Review Article

Exposure to toxoplasmosis among the Egyptian population: A systematic review

Amira Taman, Samar M Alhusseiny

Department of Medical Parasitology, Faculty of Medicine, Mansoura University, Mansoura 35516, Egypt

ABSTRACT

Toxoplasmosis affects a wide-range of vertebrate hosts with variable prevalences among different societies all over the world. In Egypt, toxoplasmosis is still considered a health problem especially during pregnancy and in immunocompromised patients. Among the different types of antibodies tested to assess the prevalence of toxoplasmosis in a community, the anti-*Toxoplasma gondii* immunoglobulin G (IgG) and immunoglobulins A and M (IgA, IgM) are the most commonly evaluated to determine association with chronic and acute infections respectively. The current review is a systematic search of the databases to retrieve studies reporting mainly the seroprevalence of IgG antibodies to determine exposure to toxoplasmosis among the Egyptian population in the different governorates. Seroprevalence was recorded from reports on the general population, blood donors, and females with normal and complicated pregnancies. Patients with different comorbidities, such as tuberculosis, rheumatoid arthritis, chronic hepatitis, renal failure, diabetes and some neuropsychiatric disorders were included. Significant risk factors comprised contact with cats and consumption of raw vegetables or insufficiently cooked meat. The review highlights the magnitude of toxoplasmosis in Egypt; however, studies on a large scale would better ascertain the burden of toxoplasmosis since there is great variation between the Egyptian governorates. Awareness of the prevalence of toxoplasmosis will help in development of policies for better controlling, particularly in high seroprevalence areas.

Keywords: Egypt, epidemiology, seroprevalence, toxoplasmosis.

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Corresponding Author: Amira Taman**, Tel.:** +20 1002351418, **E-mail:** amirataman@mans.edu.eg

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Toxoplasma gondii is an obligate intracellular parasite capable of infecting nearly all warm-blooded vertebrates causing a potential zoonotic disease[1]. Centers for disease control and prevention (CDC) considered toxoplasmosis as one of the neglected tropical diseases characterized by chronic nature and prevalence with poor hygienic habits[2]. Cats are the only known definitive hosts in which sexual multiplication occurs, while asexual replication takes place in worm-blooded vertebrates[1]. Infected cats shed immature oocysts into the environment. Oocysts maturated under suitable conditions of warmth and humidity can survive for months up to years which explains their widespread dissemination contaminating food and water sources of intermediate hosts. Human can also acquire infection by ingestion of tissue cysts in undercooked meat of ingestible intermediate hosts; by transfusion or organ transplantation from an infected person; and the most serious of all is by congenital transmission from infected mothers[1]. Most of primary infections in healthy individuals are asymptomatic or have influenza-like symptoms, while immunocompromised patients often develop life-threatening manifestations as pneumonia and encephalitis and may suffer severe dissemination which may be related to the strain of the parasite[3].

In congenital infection, a variety of neurological and ophthalmological problems are common either during infancy or later in the childhood[4]. Currently, diagnosis of toxoplasmosis depends mainly on detection of specific antibodies using several immunological tests[5]. In Egypt, toxoplasmosis was shown to exist in Ancient Egyptian mummies as confirmed by next generation sequencing (NGS)[6], probably due to prevalence and close associations with domesticated cats[7] up to worship of the cats as the Goddess 'Best'[8]. However, toxoplasmosis was identified for the first time as a "new disease" in Egypt in 1952[9]. Since then, many studies were published indicating the importance of this parasitic disease in Egypt.

We developed this systematic review from the published literature to identify the current status of *T. gondii* infection among the Egyptian population, and to highlight its relationship with different risk factors for better awareness and management of toxoplasmosis in Egypt. We depended on seroprevalence studies as a measure of the immune response to exposure of a person during his/her lifetime to an infection. In this review, we focused on the level of IgG antibodies to *T. gondii* indicating exposure, irrespective of the test that was used for evaluation. A limited number of

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studies that reported the level of IgM, were not taken in consideration; and other studies were not included due to the inclusion criteria considered in this review.

