Epidemiology of Toxoplasmosis in Iraq

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ABSTRACT

Toxoplasmosis, caused by the obligate intracellular parasite Toxoplasma gondii, is a globally prevalent zoonotic infection with varying epidemiological patterns across different regions. This abstract presents a comprehensive review of the epidemiology of toxoplasmosis in Iraq, shedding light on the prevalence, risk factors, clinical manifestations, and preventive measures against this parasitic disease. In Iraq, toxoplasmosis has been recognized as a significant public health concern. Studies conducted in various regions of the country have reported seroprevalence rates among different populations, indicating a widespread exposure to Toxoplasma gondii. Seropositivity rates have shown variability based on geographical locations, age groups, and socio-economic factors. Higher prevalence rates have been observed in rural areas, among pregnant women, and individuals with occupational exposure to soil or animals. The routes of Toxoplasma gondii transmission in Iraq encompass ingestion of contaminated food or water, contact with infected soil, consumption of undercooked meat containing tissue cysts, and vertical transmission from mother to fetus. The clinical spectrum of toxoplasmosis ranges from asymptomatic or mild flu-like symptoms to severe manifestations in immunocompromised individuals or congenitally infected infants. However, there remains a lack of comprehensive nationwide data on the burden of toxoplasmosis-associated morbidity and mortality in Iraq. Preventive measures and strategies for toxoplasmosis control in Iraq include health education campaigns to raise awareness about proper food hygiene, cooking practices, and minimizing contact with potentially contaminated sources. Additionally, antenatal screening programs for pregnant women and the implementation of serological testing in immunocompromised individuals could contribute significantly to early diagnosis and appropriate management. In conclusion, the epidemiology of toxoplasmosis in Iraq reflects a complex interplay of various socio-demographic factors influencing its prevalence and transmission dynamics. Further research efforts are warranted to establish a more precise epidemiological profile, enhance surveillance systems, and implement targeted interventions to mitigate the burden of toxoplasmosis on public health in Iraq.

Key words: Toxoplasmosis, Toxoplasma gondii, Epidemiology, Iraq, Seroprevalence, Risk factors, Clinical manifestations, Prevention, Public health

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1. INTRODUCTION

This book chapter aims to comprehensively the prevalence and epidemiology of toxoplasmosis in Iraq. For future reference, we ascertained the prevalence of *Toxoplasma* in the Iraqi population over different years. We systematically reviewed research articles published in Iraq from Google Scholar, Research gate, and PubMed. The seroprevalence of *T. gondii* against anti-toxoplasma IgG antibody among women by serological tests was higher than the IgM antibody. A high rate of infection among housewives was 35.2% and among employees was 28.5%, also the prevalence of infection was higher in women who live in rural areas compared to people who live in urban regions. This is the first comprehensive analysis of *T. gondii* infection epidemiology in Iraq. It recorded a high prevalence of toxoplasmosis among women of reproductive age. We passionately support more studies to enhance patient care, the creation of more effective diagnostic tools, and the development of preventative measures.

Toxoplasma (T) gondii is a single-celled, obligate intracellular parasite of blood and tissues. It is widely distributed among the human population and is considered the main cause of world morbidity (Murad and Eassa 2023). It belongs to the phylum Apicomplexa. The life cycle of toxoplasmosis is complex, in which, cats are considered the final host and humans and other mammals serve as their intermediate hosts as shown in Fig. 1 (Sundar et al. 2007). Humans and animals are infected with toxoplasmosis by ingestion of sporulated oocysts. After ingestion, excystion of oocysts occurs in the small intestine and sporozoites are released, which entered the epithelium of the gut and by asexual reproduction convert to tachyzoites stage. Tachyzoites are carried out by blood circulation to vital organs and cause necrosis, mainly in the placenta, and are the main causes of abortion in pregnant women. Under unfavorable conditions tachyzoites are converted to bradyzoites (Rostami et al. 2011). *T. gondii* can affect various organs and glands of the human body i.e., the thyroid gland. In a new study done in Duhok City, Kurdistan Region, Iraq, it was recorded that there is an association between autoimmune thyroid infection and toxoplasmosis which led to premature delivery, death, abortion, and new borne baby with low weight (Murad and Eassa 2023).

