Compr Health Biomed Stud. 2024 October; 3(2): e157368 https://doi.org/10.5812/chbs-157368

Published Online: 2024 October 30 **Research Article**

Seroprevalence of *Toxoplasma gondii* Infection in Cancer Patients in Southwest Iran: A Case-Control Study

Shahrzad Soltani [1], Masoud Foroutan [1,*], Sepehr Ghaderi [2], Mehdi Karimi [3]

[1] Department of Basic Medical Sciences, Faculty of Medicine, Abadan University of Medical Sciences, Abadan, Iran
[2] Student Research Committee, Abadan University of Medical Sciences, Abadan, Iran
[3] Department of Clinical Sciences, Faculty of Medicine, Abadan University of Medical Sciences, Abadan, Iran

[*] ***Corresponding Author:*** Department of Basic Medical Sciences, Faculty of Medicine, Abadan University of Medical Sciences, Abadan, Iran. Email: masoud_foroutan_rad@yahoo.com

Received: 30 March, 2024; **Revised:** 24 October, 2024; **Accepted:** 25 October, 2024

Abstract

Background: Cats are the definitive hosts of *Toxoplasma gondii*, while humans and livestock can serve as intermediate hosts. The infection is usually asymptomatic in immunocompetent individuals but can cause serious consequences, such as encephalitis, in immunocompromised patients, including those with cancer.

Objectives: Considering the potential risk of severe complications in immunocompromised patients, this study aimed to investigate the seroprevalence of *T. gondii* in cancer patients compared to a control group and assess related risk factors.

Methods: This case-control study included 128 cancer patients admitted to educational hospitals in Abadan and Khorramshahr in 2021. The control group comprised 128 outpatients without underlying diseases from the same hospitals. A questionnaire including demographic information and toxoplasmosis risk factors was completed for each participant. Five milliliters of blood samples were collected and checked for IgG and IgM antibodies against *T. gondii* by ELISA. Data were analyzed using SPSS version 19, and descriptive statistics, including frequency and percentage, were used. A P-value < 0.05 was considered significant.

Results: Among cancer patients, 51 (39.84%) were positive for IgG, and 3 (2.34%) patients were positive for IgM. In the control group, 60 (46.88%) and 4 (3.13%) were positive for IgG and IgM, respectively. No significant difference in seroprevalence rate was found between the groups. In those over 60 years, seroprevalence was higher. In the control group, female gender, living in rural areas, and consumption of untreated drinking water were significantly associated with infection.

Conclusions: Despite the lack of a significant association between cancer and toxoplasmosis, the immunosuppressed condition of cancer patients, together with the high regional prevalence, demonstrates why *T. gondii* should be monitored as an opportunistic infection.

Keywords: *Toxoplasma gondii*, Seroprevalence, ELISA, Cancer, Iran

1. Background

Toxoplasmosis is one of the most common parasitic zoonoses worldwide, affecting both humans and animals (1). The definitive hosts of *Toxoplasma gondii* are felines, which play a crucial role in the parasite's life cycle. Oocysts, a resistant form of the parasite, are found in the feces of infected cats (2). These oocysts require 1 to 5 days in the soil to become infectious and can remain viable for up to 18 months, depending on environmental factors (3). Humans and other warm-blooded animals serve as intermediate hosts in the parasite's life cycle (4). In these hosts, *T. gondii* reproduces asexually. Initially, the parasite's tachyzoites multiply rapidly within various host cells. Subsequently, tissue cysts containing bradyzoites are formed. The life cycle of *T. gondii* in the intermediate host concludes with the development of tissue cysts, where bradyzoites persist and replicate slowly throughout the host's lifetime. These tissue cysts are infectious to both definitive and other intermediate hosts. When ingested by felines, bradyzoites undergo asexual replication in the epithelial cells of the small

How to Cite: Soltani S, Foroutan M, Ghaderi S, Karimi M. Seroprevalence of *Toxoplasma gondii* Infection in Cancer Patients in Southwest Iran: A Case-Control Study. Compr Health Biomed Stud. 2024; 3 (2): e157368. https://doi.org/10.5812/chbs-157368.

intestine, followed by sexual reproduction. Oocysts are then released into the intestinal lumen and excreted in the feces, thereby contaminating the environment (1).

Infection with *T. gondii* often occurs through the ingestion of various infectious forms of the parasite. Oocysts can contaminate food and water sources, representing a route of transmission. Additionally, the consumption of raw or undercooked meat containing tissue cysts is another source of infection (5). Tachyzoites have also been identified in the milk of several intermediate hosts, suggesting that consuming contaminated unpasteurized milk may pose a transmission risk (6). Toxoplasmosis can also be transmitted through blood transfusion and organ transplantation (7, 8). Congenital transmission may occur when a pregnant mother acquires acute toxoplasmosis, allowing the parasite to cross the placenta and infect the fetus. Vertical transmission is also possible due to the reactivation of latent infection, particularly in immunocompromised pregnant women (9-11).

