, age, education level, contact with cats, hygiene practices, and dietary habits (Alvarado-Esquivel ., 2017 and Iddawela *et al.*, 2017).

These variations between previous research and the current study might be attributed to differences in the sensitivity and specificity of diagnostic methods and host's response to the parasite strain (Truyens *et al.*, 2021; Afonso *et al.*, 2012 and Whitman *et al.*, 2019). With regard to age, this study demonstrates higher seropositivity in males within the age group >56 years. Despite the, age was not identified as a statistically significant risk factor for toxoplasmosis seropositivity, since non-significant differences were observed between younger and older ages in this study. These outcomes align with other research suggesting that the incidence of toxoplasmosis can increase with age but statistically has no differences with different age group (Yu *et al.*, 2023, Rostami *et al.*, 2016).

However, the present rate contradicts with the findings of Muhsin *et al.* (2018), who reported the highest rate of toxoplasmosis in males aged between 19 and 28 years, and the lowest rate among ages of 49 to 58 years. The non-significant increase in the rate of anti-Toxoplasma IgG Abs with the age in the current study could be attributed to increased exposure to *T. gondii* sporulated oocysts due to prolonged contact with animals or soil over time or to eating infected undercooked meat at restaurants.

As regard to occupation, non-significant association was observed in the seroprevalence between employed and unemployed males These findings agree with the results of other studies such as Davarpanah *et al.* (2007), Khademvatan *et al.* (2013), , Salih *et al.* (2020) and Alsaady *et al.*, (2021),

all of them did not find any significant differences in seroprevalence of toxoplasmosis with different occupations. This could be attributed to the limited contact with animals and meats, which are known to carry higher risks of infection with the parasite. For instance, professions like dairy workers, slaughterhouse workers, veterinarians, meat processing workers, meat sellers, and cooks are often at a higher risk of contracting the infection (Zhou *et al.*, 2009).

Furthermore, no association was observed between toxoplasmosis and having contact with cats. These findings are in accordance with the study of Retmanasari *et al.* (2017). Who stated that direct contact with cats does not appear to be a significant factor in the transmission of the infection. Instead, the improper handling and management of cats' feces seem to be the primary contributors to zoonosis. This outcome contradicts with the findings of Lin *et al.* (2008) and Adeniyi *et al.* (2018), who reported a statistically significant link between interacting with cats and the prevalence of toxoplasmosis.

Chronic infection rates were marginally higher in unmarried males compared to married one, while acute infection rates in married males were higher than in unmarried males even though these differences were non-significant. This concurs with the findings of Davarpanah *et al.* (2007) and Salih *et al.* (2020) both of which indicated that the differences in seropositivity between unmarried and married individuals were non-statistically significant ($p > 0.05$). In contrast, Mahmood *et al.* (2013) demonstrated significant differences ($P < 0.01$) between married and unmarried male blood donors in terms of the presence of IgG and IgM antibodies.

Additionally, the findings of this study demonstrate that there are non-significant differences between individuals residing in Zakho city and those in suburban areas. Similarly, Ouslimani *et al.* (2019) in different Algerian governorates and Makouloutou-Nzassi *et al.* (2023) in different regions of Gabon country did not find any association between toxoplasmosis and residence. Hence, the area of residence does not appear to be a risk factor associated with the seropositivity of toxoplasmosis. Finally, the current data showed non-significant difference between the people who regularly eat homemade food or those eating at restaurants. Here, transmission of parasites can vary between restaurants depending on food handling practices, hygiene, and sanitation within restaurant environments. Proper cooking of meat, hygiene protocols, and source of the food all these factors play crucial roles in reducing the risk of contamination. It's important to note that restaurants following proper food safety procedures are generally considered lower risk for transmitting parasites compared to consuming raw or undercooked meat at home.

It's worth highlighting that many individuals with a healthy immune system who become infected with *Toxoplasma gondii* do not exhibit severe symptoms or complications. However, consuming undercooked or raw meat infected with the parasite infective stages, as well as ingesting food or water tainted with *Toxoplasma* sporulated oocysts from cat feces, are potential sources of infection. It's crucial to recognize that variations in cultural practices, hygiene standards, and climate conditions, among other factors, contribute to the varying prevalence of *T. gondii* infection among different human populations (Lafferty, 2006). Consequently, our findings should be approached with caution when attempting to generalize them to other cultures and populations.

4. Conclusion

This study findings have highlighted that toxoplasmosis, does not exhibit gender-based discrimination, since men are susceptible to infection when exposed to the parasite infected stages. However, is worth noting that no discernible connections were established between the various risk factors investigated and the incidence of infections, even though they showed some effects which were non-significant. Therefore, its suggested that there may be other contributing factors that might have potential health-related effects like behavioral characteristics and hormonal levels in infected males.

References

Adeniyi, O. T., Adekola, S. S., & Oladipo, O. M. (2018). Seroepidemiology of toxoplasmosis among pregnant women in Osogbo, Southwestern, Nigeria. *Journal of Infectious Diseases and Immunity*, 10(2), 8-16.

