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Original Article

Current Trend of Toxoplasmosis in Cancer Patients, Sohag University Hospitals, Sohag, Egypt

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ABSTRACT

Background and Aim: Human toxoplasmosis is caused by the ubiquitous intracellular apicomplexan pathogen, *Toxoplasma gondii (T. gondii)*. It has been acclaimed as the most successful parasite ever, infecting up to one-third of the global population. The objective of this study was to evaluate the seroprevalence of *T. gondii* in individuals with different types of malignancies in comparison to a control group of healthy individuals.

Patients and Methods: A case-control study was conducted from March 2022 to June 2023. Sera of 50 patients with different cancer types and 50 healthy individuals were analyzed for *Toxoplasma gondii* IgG and IgM using indirect ELISA.

Results: A total of 100 individuals were evaluated, and it was found that 67 of them (67%) tested positive for *Toxoplasma* IgG antibodies. Seroprevalence was significantly higher (p=0.016) in cancer patients (64%) than in controls. Moreover, 15% were positive for *Toxoplasma* IgM. Notably, the prevalence was found to be greater among cancer patients compared to the control group, with (18% vs 12%), respectively. Patients with hematological malignancies exhibited a slightly greater rate of IgG seropositivity compared to those with solid organ tumors (85% and 77% respectively). A similar trend of *Toxoplasma* IgM, with a prevalence of 25% in hematological malignancies and 9.1% in solid organ tumors.

Conclusion*: T. gondii* infection was shown to be substantially more common in cancer patients. Seropositive patients are at a high risk for reactivation, whereas seronegative patients are at risk for infection. Our research shows that toxoplasmosis screening must be promoted in these settings.

KEYWORDS: Cancer patients; ELISA; *Toxoplasma* IgM; *Toxoplasma* IgG; human toxoplasmosi

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Introduction

Toxoplasma gondii (T. gondii), a common intracellular apicomplexan infection, is what causes human toxoplasmosis. As the most prolific parasite ever, it has been estimated to have infected up to one-third of the world's population.(1)

The primary modes of transmission of T. gondii infections to humans involve the ingestion of contaminated food or water containing viable oocysts, as well as the consumption of undercooked or raw meat that harbors living tissue cysts.(2)

T. gondii life cycle is quite sophisticated. The only known ultimate final host are felids which harbor the sexual cycle of *T. gondii* and disseminate environmental oocysts through excrement. However, a wide variety of intermediary hosts, including humans, are capable of asexual reproduction.(3)

The initial infection caused by *T. gondii* typically leads to moderate symptoms resembling those of influenza in persons with normal immunity. However, those with impaired immune systems, such as those with AIDS, organ transplants, or cancer, are at risk of experiencing serious consequences due to the reactivation of tissue