Study area: Egypt is a Mediterranean country spanning the northeast corner of Africa. It is the world's 30th largest country, situated between latitudes 22° and 32°N, and longitudes 25° and 35°E[10]. The total population of Egypt is 101.369 million living in 27 governorates[11].

The search strategy included a systematic electronic search conducted using the Egyptian knowledge bank (EKB), which provides access to several databases including Elsevier, Web of Science, Wolters Kluwer, Taylor & Francis, Springer Nature journals, ProQuest, in addition to PubMed, Google and Google Scholar. All were searched for articles on *Toxoplasma* in Egypt published from 1970 to April 30th, 2019.

The review followed the preferred reporting for systematic review (PRISMA) guidelines[12] using English language search terms, which included "*Toxoplasma gondii*", "*T. gondii*", "toxoplasmosis", "prevalence", "epidemiology", "population", "Egypt". Our first search in the database started on December 15th, 2018 and ended April 30th, 2019.

Study selection: The inclusion criteria were based on results of studies conducted on the Egyptian population using serological techniques, mainly IgG selected as a measure for exposure to the infection. The studies included in the review were independently assessed for eligibility by two different reviewers using Newcastle Ottawa quality assessment scale[13]. Data collected from full text publications included year of publication, study location, the exact number of people screened (sample size), characteristics of the study population, diagnostic technique, number of positive cases, and risk factors. Abstracts were included if considered acceptable according to the inclusion criteria.

Out of the 8974 studies from the literature title-based search, we had 371 articles from which we excluded 323 reporting animal/birds studies and review articles in other Arab countries. Out of the 47 screened papers, only 41 were eligible for inclusion in our systematic review (40 full papers and one abstract) (Figure 1). Seven articles were excluded because of double publication, unspecified serology test, unreported prevalence, using PCR as a diagnostic tool, undetermined type of associated comorbidity, undetermined exact prevalence, and detecting antigen in urine.