The disease is asymptomatic in adult and may have mild symptoms like flu, lymphadenopathy, and fatigue (Gagne 2001), while in pregnant women it causes abortion, death, and deformities in a fetus (John and Petri 2006; Rostami et al. 2011; Hoseini et al. 2014). *T. gondii* may cause neurological disorders such as encephalitis in immunocompromised patients due to acute toxoplasmosis or due to latent infection (Jones et al. 1997). If acquired as an acute infection during pregnancy, toxoplasmosis can have serious negative effects on mother, fetus, and newborn baby. Numerous pathologies are also brought on by latent toxoplasmosis, which has also been linked to harmful effects on pregnant women (Rostami et al. 2020). The risk of acquiring acute toxoplasmosis during pregnancy is critical and precautions should be strictly followed to prevent pregnant women from picking up the disease (Rostami et al. 2019).

a. The final host is Cat
b. Infective stage, the sporulated oocysts in the feces of a cat
c. Contaminated grasses with infective stage
d. Intermediate host (human or other mammals) infected by ingestion of sporulated oocysts
e. Intermediate hosts (mice, rate, domestic ruminants)
f. Infection occurs by ingestion of tissue cysts in undercooked meat
g. Human is an intermediate host for toxoplasmosis
h. The tachyzoite stage can transmit from mother to baby through placenta

i & j. Other ways of transmission are by blood transfusion and tissue transplantation