cysts, which can be fatal. Thus, more attention should be paid to these groups of individuals.[4]
Along with this, congenital toxoplasmosis (CT) arises as a consequence of the transplacental transmission of *T. gondii* subsequent to maternal infection that occur during pregnancy, it can cause serious fetal implications, including chorioretinitis, hydrocephalus, microcephaly, or in the worst instance, ends with abortion. [5]
Cancer is the leading cause of mortality in industrialized nations, but in the developing world, it ranks as the second most prevalent cause of death. It is anticipated that the number of cancer-related fatalities will steadily rise, hitting 11 million by 2030. The prevalence of clinical toxoplasmosis among cancer patients has emerged as a significant issue in the field of public health in recent years.[6]
The relationship between toxoplasmosis and cancer remains a subject of ongoing debate due to the presence of contradictory evidence. Most individuals diagnosed with cancer exhibit impaired cellular and humoral immune responses, which can be attributed to the disease itself or the administration of chemotherapy and/or radiation therapy. Chemotherapeutic agents have the capacity to eradicate proliferating cancer cells, but unfortunately, they also induce neutropenia by adversely affecting the population of healthy white blood cells. As a result, individuals undergoing chemotherapy exhibit increased susceptibility to *Toxoplasma* infection.[7] On the contrary, persistent infections might promote malignancy by provo-king inflammation that boosts mutation rates. As an intracellular pathogen, *T. gondii* may accelerate the accumulation of oncogenic mutations. Acc-ording to scientific evidence, some malignancies, such as lymphoma, leukemia, and myeloma, have the potential to trigger reactivation of toxopla-smosis.[8] Classically, toxoplasmosis diagnosis relies on serology. To commence appropriate treat-ment in cancer patients, a timely, precise, and successful diagnosis is essential and desirable.[8]
There exists a diverse array of serological approaches that can be utilized for the identification of specific antibodies of *T. gondii*. The differences between these entities are contingent upon their respective approaches, the antigens employed, and the immunoglobulin isotype that is recognized. There have been significant advancements in recent years. The principal techniques are the Sabin–Feldman Dye Test (SFDT), enzyme-linked immunosorbent assays (ELISAs), immunosorbent agglutination assay (ISAGA), indirect hemagglutination assays (IHAs), indirect fluorescent antibody tests (IFATs), the modified agglutination test (MAT), western blotting (WB), and IgG avidity testing.[9]
The present state of toxoplasmosis in Egypt is characterized by a lack of clarity and understanding. The absence of a centralized laboratory or collective body of researchers dedicated to the study of toxoplasmosis in humans has resulted in a lack of comprehensive data on the countrywide incidence of *T*. gondii. The vast majority of serological reports commonly rely on convenience samples, which incorporate pregnant women as well as individuals with other diseases. Generally, little is known of T. gondii infection in cancer patients from Sohag governorate.[10]
The aim of this study was to assess the seroprevalence of T. gondii in persons diagnosed with various types of malignancies, in contrast to a control group consisting of healthy individuals.

Patients and methods

Ethics statement

The current research was authorized by the Ethical Institutional Review Board of the Faculty of Medicine, Sohag University, Sohag, Egypt. This study adheres to the principles outlined in the Helsinki Declaration. The researchers provided a comprehensive explanation of the study's objectives and methodologies to all participants, ensuring that each participating patient provided written informed permission. The Medical Research Ethics Committee, affiliated with the Faculty of Medicine at Sohag University, operates under the oversight of the Office for Human Research Protections (OHRP) with the assigned identification number IRB00013006.

Study design

This is a case-control study that was carried out at the Central Research Laboratory, Faculty of Medicine, Sohag University, Sohag, Egypt between April 2020, and December 202.(2)

Study participants

50 cancer patients on chemotherapy were referred to the Oncology Department, Faculty of Medicine,

Sohag University, and 50 healthy controls were randomly recruited for the study.

Sample size estimation

The determination of the sample size was conducted by considering the prevalence of toxoplasmosis in the specific geographic area. The calculation employed the Steven K. Thompson Equation, considering the prevalence rates of *T. gondii*, which were determined to be 29%. A margin of error of 0.05 and a confidence interval of 95% were also incorporated into the calculation. Consequently, the study yielded a sample size of 100.

Sample collection

3 ml of venous blood, one from each participant, was collected via venipuncture under sterile conditions and then aliquoted to pre-labelled plain blood collection tubes. The samples were promptly delivered to the Central Research Laboratory at the Faculty of Medicine, Sohag University. The plain tubes were incubated at ambient temperature for a duration of 30 minutes to allow for the formation of blood clots. The sera were subjected to centrifugation at a speed of 3000 rpm for a duration of 10 minutes. Following centrifugation, they were aliquoted into 1.5 ml Eppendorf tubes, labelled with unique codes, and stored at a temperature of -20º C until the ELISA assay was conducted.