- Afonso, A. M., Ebell, M. H., & Tarleton, R. L. (2012). A systematic review of high-quality diagnostic tests for Chagas disease. *PLoS Neglected Tropical Diseases*, 6(11), e1881.
- Alsaady, H. A. M., Aswan, A. A., & Abbood, E. S. (2021). Sero-epidemiology of *Toxoplasma gondii* among men and pregnant women in Maysan Province, south of Iraq. *Iranian Journal of Ichthyology*, 8, 27-37.
- Alvarado-Esquivel, C., Rico-Almochantaf, Y. D. R., Hernández-Tinoco, J., Quiñones-Canales, G., Sánchez-Anguiano, L. F., Torres-González, J., Schott, B., Liesenfeld, O., & Dunay, I. R. (2017). *Toxoplasma gondii* exposure and neurological disorders: an age- and gender-matched case-control pilot study. *European Journal of Microbiology and Immunology*, 7(4), 303-309.
- Ashburn, D. (1992). History and general epidemiology. In: Human toxoplasmosis, 1–25. Ho-Yen DO, Joss AWL (Eds). *Oxford Medical Publications*, Oxford, UK.
- Bahhaj, R., Ahmadpour, E., Mahami-Oskouei, M., Fallah, E., Shamsasenan, K., & Safaiyan, A. (2017). *Toxoplasma gondii* infection and related risk factors among blood donors in northwest Iran. *Archives of Clinical Infectious Diseases*, 12(2).
- Bodaghi, B., Toutou, V., Fardeau, C., Paris, L., & LeHoang, P. (2012). Toxoplasmosis: new challenges for an old disease. *Eye*, 26(2), 241-244.
- Daryani, A., Sarvi, S., Aarabi, M., Mizani, A., Ahmadpour, E., Shokri, A., Rahimi, M. T., & Sharif, M. (2014). Seroprevalence of *Toxoplasma gondii* in the Iranian general population: a systematic review and meta-analysis. *Acta tropica*, 137, 185-194.
- Davarpanah, M. A., Mehrbani, D., Neyrami, R., Ghahramanpouri, M., & Darvishi, M. (2007). Toxoplasmosis in HIV/AIDS patients in Shiraz, southern Iran.
- Fabiani, S., Pinto, B., Bonuccelli, U., & Bruschi, F. (2015). Neurobiological studies on the relationship between toxoplasmosis and neuropsychiatric diseases. *Journal of the neurological sciences*, 351(1-2), 3-8.
- Fallah, M., Rabiee, S., Matini, M., & Taherkhani, H. (2008). Seroepidemiology of toxoplasmosis in primigravida women in Hamadan, Islamic Republic of Iran, 2004. *EMHJ-Eastern Mediterranean Health Journal*, 14 (1), 163-171, 2008.
- Fuglewicz, A. J., Piotrowski, P., & Stodolak, A. (2017). Relationship between toxoplasmosis and schizophrenia: a review. *Adv. Clin. Exp. Med.*, 26(6), 1031-1036.
- Iddawela, D., Vithana, S. M. P., & Ratnayake, C. (2017). Seroprevalence of toxoplasmosis and risk factors of *Toxoplasma gondii* infection among pregnant women in Sri Lanka: a cross-sectional study. *BMC Public Health*, 17(1), 1-6.
- Khademvatan, S., Khajeddin, N., Saki, J., & Izadi-Mazidi, S. (2013). Effect of toxoplasmosis on personality profiles of Iranian men and women. *South African Journal of Science*, 109(1), 1-4.
- Lafferty, K. D. (2006). Can the common brain parasite, *Toxoplasma gondii*, influence human culture?. *Proceedings of the Royal Society B: Biological Sciences*, 273(1602), 2749-2755.
- Lin, Y. L., Liao, Y. S., Liao, L. R., Chen, F. N., Kuo, H. M., & He, S. (2008). Seroprevalence and sources of *Toxoplasma* infection among indigenous and immigrant pregnant women in Taiwan. *Parasitology Research*, 103, 67-74.
- Mahmood, S. H., AL-Qadhi, B. N., & Zghair, K. H. (2013). Prevalence of toxoplasmosis of males blood donors in Baghdad. *Iraqi J Sci*, 54(4), 832-841.
- Makouloutou-Nzassi, P., Ngoubangoye, B., Makanga, B. K., Boundenga, L., Lendzele, S. S., Maganga, G. D., & Akue, J. P. (2023). Molecular and serological pattern of *Toxoplasma gondii* among rural population in four regions of Gabon. *Journal of Public Health and Epidemiology*, 15(2), 39-49.
- Milne, G., Webster, J. P., & Walker, M. (2020). *Toxoplasma gondii*: an underestimated threat?. *Trends in Parasitology*, 36(12), 959-969.
- Mose, J. M., Kagira, J. M., Kamau, D. M., Maina, N. W., Ngotho, M., & Karanja, S. M. (2020). A review on the present advances on studies of toxoplasmosis in eastern Africa. *BioMed Research International*, 2020.
- Muhsin, S. S., Muhsin, M. A., & Nasraalla, B. A. (2018). Seroprevalence Study of Toxoplasmosis among Males in AlRuasfa Institute of Management in Baghdad Province-Iraq. *International Organisation of Scientific Research Journal of Pharmacy and Biological Sciences*, 13(2), 22-26.
- Noori, A. (2021). Comparisons of *Toxoplasma gondii* Prevalence in Rural and Urban Areas of Al-Najaf Province of Iraq Using Serological Methods. *Archives of Razi Institute*, 76(6), 1695.
- Okojokwu, O. J., Onaji, I. A., Entonu, E. E., Abubakar, B. S., Adebayo, M. B., Adamu, N. A., Ejembi, D. I., Yusuf, I. A., Ogaji, A. O., Ali, M. A., & Anejo-Okopi, J. A. (2021). Anti-*Toxoplasma gondii* Antibodies: Prevalence and Risk Factors among Pregnant Women Accessing Antenatal Care in Some Primary Health Centers in Jos Metropolis, Nigeria. *Journal of Health Science Research*, 6(1), 9-17.
- Ouslimani, S. F., Tennah, S., Azzag, N., Derdour, S. Y., China, B., & Ghalmi, F. (2019). Seroepidemiological study of the exposure to *Toxoplasma gondii* among horses in Algeria and analysis of risk factors. *Veterinary World*, 12(12), 2007.
- Retmanasari, A., Widartono, B. S., Wijayanti, M. A., & Artama, W. T. (2017). Prevalence and risk factors for