The seroprevalence of *T. gondii* worldwide ranges from 30% to 60%, with at least one-third of the global population estimated to be infected (12). Global seroprevalence shows significant variation and may exceed this range in endemic areas. For instance, in African populations, seroprevalence rates have been reported as high as 90% (13). A meta-analysis conducted in Iran estimated the seroprevalence of toxoplasmosis in the general population at 39.3%. This study also showed that in the northern areas of Iran, particularly around the Caspian Sea, where the climate is humid, infection is very common (54%). In contrast, colder mountainous areas such as Ardabil province and warm regions like Sistan and Baluchistan province reported lower seroprevalence rates of 18.3% and 22.8%, respectively (14). In another study, the seroprevalence of *T. gondii* in the general population of Abadan city was estimated at 43.95% (15).

The strength of the host immune system is a critical factor in the course of infection with *T. gondii*. In immunocompetent individuals, the infection is usually asymptomatic and remains latent (16). Tissue cysts are more common in the nervous system, ocular tissues, and skeletal muscles, though they may also form in visceral organs such as the liver. These cysts can persist without triggering a host immune response (17). In contrast, toxoplasmosis is an opportunistic infection in immunocompromised patients, often presenting as encephalitis, myocarditis, and pneumonitis. Reactivation of latent toxoplasmosis due to cyst rupture in such patients can be life-threatening (18). Cancer patients are particularly vulnerable to severe toxoplasmosis due to both disease-related immunosuppression and the immunosuppressive effects of anticancer treatments, which can reactivate latent *T. gondii* infection (19). Furthermore, the overall prevalence of T. *gondii* infection is higher among cancer patients compared to the general population, and its clinical implications in this group underscore the need for investigation (20).

2. Objectives

Given the limited number of studies conducted on the prevalence of toxoplasmosis among immunocompromised patients both globally and in the study area, further research is warranted. Therefore, the present study aimed to investigate the seroprevalence of *T. gondii* and related risk factors in cancer patients compared to a control group among patients attending teaching hospitals in Abadan and Khorramshahr, Iran.

3. Methods

3.1. Study Area

Abadan and Khorramshahr cities are located in Khuzestan province, in the southwest of Iran. Abadan is bordered by the Arvand River to the west and the Bahmanshir River to the east, and it is separated from Khorramshahr by a branch of the Karun River. These two cities are situated on the border between Iran and Iraq, approximately 53 kilometers from the Persian Gulf. The region is characterized by a desert climate. There is a noticeable difference in air temperature between summer and winter. During the summer, temperatures can exceed 50°C, while winter temperatures usually range between 16°C and 20°C. Frequent dust storms occur annually. This region experiences extremely hot and dry summers, contrasted by mild and wet winters (21, 22).

3.2. Study Population

This study included two groups: Cancer patients and a control group. The cancer patient group consisted of 128 individuals diagnosed with various types of cancer who visited Taleghani, Shahid Beheshti, and Valiasr hospitals in Abadan and Khorramshahr cities in 2021 for treatment or diagnostic procedures. A questionnaire containing demographic information was provided to each participant, and written informed consent was obtained following a full explanation of the study procedures. Cancer diagnoses were confirmed by reviewing medical documents and records under the

supervision of an oncologist. The control group included 128 individuals with no history of cancer, selected from outpatients attending the same hospitals. After obtaining written informed consent, these participants also completed the demographic questionnaire. The absence of cancer or other chronic underlying diseases was confirmed through detailed medical history and examination of their medical records. The case and control groups were matched for age and gender.

3.3. Serology

Approximately 5 mL of venous blood was collected from qualified participants in both the patient and control groups. Blood samples were transferred to tubes without anticoagulant and centrifuged at 3500 rpm for 10 minutes. The separated serum was kept at -20°C until analysis. Serological testing was performed to detect specific anti-*T. gondii* IgG and IgM antibodies using a commercial kit. All samples were tested under the same conditions. Both IgG and IgM antibodies were measured in all individuals from the case and control groups (23, 24).

3.4. Questionnaire

Each participant was asked to complete a structured questionnaire containing the following questions: Age; gender (male/female); cancer type (non-hematologic malignancy/hematologic malignancy); education level (university/high school diploma or less); place of residence (urban/rural); source of drinking water (purified/unpurified); history of consuming raw or undercooked meat (yes/no); washing and disinfection of vegetables (yes/no); owning a pet (yes/no); history of contact with cats (yes/no); and exposure to soil (yes/no).