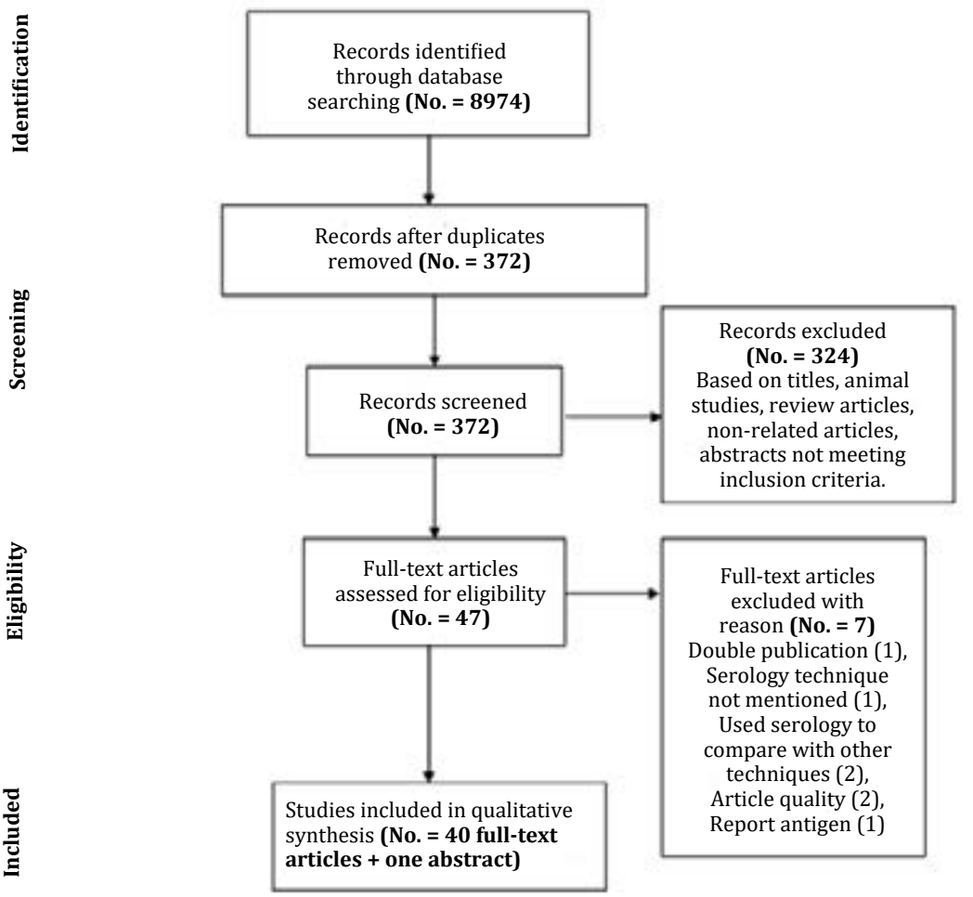

Fig 1. PRISMA flow diagram describing the study design process.

Seroprevalence of toxoplasmosis among general population and blood donors: The seroprevalence of *Toxoplasma* IgG among Egyptian general population ranged from 3% to 42.5%, and in healthy blood donors it ranged from 33.7% to 67.4% (Table 1). From the published studies (Figure 2), higher seroprevalence was detected in the Lower Egypt neighboring governorates Sharqia and Qalyubia[14] (38.8% and 27.5% respectively), and in Beni Suef (35.2%), a rural governorate at Upper Egypt[15]. Cairo also had relatively high infection rates (30%, 42.5%)[14,16], while the lowest prevalence was in El-Wadi El Gaddeed[17] (1-25%). Lower Egypt governorates are rural areas, where there is lower socioeconomic status, poor access to health services and inferior level of health knowledge as well as contact with farm animals, poultry and domesticated rabbits[14]. Regarding the prevalence rates recorded in Cairo[14,16] (Table 1), we should consider the frequent migration of individuals from rural areas because of better economic situations. Those emigrants if previously exposed to infection will carry detectable IgG antibody levels for a long period of time which is then falsely reflected as high prevalence levels in these areas. The lower prevalence (3%) reported in El-Wadi El Gaddeed[17] is probably due to its location in the desert where the hot weather is not suitable for development of oocysts[14]; but the possibility of statistical error cannot be excluded due to the larger sample size. As noticed from the analysis of previous studies, the real burden of toxoplasmosis within the general population was probably under estimated due to screening of a limited number of participants and governorates.

The climate of Egypt is a critical parameter for prevalence of toxoplasmosis and the results showed that the highest prevalence was observed in governorates near the River Nile such as Dakahlia[18-20], Sharqia[21], and Menoufia[22,23], where temperate weather is suitable for oocyst development. The higher prevalence in Alexandria and Cairo is due to their vicinity to the Mediterranean Sea[24-26] and River Nile, respectively, where appropriate humidity is suitable for oocyst sporulation. The low prevalence in Minia[27], a governorate in Upper Egypt, is justified by its hot and dry climate that reduces oocysts survival.

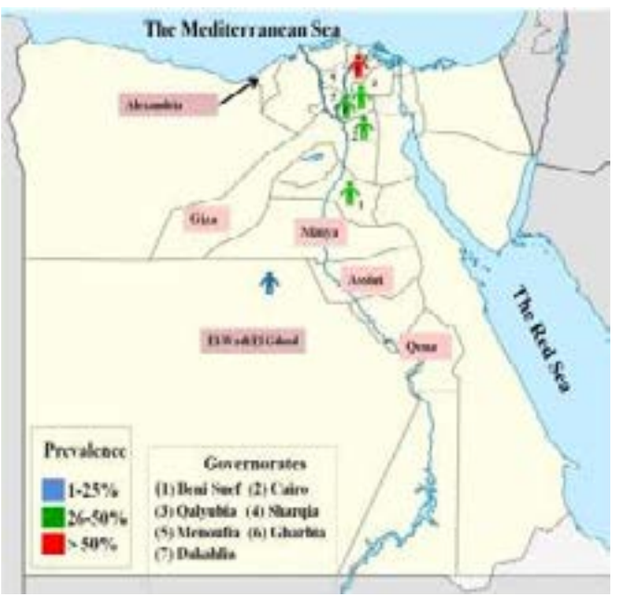

Fig 2. Map of Egypt showing the seroprevalence of toxoplasmosis in certain Egyptian governorates. Available from: http://www.esa.gov.eg/files/Topographic_Maps.pdf