Detection of *T. gondii* IgG and IgM

Serum samples were subjected to qualitative testing for the presence of *T. gondii* IgG and IgM antibodies using the SERION ELISA classic *Toxoplasma gondii* IgG and IgM kits (IgG-Institut Virion/Serion, Germany and IgM-Institut Virion/Serion, Germany) in accordance with the instructions provided by the manufacturer.

Dilution buffer was used to dilute separated sera (10 µL of serum was added to 1000 µL of dilution buffer), thoroughly mixed and pipetted into the micro test wells. Samples, ready-to-use controls, and standard sera were incubated for 60 min at 37°C before the wells were washed using the washing solution. A total of 100 µL of the ready-to-use IgG conjugate was added to all wells (except substrate blank), incubated for 30 min at 37°C and washed. A 100 µL ready-to-use substrate solution was added to each well (including the well for substrate blank) and incubated for 30 min at 37°C. The reaction was stopped by adding 100 µL stopping solution to each well, followed by gentle shaking to mix. The microliter plate reader used in this study was an automatic device (StatFax-3200, Awareness Inc., Palm City, FL, USA) to measure the optical densities (OD) of both control sera and patients' sera at 405 nm within 60 minutes. The interpretation of the results (positive, negative, or equivocal) following the equations illustrated in the table below.

IgG assay equations

OD= 0.362 x MV(STD) corresponds to the upper cut-off

OD= 0.192 x MV(STD) corresponds to the lower cut-off

IgM assay equations

OD= 0.838 x MV(STD) corresponds to the upper cut-off

OD= 0.737 x MV(STD) corresponds to the lower cut-off

Statistical analysis

Results

General characteristics of the study participants

The current research was carried out on a sample of 100 participants, whose average age was 37.18 ± 16.70 years. The age distribution of the cancer patients varied from 3 to 76 years, with a mean age of 37.36 ± 18.62 years. This is comparable to the age range observed in healthy individuals, which was 4 to 69 years, with a mean age of 37.00 ± 14.72 years. Cancer patients included 28 males (56%) and 22 females (44%). While the control group included 27 males (54%) and 23 females (46%).

The group of patients with cancer consisted of 22 cases of solid organ malignancies, which were distributed in a descending manner as follows: Out of the total cases analyzed, breast cancers accounted for 11% (n=11), hepatocellular carcinomas accounted for 4% (n=4), brain tumors accounted for 8% (n=4), lung cancers accounted for 2% (n=2), and colon cancer accounted for 1% (n=1). While hematological malignancies (28 cases) included: 12 (12%) acute lymphoblastic leukemias, 10 (10%) non-Hodgkin's lymphomas, 4 (4%) Hodgkin's lymphomas, 1 (1%) acute myeloid leukemias, and 1 (1%) chronic lymphocytic leukemias.

Seropositivity of T. gondii IgG and IgM antibodies

Regarding *Toxoplasma* IgG antibodies, 67 serum samples (67%) tested positive for this marker. Significantly higher seroprevalence (p=0.016) was observed in cancer patients 32/50 (64%) compared to controls 20/50 (40%) (odds ratio [OR] .(2)67 [95% confidence interval CI 1.25-5.99]). Regarding *Toxoplasma* IgM, a total of 15 (15%) persons tested positive for this marker. Notably, the prevalence of positive cases was found to be greater among cancer patients in comparison to the control group, with 9 (18%) individuals testing positive in the former group, while 6 (12%) individuals tested positive in the latter group.

The study observed that individuals with hematological malignancies exhibited a slightly greater rate of IgG seropositivity compared to those with solid organ tumors (85% and 77% respectively). However, this difference was not found to be statistically significant (p=0.559). The data also revealed a similar trend in relation to *Toxoplasma* IgM, with a prevalence of 25% in hematological malignancies and 9.1% in solid organ tumors. This difference was found to be statistically non-significant. Results are highlighted in Table 1.

Table1: The correlation between Toxoplasma IgG and IgM antibodies and various types of cancer.