3.5. Data Analysis

Collected laboratory results and questionnaires were analyzed using SPSS software version 19. Descriptive statistics, including frequency and percentage, were used. A P-value of less than 0.05 was considered statistically significant. No sensitivity or interaction analyses were performed due to the cross-sectional nature and primary objective of the study.

4. Results

This study included 128 cancer patients and 128 control subjects without underlying diseases, all of whom were referred to teaching hospitals in Abadan and Khorramshahr. The overall seroprevalence of anti-*T. gondii* antibodies was 41.4% (53/128) in the cancer patient group and 49.2% (63/128) in the control group. The seroprevalence of anti-*T. gondii* IgG was 39.84% (51/128) in cancer patients and 46.88% (60/128) in the control group, with no significant difference (P = 0.313). The prevalence of anti-*T. gondii* IgM antibodies was 2.34% (3/128) in cancer patients and 3.13% (4/128) in the control group, also showing no statistically significant difference (P = 1.0). One participant from each group (cancer and control) was simultaneously positive for *T. gondii* IgG and IgM antibodies.

In this study, the age range of cancer patients was 18 - 75 years, while the control group participants ranged from 17 - 70 years. Among cancer patients, the single individual under 20 years was seropositive for *T. gondii*. Seroprevalence rates in other age groups were as follows: Over 60 years, 43.6%; 41 - 60 years, 41.3%; and 21 - 40 years, 25%. However, these differences were not statistically significant (P = 0.497). In the control group, the highest seroprevalence was observed in individuals over 60 years (64.3%), followed by 21 - 40 years (51.9%), 41 - 60 years (46.5%), and 0% in those under 20 years, with no statistically significant difference among age groups (P = 0.463). Comparison between the two groups also demonstrated no significant relationship between age and seropositivity for *T. gondii* (P ≥ 0.05).

In the cancer group, the seroprevalence was 42.6% (40/94) in males and 38.2% (13/34) in females, showing no significant difference (P = 0.814). In the control group, 39.8% (37/93) of men and 74.3% (26/35) of women were seropositive for *T. gondii*; the seroprevalence was significantly higher in females than in males (P = 0.001). Furthermore, the seroprevalence of *T. gondii* in females in the control group was significantly higher than in females in the cancer group (P = 0.005).

In the cancer patient group, 41.3% (50/121) of urban residents and 42.9% (3/7) of rural residents were seropositive for *T. gondii*, with no statistically significant difference between the two groups (P = 1.000). In the control group, rural residents showed a significantly higher seroprevalence (83.3%; 10/12) compared to urban residents (45.7%; 53/116) (P = 0.029).

The seroprevalence of *T. gondii* infection in cancer patients who consumed purified water was 41.3% (50/121), and the seroprevalence in patients who consumed unfiltered water was 42.9% (3/7), with no statistically significant difference (P = 1.000). In the control group, the seroprevalence in individuals who consumed untreated water (83.3%, 10/12) was significantly higher than in those who had access to purified drinking water (45.7%; 53/116) (P = 0.029). No significant difference in seroprevalence of *T. gondii* was

Table 1. Seroprevalence of *Toxoplasma gondii* Infection in Cancer Patients and Control Group

Characteristics	Control (N = 128 Seroprevalence of *Toxoplasma gondii* Infection				Case (N = 128) Seroprevalence of *T. gondii* Infection				Case vs. Controls
	No. Tested	No. Positive	%	P-Value	No. Tested	No. Positive	%	P-Value	P-Value
Age				0.463				0.497	
≤ 20	1	0	0.0		1	1	100.0		1.0
21 - 40	27	14	51.9		8	2	25.0		0.350
41 - 60	86	40	46.5		80	33	41.3		0.599
> 60	14	9	64.3		39	17	43.6		0.309
Gender				0.001				0.814	
Male	93	37	39.8		94	40	42.6		0.813
Female	35	26	74.3		34	13	38.2		0.005
Area of residence				0.029				1.0	
Urban	116	53	45.7		121	50	41.3		0.584
Rural	12	10	83.3		7	3	42.9		0.187
Education level				1.0				0.841	
High school diploma or less	89	44	49.4		104	44	42.3		0.397
University	39	19	48.7		24	9	37.5		0.542
Drinking water				0.029				1.0	
Purified	116	53	45.7		121	50	41.3		0.584
Unpurified	12	10	83.3		7	3	42.9		0.187
Raw meat consumption				0.616				0.804	
Yes	81	38	46.9		72	31	43.1		0.752
No	47	25	53.2		56	22	39.3		0.225
Disinfection of vegetables				0.941				0.193	
Yes	109	53	48.6		111	43	38.7		0.179
No	19	10	52.6		17	10	58.8		0.970
Contact with cat				0.183				0.998	
Yes	81	44	54.3		93	38	40.9		0.105
No	47	19	40.4		35	15	42.9		1.0
Pet keeping				0.744				0.833	
Yes	52	27	51.9		63	25	39.7		0.261
No	76	36	47.7		65	28	43.1		0.734
Contact with soil				0.347				0.486	
Yes	29	17	58.6		31	15	48.4		0.593
No	99	46	46.5		97	38	39.2		0.375
Cancer type				-				0.658	
Hematologic malignancy	0	0	0.0		50	19	38.0		-
Solid tumor	0	0	0.0		78	34	43.6		-
Antibodies				-				-	
IgG	128	60	46.88		128	51	39.84		0.313
IgM	128	4	3.13		128	3	2.34		1.0

observed between the cancer patients and control groups in terms of drinking water (P ≥ 0.05).