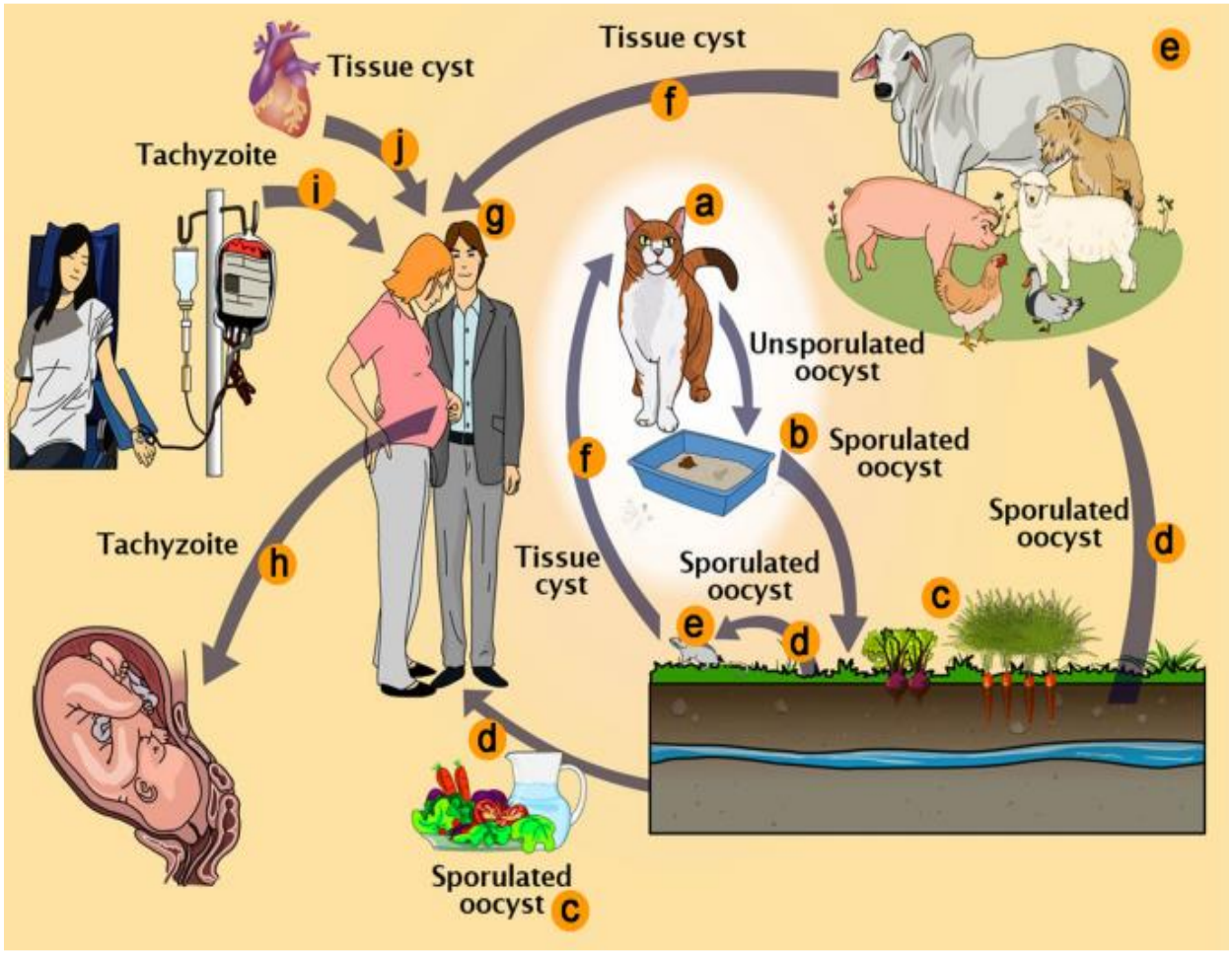

Fig. 1: The morphological stages of *T. gondii* and the routes of transmission (Attias et al. 2020)

T. gondii has three morphological stages: the trophozoite stage (tachyzoites), the tissue stage (bradyzoites) and the infective stage (oocysts) as mentioned in Fig. 1 (Attias et al. 2020). Sporulated oocysts are the infective stage for the intermediate hosts, and infection occurs by ingestion of sporulated oocysts, then excystation occurs in the gastrointestinal tract, and tachyzoites are produced which infect the intestinal epithelium, and pass to vital organs by blood circulation, and transfer to bradyzoites in tissues (Tente et al. 2000). There are several ways for transmission of toxoplasmosis, while the common ways are by ingestion of soporulated oocysts and by ingestion of undercooked infected organs or meat containing bradyzoite stage which is more popular way of transmission in Europe (Cook et al. 2000). This infection can have terrible effects on the fetus's eyes and nervous system if it is transmitted from mother to fetus. Chronic illness is linked to maternal mental illness, even though toxoplasmosis infections can have long-term effects on the fetus. The risk of congenital toxoplasmosis and the long-term effects of infection in the fetus can be decreased with effective treatment. This infection will go largely undetected if proper screening and education programs are not implemented (Deganich et al. 2020). Prevalence of toxoplasmosis in cats and other carnivorous may serve as a sign of the contamination of nature with oocysts and livestock animals (Ruminants) are infected by ingestion of sporulated oocysts from nature and humans are infected by ingestion of undercooked meat of ruminants (Skjerve et al. 1998; Shapiro et al. 2019). Domestic ruminants are

considered the main source of infection for humans. As farm animals represent a source of infection for humans and reservoirs of *T. gondii* for wildlife it has been proposed to reduce *T. gondii* infections in livestock as much as possible, particularly in pigs (Stelzer et al. 2019). A study was done in Hormozgan, Iran by Khademi et al. (2019), who reported that women who ingested undercooked red meat or have direct contact with domestic cats are the main sources of toxoplasmosis among pregnant women. The risk of getting *T. gondii* infection is higher in animals kept outdoor due to environmental contamination with an infective stage (oocysts), which is responsible for the difference in prevalence of Toxoplasmosis between animals kept indoor and outdoor, as has been reported in different species (Djokic et al. 2016). Additionally, the prevalence is known to rise with aging and the infection lasts the entirety of the host's life (Stelzer et al. 2019).