		Cancer type				*Significance*
		Hematological malignancies		*Solid malignancies*		
		n (28)	*%*	*n (22)*	*%*	
IgG-Serum	***Negative***	4	14.3%	5	2.(2)7%	^{FE}p<.559
	Positive	24	85.7%	17	77.3%	
IgM-Serum	***Negative***	21	75.0%	20	90.9%	
	Positive	7	25.0%	2	9.1%	^{FE}p<.253

^{FE} p: Fischer-Exact significance. *Results ≤ are statistically significant.

The distribution of *Toxoplasma* IgG seropositive cases in various cancer types investigated in the study is presented in Table .(2) Among all hematological malignancies, acute lymphoblastic leukemia and non-Hodgkin lymphoma exhibited the highest proportions of individuals with *Toxoplasma* IgG antibodies, accounting for 16.4% and 13.4% respectively. In relation to solid organ tumors, breast cancer exhibited the highest prevalence, accounting for 14.9% of cases with positive *Toxoplasma* IgG. However, in both instances, the obtained p-value did not reach the threshold of statistical significance.

Table 2: The distribution of *Toxoplasma* IgG seropositivity among various hematologic and solid malignancies.

Cancer type	**Negative**		**Positive**		**Significance**
	No.	**%**	**No.**	**%**	
Hematologic malignancies					
Acute lymphoblastic Leukaemia	1	3.0%	11	16.4%	
Acute Myeloid Leukaemia	0	0.0%	1	1.5%	
Chronic Lymphoblastic leukemia	0	0.0%	1	1.5%	^{MC}p<.038*
Hodgkin lymphoma	2	6.1%	2	3.0%	
Non-Hodgkin Lymphoma	1	3.0%	9	13.4%	
Solid malignancies					
Brain cancer	2	6.1%	2	3.0%	
Breast cancer	1	3.0%	10	14.9%	
Colon cancer	0	0.0%	1	1.5%	
HCC	2	6.1%	2	3.0%	
Lung cancer	0	0.0%	2	3.0%	

^{FE}p: Fischer-Exact significance. ^{MC}p: Monte-Carlo Significance.
*Results ≤ are statistically significant. Different superscripts denote significant pairwise comparisons.

The study observed the highest levels of IgM seropositivity in individuals with acute lymphoblastic leukemia and Hodgkin's lymphoma, with rates of 26.7% and 13.3% respectively. Nevertheless, in both instances, the p value yielded results that were not statistically significant (refer to Table 3).

Table 3: The distribution of seropositivity of *Toxoplasma* IgM in hematologic and solid malignancies.

Cancer type	*Negative*		*Positive*		*Significance*
	No.	*%*	*No.*	*%*	
Hematologic malignancies					
Acute lymphoblastic Leukaemia	8	9.4%	4	26.7%	
Acute Myeloid Leukaemia	1	1.2%	0	0.0%	
Chronic Lymphoblastic leukemia	1	1.2%	0	0.0%	
Hodgkin lymphoma	2	.(2)4%	2	13.3%	
Non-Hodgkin Lymphoma	9	10.6%	1	6.7%	
Solid malignancies					
Brain cancer	4	4.7%	0	0.0%	
Breast cancer	9	10.6%	2	13.3%	
Colon cancer	1	1.2%	0	0.0%	^{MC}p<.450
HCC	4	4.7%	0	0.0%	
Lung cancer	2	.(2)4%	0	0.0%	

^{FE} p: Fischer-Exact significance. ^{MC}p: Monte-Carlo Significance. *Results ≤ are statistically significant.

The sociodemographic parameters of the individuals participating in the study in relation to their seropositivity for *T. gondii*

Table 4 represents the sociodemographic characteristics of the 100 subjects studied and their correlation with *T. gondii* IgG seroprevalence. The highest seropositivity was observed in the age group of 31-50 years in both patients and controls (45.2 % and 66.7 % respectively) which showed no statistical significance. Further details are shown in table 4.