On the basis of four studies conducted on blood donors, the recorded prevalence of *T. gondii* from Dakahlia, Alexandria, and Benha was found to correlate with that of the general population[28-31] ranging from 33.6-67.4%. Transfusion medicine guidelines declared that donated blood should be screened for toxoplasmosis, because of the potential risk of infection from subjects in the acute phase of toxoplasmosis. Recently, the seroprevalence of *Toxoplasma* infection among thalassemia children from Egypt was reported as 23.2% and 53.6% for IgM and IgG anti-*Toxoplasma* antibodies, respectively[32], which calls for the implementation of pre-transfusion screening.

Table 1. Seroprevalence of toxoplasmosis in Egyptian population and blood donors.

Province	Sample size	Seroprevalence (IgG)	Reference
General population			
Cairo	40	42.5%	[14]
Qalyubia	51	27.5%	[14]
Sharkia	49	38.8%	[14]
Beni-Suef	250	35.2%	[15]
Cairo	20	30%	[16]
El-Wadi El Gaddeed	450	3%	[17]
Blood donors			
Dakahlia	260	59.6%	[28]
	360	67.4%	[29]
Alexandria	150	65.3%	[30]
Qalyubia	300	33.7%	[31]

Seroprevalence of *T. gondii* IgG in relation to pregnancy: In females with history of normal pregnancies the seroprevalence ranged from 3.8% to 67.5%, in those with spontaneous abortion the range was 27.6% to 50.7%, and in those with complicated pregnancies it was 38.3% to 57.5% (Table 2). Prevalence in females with complaints of infertility was 61.85%. Several studies targeting Egyptian females with normal pregnancy revealed a wide range of 3.8%-67.5% toxoplasmosis seroprevalence in the different governorates[19-22,24,27,33]. Similar reports from Africa and Europe recorded *Toxoplasma* seroprevalence ranging from 25.3-75.2% and 9.1-63.2%, respectively[4]. In complicated pregnancy[20,21,23,27] and abortion[25,26], the prevalence rate became higher.

Table 2. Seroprevalence of toxoplasmosis in females with normal or complicated pregnancy.

Governorate	Sample size	Seroprevalence (IgG)	Reference
Dakahlia	101	51.49% (a)	[18]
	319	61.85% (d)	[19]
	100	44.0% (a)	
	39	57.5% (c)	[20]
	39	42.5% (a)	
Sharkia	30	3.8% (a)	[21]
	100	97.7% (c)	
Menoufia	323	67.5% (a)	[22]*
	92	52.2% (c)	[23]
Gharbiya	171	36.84% (a)	[33]
	193	31.09% (a)	
Alexandria	382	57.9% (a)	[24]
Cairo	139	44.6% (b)	[25]
Cairo and Giza	73	50.7% (b)	[26]
Minia	120	38.3% (c)	[27]
	120	6.66% (a)	
Qena	76	27.6% (b)	[34]

(a): Normal pregnancy, (b): Spontaneous abortion, (c): Complicated pregnancy (Premature delivery, congenial anomaly, intrauterine fetal death, still birth), and (d): Infertile females.
*Enzyme linked fluorescence assay (ELFA) was conducted, while enzyme linked immunosorbent assay (ELZA) was done in other reports.