Among cancer patients, 50 (39.1%) had hematologic malignancies, while 78 (60.9%) had various solid tumors. The seroprevalence of *T. gondii* infection was 43.6% (34/78) in patients with solid tumors and 38% (19/50) in patients with hematological malignancies; however, this difference was not statistically significant (P = 0.658).

Furthermore, no significant associations were found between *T. gondii* seroprevalence and risk factors including education level, consumption of raw or undercooked meat, washing and disinfection of vegetables, contact with soil, contact with cats, and pet

ownership in the patient or control groups. More details of these variables are provided in Table 1.

5. Discussion

Acute infection or reactivation of latent *T. gondii* infection can cause life-threatening complications such as encephalitis, particularly in immunocompromised individuals (5). Cancer patients represent a vulnerable population due to their suppressed immune system resulting from the malignancy and from chemotherapy, immunosuppressive drugs, and long-term hospitalizations (25). Consequently, cancer patients need special attention, as they are at risk for developing severe complications from toxoplasmosis.

The seroprevalence of anti-*T. gondii* IgG in the cancer patient group of the present study is similar to findings from studies conducted in cancer patients in Ahvaz (45.2%) (26) and Tabriz (40.66%) (27). Additionally, the seroprevalence of anti-*T. gondii* antibodies in the control group (49.2%) was higher than the reported average in the general Iranian population (39.3%) (14). In a study conducted by Cong et al. in China (28), the seroprevalence of anti-*T. gondii* IgG was 35.56% in cancer patients and 17.44% in the control group, both markedly lower than the rates observed in our study. Moreover, their study reported a significantly higher seroprevalence in cancer patients compared to the control group, which is not consistent with our study. In another study conducted in Saudi Arabia in cancer patients (29), the seroprevalence rates of anti-*T. gondii* IgG and IgM were 29.9% and 0.7%, respectively, which are lower than those observed in the present study. The seroprevalence of anti-*T. gondii* IgM in cancer patients of the present study was lower than that reported in the investigations by Ghasemian et al. (26), Khayat and Ghareh (27), and Cong et al. (28).

Variations in climate, nutrition, and public health levels may account for differences in *T. gondii* seroprevalence in studies conducted in different geographic regions. Also, the presence of stray animal populations and limited public access to properly purified water in the study area may contribute to the elevated number of seropositive cases observed. In general, the seroprevalence of toxoplasmosis tends to increase with age (30), likely due to an increased chance of exposure to various infectious forms of *T. gondii* over a lifetime. In the present study, only one cancer patient under the age of 20 tested seropositive for *T. gondii*. In other age groups, the seroprevalence of toxoplasmosis increased with age: 43.6% in those older than 60 years, 41.3% in the 41 - 60 years group, and 25% in the 21 - 40 years group. However, the differences in seroprevalence across these age groups were not statistically significant (P = 0.497). In the control group, the highest seroprevalence was observed in individuals over 60 years of age (64.3%), though this difference was also not statistically significant (P = 0.463).

Several studies on toxoplasmosis in cancer patients have reported that with increasing age, the seroprevalence of *T. gondii* also increases (26, 29, 31). In the present study, the unequal distribution of cancer patients across different age groups, especially the limited number of cases under 20 years old, which caused a high seroprevalence (100%), may have influenced the comparability of our findings with those of other studies. Additionally, differences in lifestyle, health misconceptions, and prolonged exposure to infectious agents may contribute to the higher seroprevalence observed in older patients. Gender may also indirectly affect the risk of toxoplasmosis through job roles and exposure to sources of infection in daily life.

In the present study, the seroprevalence of *T. gondii* among male cancer patients (42.6%) was higher than among female patients (38.2%), although this difference was not statistically significant. However, in the control group, the seroprevalence of *T. gondii* in females (74.3%) was significantly higher than in males (39.8%) (P = 0.001). Moreover, the difference between women in the patient group and women in the control group was also significant (P = 0.005).