Table 4: Correlation of the sociodemographic characteristics of the study participants with *Toxoplasma* IgG.

	Positive IgG				*Significance*
	Control group		*Cancer group*		
	n (26)	*%*	*n (41)*	*%*	
Age in years					
1-17	6	23.1%	10	24.4%	
18-30	3	11.5%	5	1.(2)2%	^{MC}p<.966
31-50	11	4.(2)3%	19	46.3%	
>51	6	23.1%	7	17.1%	
Sex					
Female	14	53.8%	21	51.2%	P<.834
Male	12	46.2%	20	48.8%	
Residence					
Rural	14	53.8%	31	75.6%	P<.065
Urban	12	46.2%	10	24.4%	

^{FE} p: Fischer-Exact significance. MCp: Monte-Carlo Significance. *Results ≤ are statistically significant.
Different superscripts denote significant pairwise comparisons.

The highest *T. gondii* IgM seropositivity (33.3%) was equal in age range (1-17) in cancer patients and healthy controls. However, it was 50% in healthy controls of the age range (31-50). There was no statistical difference in the seropositivity of anti-*T. gondii* IgM among the different age groups in both study groups (Table 5).

Table 5: Sociodemographic characteristics of the participants in relation to *T. gondii* IgM seropositivity

	Positive IgM				*Significance*
	Healthy		*Cancer*		
	n (6)	*%*	*n (9)*	*%*	

Age in years					[Mc]p<.875
1-17	2	33.3%	3	33.3%	
18-30	0	0.0%	1	11.1%	
31-50	3	50.0%	2	2.(2)2%	
>51	1	16.7%	3	33.3%	
Sex					
Female	4	66.7%	5	55.6%	[FE]p<1
Male	2	33.3%	4	44.4%	
Residence					
Rural	1	16.7%	6	66.7%	[FE]p<.119
Urban	5	83.3%	3	33.3%	

[FE] p: Fischer-Exact significance. MCp: Monte-Carlo Significance. *Results ≤ are statistically significant.

The existence of both Anti-*Toxoplasma* IgG and IgM antibodies was detected concurrently in 18% of cancer patients and 12% of healthy controls. This was of statistical significance (P value< 0.016). Further serologic combinations are illustrated in table 6.

Table 6: *T. gondii* serologic combinations.

	Healthy Control		***Cancer group***		***Significance***	***OR (95 % CI)***
	Frequency (50)	***%***	***Frequency (50)***	***%***		
IgG-/ IgM-	24	48.0%	9	18.0%	<.001*	.238(.096-.591)
IgM+/ IgG-	0	0.0%	0	0.0%	--	
IgM-/ IgG+	20	40.0%	32	64.0%	<.016*	.(2)67(1.19-5.99)
IgM+/IgG+	6	1.(2)0%	9	18.0%	<.401	1.61(0.53-4.92)

*Results ≤ are statistically significant. OR: Odds ratio. CI: Confidence Interval

Discussion

Toxoplasmosis is an infectious disease that is attributed to the pathogenic protozoan *T. gondii*, which has demonstrated remarkable adaptability and widespread prevalence. This eukaryotic parasite infects around 30% of the world's population.[11]

Cancer patients undergoing chemotherapy are immunocompromised. Therefore, the recurrence of chronic toxoplasmosis and the subsequent reactivation of *T. gondii* tissue cysts have a significant and deleterious impact.[12] The clinical manifestations of toxoplasmosis lack specificity, rendering them unreliable for diagnostic purposes. Consequently, serological techniques are frequently employed for diagnosis. Notably, the timely and precise identification of toxoplasmosis is of utmost importance, particularly in individuals with impaired immune system. [13]

Based on a comprehensive meta-analysis, it was observed that individuals diagnosed with cancer had a greater overall incidence of *T. gondii* infection in comparison to individuals without a cancer diagnosis. In addition, the odds ratio for toxoplasmosis among individuals with cancer was shown to be 3.1 times higher when compared to the odds ratio among control subjects (95% confidence interval: .(2)5–3.8, p-value less than 0.0001).[8]

The objective of this study was to examine the seroprevalence trend of *T. gondii* in cancer patients receiving chemotherapy, as compared to a control group of healthy individuals. The study was conducted at Sohag University Hospitals in Sohag, Egypt.