Genotyping in toxoplasmosis: In Assiut and Menoufia, *Toxoplasma* genotype I apparently dominated in 55.2% and 34.6% of females with complicated or high risk pregnancy, respectively. In Alexandria genotype I was recorded as 57.1% and 60%, respectively in pregnant females with symptomatic toxoplasmosis and in asymptomatic pregnant females. Also from Alexandria atypical lineage of *Toxoplasma* was reported in 42.9% and 40% of pregnant females with symptomatic and asymptomatic toxoplasmosis, respectively (Table 3). In Egypt, females are not obliged to submit to mandatory prenatal serological screening for toxoplasmosis as part of their antenatal care. Therefore an integrated preventive control program including educational programs as well as regular screening of pregnant females by an appropriate method is recommended to reduce complications of *Toxoplasma* infection.

According to virulence, *T. gondii* was assembled into three genotypes (I, II, and III). Type I includes highly virulent strains that correlate with increased risk of congenital transmission and more tissue damage, while types II and III strains were designated as avirulent[35]. But recently, the genetic makeup of *Toxoplasma* proved to be more diverse in its association with the clinical outcomes[35]. The majority of *Toxoplasma* strains in North America and Europe are type II and III, while in Asia and Africa the same genotypes are prevalent in addition to two regional clonal lineages Chinese 1 in China and Africa 1, 3 in Africa[36,37]. In South America, studies revealed high genetic diversity among *T. gondii* strains[38]. In Brazil, type II and III are infrequently encountered[39] and BrI, BrII, BrIII and BrIV were considered the common clonal lineages[40].

In Egypt, three studies attempted to investigate the involved *T. gondii* genotype in pregnant females (Table 3). Studies conducted on females with complicated pregnancy revealed predominance of type I[23,41,42], which is consistent with other Arab countries as Tunisia[43]. Atypical strains were reported in pregnant females from Alexandria but with no relation to symptoms[42]. Because reinfection by different strains may increase the diversity and the development of atypical strains, further characterization is recommended.

Table 3. *Toxoplasma gondii* genotypes among Egyptian females with normal or complicated pregnancy.

Governorate	No.	Population	Genotype	Reference
Alexandria	7	Symptomatic pregnant females	I: 57.1%, atypical: 42.9%	[42]
	5	Asymptomatic pregnant females	I: 60%, atypical: 40%	
Menoufia	26	At risk pregnant females	I: 34.6%,	[23]
Assiut	17	Complicated pregnancy	I: 55.2%,	[41]

Risk factors in toxoplasmosis: Seroprevalence was also recorded with variable significant accounts for all of the risk factors (Table 4). Infection was higher in residents of rural areas, with direct contact with cats; consumption of raw vegetables or insufficiently cooked meat. Infected cats can spread the oocysts in the environment to infect livestock via hay or straw contaminated with feces; and persons especially farmers who come in contact with these animals are at risk of infection. Our compiled data (Table 4) showed that contact with farm animals and cats are significant[22,27]. Cats as the final host of *T. gondii*, release millions of oocysts increasing the likelihood of disease transmission to their contacts.

In rural areas, cats wander easily into houses and farms shedding large amounts of oocysts in their feces. Taking into consideration the high seroprevalence of *T. gondii* in Egyptian stray cats[22,44], soil and water sources are suspected to be heavily contaminated and represent a potential source of infection to human and farm animals. Residence is another significant factor, where living in rural areas increases the infection prevalence since the lifestyle of villagers brings them in direct contact with soil and livestock[22,23,27]; besides utilization of raw milk for production of homemade cheese[22], could increase the risk of infection. Added to

this, the low socioeconomic status[22,27], poor hygienic measures and low education level are significant factors. As reported previously, increasing level of education and awareness could reduce the seroprevalence of toxoplasmosis[45].

The results also showed that consumption of improperly cooked meat as grilled lamb[18] or meat products from domesticated animal, rabbits and poultry is a major risk factor[14]. Since meat is an essential ingredient in meals of most Egyptian people, especially those in rural areas[14], the rate of infection may be increased in this sector.

Significant increase in seroprevalence with age was reported, and females above 25 or 30 years have shown higher seropositivity[22,23,27], which is consistent with a previous work[46]. The reason why seroprevalence rate is higher in older age groups is probably due to a wider scope of exposure over time to risk factors; and/ or acquiring infection through different transmission routes.