Several studies on cancer patients have also reported no significant association between the seroprevalence of *T. gondii* and gender (26, 28, 31-33), which aligns with the results in cancer patients of this study. Most of these studies reported a higher seroprevalence of *T. gondii* in females than in males (26, 28, 31, 33), similar to our control group. In the study conducted by Mostafa et al. (34), a significantly higher seroprevalence was observed in females than in males. The lower number of female participants in our study may affect the results.

In the study area, women are often housewives who are more frequently involved in food preparation. They may have more contact with meat, fruit, and vegetables potentially contaminated with *T. gondii*, particularly if proper hand hygiene is not observed, which may justify the significantly higher seroprevalence observed among women in the control group. In rural areas, the occupation of most people is agriculture and animal husbandry, and hygiene standards are generally lower than in urban areas. These factors may contribute to an increased risk of toxoplasmosis.

In the present study, the seroprevalence of anti-*T. gondii* antibodies in cancer patients was higher in rural

residents (42.9%) compared to urban residents (41.3%), but this difference was not statistically significant (P = 1.0). However, in the control group, rural residents exhibited a significantly higher seroprevalence of *T. gondii* compared to urban residents (83.3% vs. 45.7%, P = 0.029). A study conducted by Yu et al. (35) on patients with colorectal malignancies reported a higher seroprevalence in rural residents, and this difference was statistically significant in the patient group. Studies by Barazesh et al. (33) and Ali et al. (31) found higher seroprevalence of *T. gondii* in the urban population, although these differences were not statistically significant.

The higher seroprevalence rates in rural areas may be attributed to lower knowledge of disease prevention among residents and greater environmental exposure to *T. gondii* oocysts in soil that has been contaminated by infected cat feces. The majority of rural residents in the current study work in agriculture, which increases their exposure to contaminated soil. One of the largest outbreaks of symptomatic toxoplasmosis in Canada resulted from contamination of a municipal water supply with oocysts shed by mountain lions (36). *Toxoplasma gondii* oocysts can survive in cold water for up to 54 months and remain infective. While they are resistant to conventional drinking water chlorination, many modern municipal water treatment systems in developed countries can remove them from drinking water (37).

In the present study, the seroprevalence of *T. gondii* was lower among individuals who used purified drinking water compared to those without access to purified water. Although this difference was not statistically significant in the cancer patient group, it was significant in the control group (P = 0.029). Yu et al. (35) similarly reported a lower seroprevalence of *T. gondii* in people who consumed treated municipal water compared to those who obtained their drinking water from untreated sources like wells or rivers, though the difference was not statistically significant. Cong et al. (28) found no significant relationship between the source of drinking water consumed and the seroprevalence of *T. gondii*, in line with our results obtained in cancer patients.

The uncontrolled growth of stray cats and their prey species in the current study area enables *T. gondii* to complete its life cycle, resulting in the widespread environmental shedding of oocysts. The oocysts remain in the environment for long periods after contaminating water sources. The oocysts' resistance to standard chlorination processes, combined with restricted access to properly purified drinking water in this region, makes contaminated water a primary transmission route. This environmental risk factor could explain why *T. gondii* seroprevalence is high in the study population.

In many hematological malignancies, a degree of cellular immunodeficiency is present. The immunosuppressive effects of chemotherapy and other treatment modalities make patients with these cancers highly susceptible to acute *T. gondii* infection or reactivation of latent toxoplasmosis (31). In the present study, the seroprevalence of *T. gondii* was higher among patients with solid tumors (43.6%) than in those with hematological malignancies (38.0%), although this difference was not statistically significant (P = 0.658). Abdel Malek et al. (19) observed a higher seroprevalence in solid tumor patients than in hematologic malignancy patients, although the difference was not statistically significant (P = 0.06). Conversely, in the study conducted by Ali et al. (31), the seroprevalence of anti-*T. gondii* IgG was significantly higher in patients with hematological malignancies compared to those with solid tumors, which is contrary to the findings of our study (P = 0.002).

The observed differences between studies can be explained by multiple factors, including variations in chemotherapy protocols, cancer stage at sampling time, and patient health and immune status. These variables affect susceptibility to opportunistic infections such as toxoplasmosis.

5.1. Conclusions

The results of this study show a high prevalence of *T. gondii* infection in Abadan and Khorramshahr. In the control group, living in rural areas, the consumption of untreated drinking water, and female gender were significantly associated with higher seroprevalence of infection. Although no statistically significant association was observed between cancer and the seroprevalence of anti-*T. gondii* antibodies, cancer patients face an elevated risk of toxoplasmosis complications. Therefore, it is necessary to consider toxoplasmosis as an opportunistic infection in the management and treatment of cancer patients. It is recommended to perform screening tests before prescribing immunosuppressive drugs in these patients.

5.2. Limitations

In this case-control study, the ELISA test was performed on collected sera. The lack of molecular-based techniques to confirm serological findings, which

could have strengthened the diagnostic accuracy, is the main limitation of this research project.