The current research revealed a high prevalence of seropositivity to *T. gondii* IgG (67%) among cancer patients, with *Toxoplasma* IgM being found in 15 (15%) individuals. These findings coincide with the outcomes of a study conducted in Iran. A total of 350 serum samples obtained from cancer patients in the Mazandaran province were analyzed. Among these samples, 264 (75.4%) tested positive for anti-*T. gondii* IgG antibodies, while 9 (.(2)57%) samples were found to be positive for anti-*T. gondii* IgM antibodies using ELISA.[14]

In contrast, a study was conducted in the southeastern region of Iran, where a total of 154 serum samples from patients were tested for the detection of IgG and IgM antibodies against *T. gondii* using the ELISA test. A total of 39.4% of the sampled sera exhibited positive results for IgG, which is somewhat lower in comparison to the findings of the present study. [15]

Seroprevalence was significantly higher (p=0.016) in cancer patients (64%) than in controls (40%). Similarly, a case control study reported that *T. gondii* IgG positivity was 60% of the 100 cancer

patients receiving chemotherapy in Turkey and 27% of the control group. Also, The difference between the two groups was found to be statistically significant.[16]

The existence of anti-*T. gondii* IgG was observed in 41.5% of blood samples collected from cancer patients at Imam Reza Hospital in Tehran. This result is quite lower than our own research outcomes.[17]

The reported discrepancy could potentially be clarified through various factors, including geographical area, climatic circumstances, temperature, humidity (for instance, the survival of oocysts discharged by felines), dietary routines, and health awareness. The current research has revealed that the frequencies of *T. gondii* IgG and IgM were higher in patients diagnosed with hematologic malignancies in comparison to those with solid tumors. However, it is important to note that this difference did not achieve statistical significance. Furthermore, the analysis of serological data indicated a higher prevalence of anti-*Toxoplasma* IgG antibodies among persons who have been diagnosed with lymphoma and leukemia ($p=0.001$).[14] This finding aligns with a recent study conducted in Egypt, which demonstrated that individuals diagnosed with hematological malignancies exhibited a greater prevalence of IgG seropositivity compared to those with solid organ tumors (40% versus 26.7%, respectively). The observed discrepancy was determined to have a statistically significant association ($p = 0.002$, $OR = 3.5$).[18]

However, the findings can be elucidated by two possible justifications. One notable aspect is that most patients with blood-related malignancies are categorized as high-risk neutropenic individuals. Additionally, corticosteroids play a crucial role in most chemotherapy protocols administered to individuals with hematological malignancies. The regulation of apoptosis and anti-apoptosis was governed by microRNAs (miRNAs). *T. gondii* has the capability to phagocytose these microRNAs, potentially leading to dysregulation of gene expression in its host and contributing to the development of carcinogenesis.[19] Hodgkin's disease has been identified as a contributing factor in the reactivation of *T. gondii* in around 40% of individuals with a compromised immune system. Furthermore, a considerable body of research has been conducted to investigate the correlation between toxoplasmosis and non-Hodgkin lymphoma, as well as chronic myeloid and lymphatic leukemia.[20] In contrast, a notable difference was noted in the prevalence rates of toxoplasmosis between individuals diagnosed with solid organ tumors (24%) and those with hematological malignancies (12%). Nevertheless, it is crucial to note that this difference failed to attain statistical significance ($p=0.06$) .[21]