Table 4. Risk factors associated with transmission of *Toxoplasma gondii* infection as reported among Egyptian population.

Risk factor	*P* value	Reference
Contact with cat	0.265	[22]
	0.06	[27]
Rural area	0.02	
Education level (illiterate)	0.03	
Poor hygienic measures	0.023	[22]
Awareness about mode of transmission	0.0001	[22]
Age (more than 30 years)	0.0001	[22]
	> 0.05	[23]
	0.0007	[27]
Low socioeconomic	0.0001	[27]
	0.067	[22]
Consumption of under cooked meat	0.0001	[27]
Consumption of milk and milk products	0.00001	[22]
Consumption of unwashed raw vegetables	0.0011	[23]
	0.00001	[27]
Contact with soil	0.0007	[22]
	0.035	[23]
	0.02	[27]
Contact with farm animals	0.0002	[22]

Seroprevalence of toxoplasmosis in associated co-morbidities (Table 5): Certain co-morbidities have been reported with toxoplasmosis. Recording of increased prevalence could be due to modulation of the immune system by underlying immuno-compromising disease conditions. The host becomes more susceptible to infection or reactivation of latent toxoplasmosis. Also, chronically infected patients are at risk of toxoplasmosis since humoral and cell-mediated immune defects are expected.

Due to neurotropism of *T. gondii* and its association with congenital brain dysfunction, researchers suggested the existence of a link between toxoplasmosis and certain neuropsychiatric disorders. Infection by *T. gondii* in subjects with schizophrenia was reported in one study in which the high rate supported the association between toxoplasmosis and schizophrenia[16]. In such cases, the genetic factor, parasite strain, route and timing of infection should be considered.

Shehata *et al*.[47], reported high toxoplasmosis seropositivity significantly associated with non-schizophrenic neurodevelopmental disorders, but there was no significant association with cognitive impairment[47]. On the contrary, *Toxoplasma* seroprevalence was reportedly high (52.9%) in patients with cognitive impairment[48]. The discrepancy could be due to difference in population, sample size and test used.

Based on studies of depression disorders, high seroprevalence of toxoplasmosis was reported in Egyptian patients[16,49], but the status of the disease and the correlation with the level of anti-*Toxoplasma* antibodies were not reported.

The link between cryptogenic epilepsy (a group of epilepsy syndromes where aetiology is unknown but an underlying brain disease is suspected) was elucidated in three studies; the seroprevalence rate was higher in children with cryptogenic epilepsy[49-51], compared to healthy controls and those that are non-cryptogenic. Limitations of these studies included the screened children without mention of the type of epilepsy if it is focal or generalized.

Another case control study was carried out to determine seroprevalence of *T. gondii* in mentally retarded children, and recorded a prevalence of 42% in diseased children, compared to 17.5% in their controls[52]. In these patients, treatment should be given early to pregnant females immediately after seroconversion to avoid detrimental consequences on the fetus.

The prevalence was also high in Egyptian patients suffering from dementia especially those having degenerative dementia including Alzheimer's disease, than in those with vascular or mixed dementia, but the small sample size is the main concern[53].

A case-control study was conducted to investigate anti-*T. gondii* IgG antibodies in 30 idiopathic Parkinson's patients[54]. Seroprevalence in the patients was 43.3% versus 46.67% in controls, refuting the

possible association, although the highest percentage of seropositivity was detected in stage three of the disease (38.5%). However, in this study it appeared that the Parkinson's patients were more exposed to several risk factors, indicating a possible role of the infection.

Only one study was conducted on autistic children from Cairo. Seroprevalence was higher in autistic children (23.9%) compared to controls (4%). Although the risk factors were not determined in the study, latent chronic *T. gondii* infection could have an important impact on triggering and development of Autism spectrum disorders (ASD) based on the levels of nitric oxide and IFA-γ, and it was recommended that toxoplasmosis should be considered while diagnosing and treating ASD[55].