There are many factors linked to the prevalence and epidemiology of toxoplasmosis i.e., nutritional status, poor hygiene, poor economic condition, poor or lack of education, cultivating gardens, coming into contact with pets mainly domestic cats (Alvarado-Esquivel et al. 2017), contamination of water food, grasses and the environment with sporulated oocysts (Rostami et al. 2020). Climate and geographic factors can also affect the spread of toxoplasmosis (Spalding et al. 2005). Screening for toxoplasmosis in women of reproductive age is important because it helps to manage the innate toxoplasmosis and identifies those who are at risk of infection (Montoya et al. 2004).

Toxoplasmosis may be asymptomatic in normal people but may have life-threatening symptoms (Dubey and Jones 2008), and the risk of toxoplasmosis increases in case of pregnant women (Teweldemedhin et al. 2019). Many factors that can affect the virulence of symptoms such as the infective dose of ingested oocysts, strain variation of *T. gondii*, genetics, and host immune response (Montoya et al. 2004). General clinical signs of toxoplasmosis in normal people are headache, fever, general weakness, and enlargement of lymph nodes, while there are some dangerous defects like pneumonia, chorioretinitis, and encephalitis (Cantos et al. 2000). While pregnant women can cause the death of a fetus, epilepsy in infants, small or very large size of infant's head, blindness, and abortion (Khan et al. 2011). Generally, infection in infants is asymptomatic at birth, later, several complications may appear such as blindness, loss of hearing, and mental disorders (Fan et al. 2006). Clinical symptoms in immunocompromized patients are confusion, seizure, schizophrenia, ocular disorder, loss of intelligence and respiratory disorders such as difficulty in breathing (Dogruman Al et al. 2009; Odeniran et al. 2020; Dupont et al. 2021).

Prior epidemiological studies have found that different countries have different rates of toxoplasmosis in pregnant women, ranging from 9 to 67% in European countries (Nash et al. 2005), 34.1% in Sudan (Elnahas et al. 2003), 33% in New Zealand (Morris and Croxson 2004), and 70.9% in Cuba (González-Morales et al. 1995). Although the prevalence of toxoplasmosis was low (28.6%), seroconversion testing during pregnancy revealed that 9 out of 12 women had an acute infection, and 5 (41.6%) of those women had infants with congenital toxoplasmosis (Muñoz Batet et al. 2004).

The routine diagnosis of toxoplasmosis is done by two methods, first by detection of antibodies (IgM and IgG) against toxoplasmosis in blood samples by Latex Agglutination Test or Enzyme Linked Immunosorbent Assay (ELISA) (Montoya 2002; Molan and Rasheed 2016; Ibrahim 2018) and second by the direct detection of parasites in body fluid or tissue sections, which are done by histology, cell culture (Alfonso et al. 2009), conventional polymerase chain reaction (PCR), and real -time PCR (Montoya 2002; Su et al. 2010; Ybañez et al. 2020; Ismael 2021) or indirect methods by ELISA and biochemical tests (Montoya and Liesenfeld 2004). This chapter aims to determine the epidemiology of *T. gondi* in Iraq. It is based on information gathered from articles written by Iraqi researchers from the north to the south. These were collected from academic journals published in Iraq and Google Scholar. These studies were limited to looking at the epidemiology of toxoplasmosis in Iraq.

Toxoplasmosis is recognized as a significant contributor to perinatal morbidity. Acute infection during pregnancy can result in fetal infection, which can cause fetal loss or the birth of an infant who is clearly or latently infected. However, it is a disease that can be avoided. Significant differences have been observed in Europe, not only between nations but also within a single nation, indicating regional variations in the impact of epidemiological factors causing infection. As a result, numerous European nations have put prevention programs into place in proportion to their respective estimated risks of congenital toxoplasmosis. A preventative strategy and hygienic advice should be given to expectant women, in addition to identifying the specific populations at a higher risk of infection, who will then be specifically screened (Bobić et al. 2003).