The results of our study indicated that individuals diagnosed with acute lymphoblastic leukemia had the greatest levels of *T. gondii* IgG and IgM seropositivity, with rates of 16.4% and 26.7% respectively. A cross-sectional study conducted in Turkey revealed a higher prevalence of seropositivity for Toxo IgM and IgG (15.4% versus 34.7%) in patients diagnosed with lymphoma compared to persons with other malignancies .[22]

This study revealed that the age group ranging from 31 to 50 years exhibited the highest IgG seropositivity in both the patient and control groups. Additionally, the highest seroprevalence rate of T. gondii IgM was similarly detected in cancer patients belonging to two distinct age groups: 1 to 17 years old and above 51 years old. The prevalence of *T. gondii* infection may exhibit an upward trend in correlation with advancing age, as the cumulative exposure to potential sources of infection increases over time .[23] Toxoplasmosis used to be thought to be acquired during the early years of life, with its prevalence subsequently increasing as individuals age and declining in later life.[24]

Conversely, it was shown that children diagnosed with leukemia at or below the age of 2 exhibited the highest seroprevalence compared to other subgroups. One possible explanation for this phenomenon is that individuals diagnosed with leukemia experience impaired immune systems, rendering them susceptible to opportunistic infections. Additionally, young patients may possess immune systems that are not yet fully developed or robust enough to effectively combat such infections.[25]

Female patients and controls were more seropositive for both IgG and IgM than males in both study groups without a statistical significance. The noticed phenomenon can be attributed to the differential susceptibility of females compared to males towards sources of *T. gondii* infection.

However, in a study conducted in Iran, it was observed that anti-*T. gondii* IgG was detected in 41.5% of the participants. This prevalence was found to be approximately comparable among both male and female patients.[17]

Malek et al. (2018) conducted a study wherein a cohort of cancer patients was studied to determine the prevalence of *T. gondii*. The results revealed that the occurrence of *T. gondii* was marginally higher among males (18%) in comparison to females (16%). Nonetheless, it is important to note that the difference wasn't statistically significant. The potential explanation for this phenolmenon could be attributed to the heightened susceptibility of men, which may be a result of their greater engagement in outdoor pursuits and consumption of fast food. Likewise, a study conducted in Saudi Arabia revealed a trend of seropositivity among female patients (57.1%) compared to males (4.(2)9%). However, the observed difference was not of statistical significance ($p>0.05$).[26]

The present study did not find a statistically significant association between the area of residency and toxoplasmosis. This lack of significance could potentially be attributed to the advancements in healthcare infrastructure in rural regions of the Sohag governorate. This finding aligns with the outcomes of a cross-sectional study conducted in Zahedan, Iran. [15] The results of this study agree with the research conducted by Walle et al. (2013), which also documented a greater occurence of toxoplasmosis among those living in urban regions in comparison to those live in rural areas. The disparity in question was attributed by the authors of the study to factors such as environmental variances, eating preferences, and individuals' ownership of pets.[27] In contrast, a recent case-control study conducted at Zagazig University Pediatrics Hospital in Egypt revealed that most seropositive patients (43 out of 64%) were residing in rural areas. The study was to evaluate the prevalence of toxoplasmosis seropositivity among pediatric hemodialysis patients. [28]

One of this study limitations is the relatively small sample size, which consequently resulted in certain findings being ambiguous. This limitation can be attributed to the study being self-funded. Additionally, it is imperative to do further research with centers located in various regions of the country.

Conclusions

In summary, the current study has provided evidence indicating a high prevalence of *T. gondii* infection among cancer patients in Sohag governorate, Egypt. These findings emphasize the crucial significance of regularly screening cancer patients for *T. gondii* infection. Healthcare professionals ought to apply extra caution when providing care to cancer patients. In addition, it is imperative to do routine parasitological assessments among individuals diagnosed with cancer to proactively mitigate the potential risks associated with severe toxoplasmosis. Primarily, it is imperative to ensure that individuals belonging to high-risk groups are effectively shielded from potential sources of toxoplasmosis infection.

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