Footnotes

Authors' Contribution: S. S., M. K., and M. F. designed the study protocol. S. S. and S. G. collected the data and involved in statistical analysis. S. S. and S. G. performed the experiments. S. G. drafted the manuscript. S. S. and M. F. critically revised the manuscript. All authors read and approved the final version of the manuscript.

Conflict of Interests Statement: The authors declare no conflict of interests.

Data Availability: The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval: The study protocol was received the approval from the Ethics Committee of Abadan University of Medical Sciences (IR.ABADANUMS.REC.1400.012).

Funding/Support: The present study has been financially supported by Abadan University of Medical Sciences (grant No. 1204).

Informed Consent: A signed written informed consent was obtained from all participants.

References

1. Tenter AM, Heckeroth AR, Weiss LM. Toxoplasma gondii: from animals to humans. *Int J Parasitol*. 2000;**30**(12-13):1217-58. [PubMed ID: 11113252]. [PubMed Central ID: PMC3109627]. https://doi.org/10.1016/s0020-7519(00)00124-7.
2. Halonen SK, Weiss LM. Toxoplasmosis. *Handb Clin Neurol*. 2013;**114**:125-45. [PubMed ID: 23829904]. [PubMed Central ID: PMC4157368]. https://doi.org/10.1016/B978-0-444-53490-3.00008-X.
3. Maleki B, Ahmadi N, Olfatifar M, Gorgipour M, Taghipour A, Abdoli A, et al. Toxoplasma oocysts in the soil of public places worldwide: a systematic review and meta-analysis. *Trans R Soc Trop Med Hyg*. 2021;**115**(5):471-81. [PubMed ID: 33205208]. https://doi.org/10.1093/trstmh/traa133.
4. Dubey JP. History of the discovery of the life cycle of Toxoplasma gondii. *Int J Parasitol*. 2009;**39**(8):877-82. [PubMed ID: 19630138]. https://doi.org/10.1016/j.ijpara.2009.01.005.
5. Montoya JG, Liesenfeld O. Toxoplasmosis. *Lancet*. 2004;**363**(9425):1965-76. [PubMed ID: 15194258]. https://doi.org/10.1016/S0140-6736(04)16412-X.
6. Cenci-Goga BT, Rossitto PV, Sechi P, McCrindle CM, Cullor JS. Toxoplasma in animals, food, and humans: an old parasite of new concern. *Foodborne Pathog Dis*. 2011;**8**(7):751-62. [PubMed ID: 21486145]. https://doi.org/10.1089/fpd.2010.0795.
7. Foroutan M, Majidiani H, Hassanipour S, Badri M. Toxoplasma gondii seroprevalence in the Iranian blood donors: A systematic review and meta-analysis. *Heliyon*. 2024;**10**(6). e28013. [PubMed ID: 38509978]. [PubMed Central ID: PMC10951657]. https://doi.org/10.1016/j.heliyon.2024.e28013.
8. Wang ZD, Liu HH, Ma ZX, Ma HY, Li ZY, Yang ZB, et al. Toxoplasma gondii Infection in Immunocompromised Patients: A Systematic Review and Meta-Analysis. *Front Microbiol*. 2017;**8**:389. [PubMed ID: 28337191]. [PubMed Central ID: PMC5343064]. https://doi.org/10.3389/fmicb.2017.00389.
9. Fallahi S, Rostami A, Nourollahpour Shiadeh M, Behniafar H, Paktinat S. An updated literature review on maternal-fetal and reproductive disorders of Toxoplasma gondii infection. *J Gynecol Obstet Hum Reprod*. 2018;**47**(3):133-40. [PubMed ID: 29229361]. https://doi.org/10.1016/j.jogoh.2017.12.003.