2. EPIDEMIOLOGY OF TOXOPLASMOSIS IN DIFFERENT CITIES OF IRAQ

About one-third of the population in the world is infected with *T. gondii*. In North Europe, North America, Africa, and Southeast Asia, there was a decrease in the seroprevalence of toxoplasmosis from 10–30%. In South and Central European countries and in Latin American and tropical African nations, there were high prevalence rates (Dubey 2008; Robert-Gangneux and Darde 2012). *T. gondii* has a complex life cycle and can be transmitted vertically (from mother to baby) (Borna et al. 2013; Daryani et al. 2014) or horizontally by ingestion of undercooked meat containing bradyzoites or by ingestion of sporulated oocysts in food, grasses, and water (Kirby 2012; Torgerson and Mastroiacovo 2013). According to a study done in Western Romania by Mihu et al. (2022), *T. gondii* IgG seroprevalence is high (46.09%) in females of reproductive age. However, testing for IgA may increase the likelihood of detecting a recently acquired toxoplasmosis in people with demonstrable *T. gondii* IgG and IgM antibodies. According to estimates, 33% of blood donors worldwide carry the *T. gondii* infection and seroprevalence varies significantly between countries (Lupu et al. 2022).

Women who are exposed to primary toxoplasmosis after conception are at significantly higher risk of transmitting the infection from mother to child during pregnancy than those who were exposed to the infection prior to conception. As a result, diagnosing recent primary toxoplasmosis through laboratory testing is crucial for managing pregnant women who may have been exposed to toxoplasmosis (Boyer et al. 2005). Toxoplasma IgM detection is a sensitive marker for the presence of primary toxoplasmosis, but the specificity of the marker is limited because natural IgM antibodies can occasionally bind to Toxoplasma antigens even in the absence of an infection. Additionally, after the initial infection, Toxoplasma IgM can occasionally remain in blood serum for several months or years (Joynson and Guy 2001).

The type of toxoplasma is recognized as the most virulent factor (Rico-Torres et al. 2016; Sasai and Yamamoto 2019). There are three major types of *T. gondii* including type (I), type (II), and type (III), and each type causes varying degrees of severity (Sibley et al. 2009). Type I is the most severe and virulent type in humans, the second type causes a chronic infection in both humans and animals and may be very severe in immunocompromized patients, and the third type is found in birds with less severity (Sibley et al. 2009; Xiao and Yolken 2015).

In Iraq, the incidence rates of toxoplasmosis vary from region to region depending on the hygiene of personal and community sanitation, and climatic conditions. For example, in Duhok City, research was done by Mikaeel and Al-Saeed (2020), and they found that the seroprevalence of toxoplasmosis against anti-toxoplasma IgG antibody among women by ELISA technique was 28% and for IgM antibody was 0.46%. Another study was done in the same city by Al-Atroshi and Mero (2013), who reported different results for the seroprevalence of toxoplasmosis in women with prevalence rate of 27.7%. In 2020, in Akre, Duhok City, Iraq, the prevalence of Toxoplasma IgM and IgG among