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- toxoplasmosis in Middle Java, Indonesia. *EcoHealth*, 14, 162-170.
- Robert-Gangneux, F., & Dardé, M. L. (2012). Epidemiology of and diagnostic strategies for toxoplasmosis. *Clinical microbiology reviews*, 25(2), 264-296.
- Rostami, A., Seyyedtabaei, S. J., Aghamolaie, S., Behniafar, H., Lasjerdi, Z., Abdolrasouli, A., Mehravar, S., & Alvarado-Esquivel, C. (2016). Seroprevalence and risk factors associated with *Toxoplasma gondii* infection among rural communities in northern Iran. *Revista do Instituto de Medicina Tropical de São Paulo*, 58.
- Salih, J. M., Mero, W. M. M., & Eassa, S. (2020). Seroprevalence and some demographic factors associated with *Toxoplasma gondii* infection among male population in Duhok Province/Iraq. *Baghdad Science Journal*, 17(2), 0431-0431.
- Suzuki, Y., & Joh, K. (1994). Effect of the strain of *Toxoplasma gondii* on the development of toxoplasmic encephalitis in mice treated with antibody to interferon-gamma. *Parasitology research*, 80, 125-130.
- Truyens, C., Dumonteil, E., Alger, J., Cafferata, M. L., Ciganda, A., Gibbons, L., Herrera, C., Sosa-Estani, S., & Buekens, P. (2021). Geographic variations in test reactivity for the serological diagnosis of *Trypanosoma cruzi* infection. *Journal of Clinical Microbiology*, 59(12), e01062-21.
- Villard, O., Cimon, B., L'ollivier, C., Fricker-Hidalgo, H., Godineau, N., Houze, S., Paris, L., Pelloux, H., Villena, I., & Candolfi, E. (2016). Serological diagnosis of *Toxoplasma gondii* infection: recommendations from the French National Reference Center for Toxoplasmosis. *Diagnostic Microbiology and Infectious Disease*, 84(1), 22-33.
- Whitman, J. D., Bulman, C. A., Gunderson, E. L., Irish, A. M., Townsend, R. L., Stramer, S. L., Sakanari, J. A., & Bern, C. (2019). Chagas disease serological test performance in US blood donor specimens. *Journal of Clinical Microbiology*, 57(12), 10-1128.
- Yousefvand, A., Mirhosseini, S. A., Ghorbani, M., Mohammadzadeh, T., Moghaddam, M. M., & Mohammadyari, S. (2021). Molecular and serological detection and of *Toxoplasma gondii* in small ruminants of southwest Iran and the potential risks for consumers. *Journal of Consumer Protection and Food Safety*, 16, 117-127.
- Yu, C. P., Chen, B. C., Chou, Y. C., Hsieh, C. J., & Lin, F. H. (2023). The epidemiology of patients with toxoplasmosis and its associated risk factors in Taiwan during the 2007–2020 period. *Plos one*, 18(8), e0290769.
- Zhou, P., Zhang, H., Lin, R. Q., Zhang, D. L., Song, H. Q., Su, C., & Zhu, X. Q. (2009). Genetic characterization of *Toxoplasma gondii* isolates from China. *Parasitology International*, 58(2), 193-195.