10. Foroutan-Rad M, Khademvatan S, Majidiani H, Aryamand S, Rahim F, Malehi AS. Seroprevalence of Toxoplasma gondii in the Iranian pregnant women: A systematic review and meta-analysis. *Acta Trop*. 2016;**158**:160-9. [PubMed ID: 26952970]. https://doi.org/10.1016/j.actatropica.2016.03.003.
11. Rostami A, Riahi SM, Contopoulos-Ioannidis DG, Gamble HR, Fakhri Y, Shiadeh MN, et al. Acute Toxoplasma infection in pregnant women worldwide: A systematic review and meta-analysis. *PLoS Negl Trop Dis*. 2019;**13**(10). e0007807. [PubMed ID: 31609966]. [PubMed Central ID: PMC6822777]. https://doi.org/10.1371/journal.pntd.0007807.
12. Rahmanian V, Rahmanian K, Jahromi AS, Bokaie S. Seroprevalence of toxoplasma gondii infection: An umbrella review of updated systematic reviews and meta-analyses. *J Family Med Prim Care*. 2020;**9**(8):3848-55. [PubMed ID: 33110778]. [PubMed Central ID: PMC7586519]. https://doi.org/10.4103/jfmpc.jfmpc_753_20.
13. Milne G, Webster JP, Walker M. Toxoplasma gondii: AnUnderestimated Threat? *Trends Parasitol*. 2020;**36**(12):959-69. [PubMed ID: 33012669]. https://doi.org/10.1016/j.pt.2020.08.005.
14. Daryani A, Sarvi S, Aarabi M, Mizani A, Ahmadpour E, Shokri A, et al. Seroprevalence of Toxoplasma gondii in the Iranian general population: a systematic review and meta-analysis. *Acta Trop*. 2014;**137**:185-94. [PubMed ID: 24887263]. https://doi.org/10.1016/j.actatropica.2014.05.015.
15. Soltani S, Foroutan M, Afshari H, Hezarian M, Kahvaz MS. Seroepidemiological evaluation of Toxoplasma gondii immunity among the general population in southwest of Iran. *J Parasit Dis*. 2018;**42**(4):636-42. [PubMed ID: 30538365]. [PubMed Central ID: PMC6261153]. https://doi.org/10.1007/s12639-018-1047-2.
16. Abdoli A, Barati M, Pirestani M, Dalimi A. Screening of toxoplasmosis in cancer patients: a concern. *Trop Doct*. 2019;**49**(1):31-4. [PubMed ID: 30270766]. https://doi.org/10.1177/0049475518801618.
17. Dubey JP, Lindsay DS, Speer CA. Structures of Toxoplasma gondii tachyzoites, bradyzoites, and sporozoites and biology and development of tissue cysts. *Clin Microbiol Rev*. 1998;**11**(2):267-99. [PubMed ID: 9564564]. [PubMed Central ID: PMC106833]. https://doi.org/10.1128/CMR.11.2.267.
18. Ahmadpour E, Daryani A, Sharif M, Sarvi S, Aarabi M, Mizani A, et al. Toxoplasmosis in immunocompromised patients in Iran: a systematic review and meta-analysis. *J Infect Dev Ctries*. 2014;**8**(12):1503-10. [PubMed ID: 25500647]. https://doi.org/10.3855/jidc.4796.
19. Abdel Malek R, Wassef R, Rizk E, Sabry H, Tadros N, Boghdady A. Toxoplasmosis an Overlooked Disease: Seroprevalence in Cancer Patients. *Asian Pac J Cancer Prev*. 2018;**19**(7):1987-91. [PubMed ID: 30051689]. [PubMed Central ID: PMC6165665]. https://doi.org/10.22034/APJCP.2018.19.7.1987.
20. Anvari D, Sharif M, Sarvi S, Aghayan SA, Gholami S, Pagheh AS, et al. Seroprevalence of Toxoplasma gondii infection in cancer patients: A systematic review and meta-analysis. *Microb Pathog*. 2019;**129**:30-42. [PubMed ID: 30708042]. https://doi.org/10.1016/j.micpath.2019.01.040.