pregnant women was 4.44% and 54.46 %, respectively (Shukri and Jumaa 2020). Recently, in Duhok City, Iraq, a high prevalence of toxoplasma IgG has been reported by Murad and Eassa, (2023) and was 31.8%. In Erbil City, a study was done by Husain et al. (2011), the researchers reported that the seroprevalence rates of both Toxoplasma IgG and Human cytomegalovirus (HCMV) IgM among 348 sera samples collected from pregnant women who had a history of abortion at the Rezan Private Laboratory were 2:9.05% and 45.25%, respectively. Another research done by Abdul Ameer Jaber and Noori (2021) in Erbil Province, Iraq, also found a high prevalence rate of *T. gondii* IgG (42.1%), and no IgM was found. A study was done by Ibrahim (2018) in Garmian, Kurdistan Region, Iraq, who reported that a high rate of infection among housewives was 35.2% and among employees was 28.5%. He also reported that the infection rate was higher in people who live in rural areas than in people who live in urban regions. Research work by Edrees and Ibrahim (2020) in Mosul City, Iraq, determined that the seroprevalence rate of toxoplasma IgG by ELISA Technique was 26.7% among pregnant women who attended the antenatal clinic, in Mosul City, Iraq from the period of November 2019 to January 2020. As reported by Addor (2011) in Salaha-Adden City and Mohammed (2011) in Baghdad City, who reported higher seroprevalence, rates of 29.2% and 28.77%, respectively, of *T. gondii* infection among women. However, some Iraqi Cities have reported much higher seroprevalence rates of toxoplasmosis, with rates of 55.26%, 52.6%, and 42.6%, respectively (Fatohi 1985; Al-Attar 2000; Al-Timimi 2004; Hadi et al. 2016). A high prevalence rate of toxoplasmosis in pregnant women in Al-Muthanna province during October, November, and December 2009 and January of 2010 was recorded by Al-Se'adawy and Hemza (2010). Higher rates of unemployed women than employed women were 75% and 25%, respectively.

Table 1: Prevalence rate of Toxoplasmosis among pregnant women in Iraq during 2008 -2023

No. of Pregnant women Examined	Year	Prevalence (%)		References
		IgM	IgG	
350	2008	8.3	58.3	Al-Mishhadani and Al-Janabi 2008
45	2009	33	94	Mossa 2009
81	2010	0	13.81	Al-Se'adawy and Hemza 2010
348	2011	45.25	29.05	Husain et al. 2011
51	2012	31.70	24.39	Al-Warid and Al-Qadhi 2012
100	2013	0.05	55	Al-Ethawi et al. 2013
62	2014	11.29	48.3	Hamad and Khdir 2014
96	2015	9.7	32.3	Bakre et al. 2015
120	2016	3.2	35.4	Hadi et al. 2016
263	2017	12.93	34.8	Abduallah and Mohmood 2017
150	2018	4.0	48	Darweesh et al. 2018
118	2019	20.6	.0	Raza et al. 2019
57	2020	2.7	96.7	Jwad et al. 2020
210	2021	3.33	9.5	Barzinij 2021
15	2022	51.0	8	Hamza et al. 2022
110	2023	0	22.75	Murad and Eassa 2023

Recently, results for the prevalence of toxoplasmosis were reported by several Iraqi researchers. Barzinij (2021) revealed that the prevalence of toxoplasmosis IgG was 9.05% and for IgM it was 3.33%, and these results were significant at a P value <0.05. Another study was done by Abdul Ameer Jaber and Noori (2021) in several rural and urban areas in Al-Najaf province, Iraq. They recorded the prevalence rate of IgM and IgG as 0.0% and 42.1%, respectively by both ELISA and the Rapid Diagnostic Immunochromatographic test.

Data mentioned in Table 1 shows a history of toxoplasmosis in pregnant women in Iraq from 2008 to 2023. The serological test revealed the prevalence of toxoplasma IgG and IgM as 75% and 25%, respectively. These are a critical percentage which is a risk factor among pregnant women in Iraq and needs continuous screening of women before pregnancy to prevent abortion and deformity in newborn baby.

3. CONCLUSION

The sharp increase in prevalence of toxoplasmosis led to an increase in the number of pregnant women who were exposed to the infection, which increased the risk of congenital toxoplasmosis. Based on the previously mentioned information, we suggest that, as an epidemiologically sound and financially viable alternative to a general screening-in-pregnancy program, all pregnant women should receive health education along with serological testing of those who have been exposed to infection predictors. Furthermore, a new viewpoint on risk factors gives a modern foundation for approaching preventive measures.

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