More recent, a case-control study was included involving children suffering from central nervous system manifestations without apparent chromosomal anomalies, and children with Down syndrome. Results showed that anti-*T. gondii* IgG was high in neurologically disabled non-syndromic children (63.3%), followed by Down syndrome (13.3%), as compared to controls (10%). Additionally a statistically significant association was reported between toxoplasmosis seropositivity and hydrocephalus[56], but the association has yet to be elucidated.

In late chronic toxoplasmosis, $CD8^+$ T lymphocytes become progressively exhausted and this dysfunction is probably responsible for the reactivation of latent infection, leading to life-threatening complication in immunocompromised individuals such as cancer patients with chemotherapy, AIDS patients, and organ-transplant recipients. In addition, *T. gondii* is thought to be responsible for the progression of malignant disease by inhibiting apoptosis and increasing the motility of macrophages and dendritic cells[57].

In Egypt, there is no estimate for toxoplasmosis seroprevalence in AIDS and organ transplantation, but one study reported the seroprevalence rate in 30

Table 5. Seroprevalence of *Toxoplasma gondii* relative to associated disease conditions.

Associated disease	Sample size	Technique	Seroprevalence (IgG)	Reference
Neurological diseases				
Schizophrenia	60	ELISA	56.7%	[16]
Non-schizophrenia	188	ELISA	50%	[47]
Depression disorders	30	ELISA	40%	[16]
	118	ELISA	20.3%	[49]
Cryptogenic epilepsy	72	ELISA	34.7%	[49]
	132	ELISA	60.6%	[50]
	40	ELISA	20%	[51]
Non-cryptogenic epilepsy	30	ELISA	0%	[51]
	40	ELISA	2.5%	[49]
Dementia	37	ELISA	18.9%	[53]
Cognitive impairment	258	ELISA	52.9%	[48]
Mentally retarded	200	IHA	42%	[52]
Parkinson's disease	30	ELISA	43.3%	[54]
Autism	46	ELISA	23.9%	[55]
Neurologically disabled				
Down's syndrome	30	ELISA	13.3%	[56]
Non Down's syndrome	30	ELISA	63.3%	[56]
Tumors/Cancer				
Hepatocellular carcinoma (HCC)	60	ELISA	36.8%	[64]
Solid	188	ECLIA	55.8%	[60]
Hematological	30	LFCA	24%	[61]
	118	LFCA	12%	[61]
Chronic hepatitis				
HCV				
HCV alone	60	ELISA	76.9%	[62]
HCV and related cirrhosis	188	ELISA	41.7%	[63]
HCV and hepatocellular carcinoma	30	ELISA	64.2%	[64]
HBV and related cirrhosis	118	ELISA	15%	[63]
Renal failure and dialysis	150	ELISA	60%	[67]
Diabetes	60	ECLIA	46%	[72]
	188	ELISA	78.4%	[71]
Rheumatoid arthritis	60	ELISA	54%	[73]
	188	ELISA	76.6%	[74]
Tuberculosis	60	ELISA	67.4%	[75]

ECLIA: Electro-chemiluminescence immunoassay, **ELISA:** Enzyme linked immunosorbent assay, **IHA:** Indirect hemagglutination test**, LFCA:** Lateral flow chromatographic assay

immunocompromised patients from Cairo, Qalyubia, and Sharqia[14]. Although the authors did not report the etiology of immunosuppression, prevalence was 39.4%; higher than that reported from Mexico[58] and lower than reports from Iran[59].

According to two Egyptian studies, toxoplasmosis is higher in cancer patients[60,61], particularly those suffering from breast carcinoma (69.1%) and brain tumors (69.2%), which is nearly similar to reports from Iran[59]. Besides, the prevalence of toxoplasmosis in solid organ tumors was higher compared to hematological malignancies, and the prevalence was not affected by the type of treatment whether chemoprophylaxis or radiotherapy[61]. Unfortunately these studies screened a few patients, did not cover many types of cancers and used different techniques. Exclusion diagnosis of toxoplasmosis in those patients should be periodically performed to prevent the possibility of severe disease and for possible management of these malignancies through control of *Toxoplasma* infection.