21. Soltani S, Foroutan M, Hezarian M, Afshari H, Kahvaz MS. Cutaneous leishmaniasis: an epidemiological study in southwest of Iran. *J Parasit Dis*. 2019;**43**(2):190-7. [PubMed ID: 31263323]. [PubMed Central ID: PMC6570722]. https://doi.org/10.1007/s12639-018-1073-0.
22. Foroutan M, Vafae Eslahi A, Soltani S, Kamyari N, Moradi-Joo E, Magnaval JF, et al. Seroprevalence and Potential Risk Factors of Toxocariasis among General Population in Southwest Iran: Implications on the One Health Approach. *J Immunol Res*. 2024;**2024**:4246781. [PubMed ID: 38380080]. [PubMed Central ID: PMC10878754]. https://doi.org/10.1155/2024/4246781.
23. Soltani S, Kahvaz MS, Soltani S, Maghsoudi F, Foroutan M. Seroprevalence and associated risk factors of Toxoplasma gondii infection in patients undergoing hemodialysis and healthy group. *BMC Res Notes*. 2020;**13**(1):551. [PubMed ID: 33287882]. [PubMed Central ID: PMC7720589]. https://doi.org/10.1186/s13104-020-05396-5.
24. Soltani S, Ghaffari AD, Kahvaz MS, Sabaghan M, Pashmforosh M, Foroutan M. Detection of Anti-Toxoplasma gondii IgG and IgM Antibodies and Associated Risk Factors during Pregnancy in Southwest Iran. *Infect Dis Obstet Gynecol*. 2021;**2021**:5547667. [PubMed ID: 34135564]. [PubMed Central ID: PMC8175175]. https://doi.org/10.1155/2021/5547667.
25. Sanchez-Ramon S, Bermudez A, Gonzalez-Granado LI, Rodriguez-Gallego C, Sastre A, Soler-Palacin P, et al. Primary and Secondary Immunodeficiency Diseases in Oncohaematology: Warning Signs, Diagnosis, and Management. *Front Immunol*. 2019;**10**:586. [PubMed ID: 30984175]. [PubMed Central ID: PMC6448689]. https://doi.org/10.3389/fimmu.2019.00586.
26. Ghasemian M, Maraghi SH, Saki J, Pedram M. Determination of antibodies (IgG, IgM) against Toxoplasma gondii in patients with cancer. *Iran J Parasitol*. 2007.
27. Khayat NM, Ghareh DY. [Survey of toxoplasma contamination in malignant canceric patients by elisa method and comparison it with control group in tabriz (1386)]. *J Veterinary Microbiol*. 2009;**5**(1):53-9. FA.
28. Cong W, Liu GH, Meng QF, Dong W, Qin SY, Zhang FK, et al. Toxoplasma gondii infection in cancer patients: prevalence, risk factors, genotypes and association with clinical diagnosis. *Cancer Lett*. 2015;**359**(2):307-13. [PubMed ID: 25641340]. https://doi.org/10.1016/j.canlet.2015.01.036.
29. Imam A, Al-Anzi FG, Al-Ghasham MA, Al-Suraikh MA, Al-Yahya AO, Rasheed Z. Serologic evidence of Toxoplasma gondii infection among cancer patients. A prospective study from Qassim region, Saudi Arabia. *Saudi Med J*. 2017;**38**(3):319-21. [PubMed ID: 28251231]. [PubMed Central ID: PMC5387912]. https://doi.org/10.15537/smj.2017.3.18535.
30. Nowakowska D, Wujcicka W, Sobala W, Spiewak E, Gaj Z, Wilczynski J. Age-associated prevalence of Toxoplasma gondii in 8281 pregnant women in Poland between 2004 and 2012. *Epidemiol Infect*. 2014;**142**(3):656-61. [PubMed ID: 23721799]. [PubMed Central ID: PMC9151098]. https://doi.org/10.1017/S0950268813001179.
31. Ali MI, Abd El Wahab WM, Hamdy DA, Hassan A. Toxoplasma gondii in cancer patients receiving chemotherapy: seroprevalence and interferon gamma level. *J Parasit Dis*. 2019;**43**(3):464-71. [PubMed ID: 31406412]. [PubMed Central ID: PMC6667530]. https://doi.org/10.1007/s12639-019-01111-9.
32. Nimir A, Othman A, Ee S, Musa Z, Majid IA, Kamarudin Z, et al. Latent toxoplasmosis in patients with different malignancy: a hospital based study. *J Clin Med Res*. 2010;**2**(3):117-20. [PubMed ID: 21629523]. [PubMed Central ID: PMC3104645]. https://doi.org/10.4021/jocmr2010.06.375w.
33. Barazesh A, Sarkari B, Mehrabi Sisakht F, Abdolahi Khabisi S, Nikbakht R, Ravanbod MR. Seroprevalence and Molecular Evaluation of Toxoplasmosis in Patients Undergoing Chemotherapy for Malignancies in the Bushehr Province, Southwest Iran. *Jundishapur J Microbiol*. 2016;**9**(9). e35410. [PubMed ID: 27800144]. [PubMed Central ID: PMC5086028]. https://doi.org/10.5812/jjm.35410.
34. Mostafa NES, Abdel Hamed EF, Rashed HES, Mohamed SY, Abdelgawad MS, Elasbali AM. The relationship between toxoplasmosis and different types of human tumors. *J Infect Dev Ctries*. 2018;**12**(2):137-41. [PubMed ID: 31825916]. https://doi.org/10.3855/jidc.9672.
35. Yu Y, Guo D, Qu T, Zhao S, Xu C, Wang L, et al. Increased Risk of Toxoplasma gondii Infection in Patients with Colorectal Cancer in Eastern China: Seroprevalence, Risk Factors, and a Case-Control Study. *Biomed Res Int*. 2020;**2020**:2539482. [PubMed ID: 33083457]. [PubMed Central ID: PMC7563061]. https://doi.org/10.1155/2020/2539482.
36. Hill D, Dubey JP. Toxoplasma gondii: transmission, diagnosis and prevention. *Clin Microbiol Infect*. 2002;**8**(10):634-40. [PubMed ID: 12390281]. https://doi.org/10.1046/j.1469-0691.2002.00485.x.
37. Jones JL, Dubey JP. Waterborne toxoplasmosis--recent developments. *Exp Parasitol*. 2010;**124**(1):10-25. [PubMed ID: 19324041]. https://doi.org/10.1016/j.exppara.2009.03.013.