Three studies reported higher percentage of toxoplasmosis in Egyptian cirrhotic patients, complaining of chronic HCV or chronic HCV with hepatocellular carcinoma compared with controls[62-64]. A more recent study that used PCR confirmed the previous results[65], which were higher than in China[66], probably due to heterogeneity of the studied population and geographic variability.

A study conducted on Egyptian patients with chronic renal failure (CRF) undergoing haemodialysis showed high prevalence of positivity for anti-*Toxoplasma* antibodies[67]. The prevalence reported from those studies is in accordance with studies from Iran[68] and Mexico[69]. The results demonstrated that CRF patients on haemodialysis are more susceptible to toxoplasmosis due to the impaired immune response, besides having to spend prolonged periods of time in a healthcare facility and possibility of requiring blood transfusion, both of which may increase the risk of infection. Therefore it is recommended for CRF patients to be screened for *Toxoplasma* before dialysis to prevent the dissemination of infection. As reported previously, the level of *Toxoplasma* IgG correlated with the number and length of the dialysis sessions[70], which stresses the role of the dialysis procedure in infection transmission.

Diabetic patients are susceptible to infections[71] including *T. gondii* which replicates inside any nucleated cells including those of pancreas; thus, theoretically, toxoplasmosis could play a possible role in the development of diabetes type 1 (T1D). In Egypt, two studies recorded the higher seropositivity of anti-*Toxoplasma* IgG among T1D in comparison with diabetes type 2[71, 72]. But the small sample size selected from restricted communities with no details about disease condition and duration in each case besides using different methods for *Toxoplasma* diagnosis limited their findings.

Two studies tested 160 Egyptian patients suffering from rheumatoid arthritis[73,74]. The elucidated high prevalence of anti-*Toxoplasma* antibodies in those patients, was close to those reported in Europe[76,77]. Prevalence apparently increased with treatment involving immunosuppressive agents[78]. Despite the limited sample size, none of these studies reported the relation of risk factors as age and sex with toxoplasmosis.

One study conducted on 43 tuberculosis patients reported that chronic *Toxoplasma* infection was apparently more common in rifampicin-sensitive patients compared with healthy controls and rifampicin-resistant ones[75], but the study did not test for acute infection.

Conclusion: This systematic review provides a general overview of the seroprevalence of *T. gondii* infection and its related risk factors among the Egyptian population, and the relation between *T. gondii* seroprevalence in relation to normal and complicated pregnancy, as well as different co-morbid conditions. From data summarized here, it is evident that toxoplasmosis had higher prevalence in Lower Egypt governorates and Cairo. Higher *Toxoplasma* seroprevalence was recorded in complicated pregnancy. Risk factors include residency in rural areas, contact with cats, and consumption of undercooked meat and unwashed fruits and vegetables. Among neurological diseases, cryptogenic epilepsy reported the highest seroprevalence followed by schizophrenia. Solid tumors had higher seroprevalence than hematological ones. HCV patients were more exposed to infection, when compared with those infected with HBV.

For chronic diseases, diabetes is associated with higher *T. gondii* seroprevalence than renal failure. The results highlight that more interventions are needed to reduce human infection by providing veterinary care to farm animals, pets and birds, in addition to satisfactory hygienic measures, proper processing and cooking of meat. The results also suggested the positive correlation between toxoplasmosis and various diseases, thus the role of latent toxoplasmosis in the etiology of these diseases deserves more attention.

Limitations: The study was subjected to several limitations. First, there were only few seroprevalence studies that did not cover all governorates of Egypt. Second, the studies usually included small numbers of clinically or socially homogeneous populations; and there were no multi-governorates surveys including large number of participants with different age, sex and social level to represent the national seroprevalence rate. Third, different serological methods were used which are not standardized and usually differ in

sensitivity, specificity and predictive values. Fourth, lack of evaluation of risk factors was observed in most of the reports.

Author's contribution: Taman A initiated the idea, collected and revised the selected studies, and wrote the manuscript. Alhusseiny SM participated in collection; selection of studies used, and revised the manuscript.

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