

AN EDUCATIONAL PROGRAM ON KNOWLEDGE AND AWARENESS FOR JOEF UNIVERSITY BIOLOGY STUDENTS ON CONGENITAL TOXOPLASMOSIS, SAUDI ARABIA

By

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Abstract

Toxoplasma gondii is a worldwide zoonotic protozoan parasite of that infects species of warm-blooded animals and birds, including humans. Infection can occur by ingestion of oocysts dropped from cats, ingestion of tissue cysts, Blood transfusion or organ transplants, and Transplacental transmission. Congenital toxoplasmosis is widely recognized public health problem due to the devastating results it can have on the unborn fetus including miscarriage, mental retardation, visual, and hearing problems.

Key words: Saudi Arabia, Congenital toxoplasmosis, Knowledge, Awareness, Students.

Introduction

Toxoplasma gondii that causes toxoplasmosis is a zoonotic protozoan of worldwide prevalence (Abbas *et al*, 2020). *T. gondii* can infect all warm-blooded animals and birds and even man are intermediate hosts, but cats and other felids are the definitive hosts (Dubey, 2010). Most toxoplasmal infections in humans are asymptomatic, but at times parasite can produce devastating disease. Infection may be congenitally or postnatal, the congenital one occurs if a woman was infected during pregnancy 1st trimester was more severe than those acquired in 2nd & 3th ones (Desmonts and Couvreur, 1974), or occupational as needle stick injury (Abdel-Motagally *et al*, 2017), hospital acquired or nosocomial infection (Saleh *et al*, 2016), also, solid organ transplants of heart, liver, kidney, pancreas and small bowel, and bone marrow transplants were involved in having *T. gondii* from infected donor (Coster, 2013). In the human host, cysts in tissue, most commonly in skeletal muscle, myocardium, brain, and/or eyes may remain alive throughout host's life span (CDC, 2024a).

Diagnosis of toxoplasmosis can be serologic as Sabin-Feldman dye test, indirect fluorescent antibody test (IFAT), indirect hemagglutination test, latex agglutination test, modified agglutination test, enzyme-linked immunoabsorbent assay (ELISA) and/or PCR or histocytologic tissue examination in

host by biopsy or at necropsy (Montoya, 2002).

Clinical toxoplasmosis signs are nonspecific and cannot be depended on for a definite diagnosis; infection clinically mimics several other infectious diseases (Mittal and Ichh-pujani, 2011). Usually, people may have few weeks or months of mild, flu-like illness such as muscle aches and tender lymph nodes, or eye problems may develop. Those with a weakened immune system, severe symptoms such as seizures, and poor coordination may occur (Milne *et al*, 2020). If a woman becomes infected during pregnancy, she don't have clinical manifestations, but some may have a mild mononucleosis-like syndrome, regional lymphadenopathy, or occasionally chorioretinitis. The infected neonates are usually asymptomatic at birth, but manifestations may include: Prematurity, intrauterine growth restriction, jaundice, hepatosplenomegaly, myocarditis, pneumonitis, or various skin rashes (Rostami *et al*, 2022). The classic triad consists of chorioretinitis, hydrocephalus, and intra-cranial calcifications that can appear later on (Al-Agroudi *et al*, 2017).

Toxoplasmosis differential diagnosis may include the following; 1- CNS lymphoma, 2- Metastatic brain lesions, 3- Progressive multifocal encephalopathy, 4- Cerebral tuberculosis, 5- Bacterial or fungal brain abscess, 6- Cytomegalovirus, 7- Acute HIV infection, & 8- Herpes simplex encephalitis (Medscape,

2022). Also, toxoplasmosis is involved in the TORCH syndrome, which is a cluster of symptoms caused by congenital toxoplasmosis infection with, rubella, cytomegalovirus, and *Herpes simplex* as well as others including syphilis, parvovirus, Varicella zoster and/or Zika virus (Morsy *et al*, 2022).

Prevention: Hygiene measures are effective to reduce toxoplasmosis and avoid congenital toxoplasmosis is by 1- avoiding consumption of undercooked meat, raw vegetables, and/or fruits as well as contaminated water, 2- contact with stray or pet cat or with soil during gardening (Wehbe *et al*, 2022).

Treatment: Tachyzoites characterize active toxoplasmosis, but tissue cysts indicate latent infection. So, treatment includes combinations of an anti-*Toxoplasma*, most often inhibitors of dihydrofolate reductase (DHFR) (Pyrimethamine[®] and Trimethoprim[®]), and dihydropteroate synthetase (sulfonamides, such as sulfadiazine, sulfamethoxazole, and sulfadoxine), which block folic acid synthesis.

Pyrimethamine, a key DHFR inhibitor, is the most effective drug against *T. gondii* and basis for effective regimens. This includes pyrimethamine-sulfadiazine (pyr-sulf), the gold standard against which others are measured, and pyrimethamine combined with clindamycin, atovaquone, clarithromycin, or azithromycin (Dunay *et al*, 2018).

CDC (2025) reported that women who are not pregnant with healthy immune systems often recover from toxoplasmosis without treatment, but If treatment was indicated, a combination of drugs such as pyr-sulf, plus folic acid. Treatment for ocular diseases should be based on a complete ophthalmologic evaluation, including lesion acuteness, degree of inflammation, visual acuity, and lesion size, location, and persistence. For the adults: 100mg for one day as a loading dose, then 25- 50mg/ day, plus sulfadiazine 2 to 4 gm daily for 2 days, followed by 500mg to 1 gm dose 4x/day and folic acid (leucovorin[®]), 5-25mg pyrimethamine with each dose (CDC, 2024b).

Serologic toxoplasmosis prevalence: Bigna *et al*. (2020) in a review of 250 studies with 723,655 pregnant women reported that the global IgM seroprevalence was 1.9% (95%CI: 1.7-2.3). At the regional level, Eastern Mediterranean had the highest IgM seroprevalence (4.1%, 95%CI: 2.8-5.5), & the Americas, the lowest (1.1%, 0.8-1.4), with a significant difference between WHO regions ($p < 0.0001$). Global IgG seroprevalence was 32.9% (95%CI: 29.4-36.4). Among WHO regions of Americas had highest prevalence (45.2%, 95%; CI: 33.4-53.4) & Western Pacific least (11.2%, 7.8-15.1), with a significant difference between regions ($P < 0.0001$).

Subjects, Materials and Methods

The sample consisted of 38 female university biology students who participated in the research and met inclusion criteria. Size sample used was as recommended formula (WHO, 1991)

Rationale: Toxoplasmosis is a zoonotic protozoan with global geographical and zoological distributions. Apart from acquired infection congenital transmission affects both the mother pregnancy and fetus outcome.

Objectives: To assess the university student's knowledge as regard the risks of toxoplasmosis particularly among women marriage or unmarried with a detailed review on toxoplasmosis in Saudi Arabia.

Research design: Questionnaires (39) were designed based on detailed lectures on *T. gondii* and toxoplasmosis as to 1- Lifecycle , 2- Mode of infections, 3- Reservoir hosts, 4- Diagnosis, 5- Differential diagnosis, 6- Signs and symptoms, 7- Treatment, and 8- Prevention.

Study setting: The study was conducted in Faculty of Science, Jouf University.

Inclusion criteria: All female students the 4th class levels who agreed to participate in the educational program on knowledge and awareness.

Scoring system: Each question was evaluated by giving score of "1" for each correct answer, and zero for each wrong answer. These scores were converted into percentages. The kno-

wledge was correct "Yes" or if score was 60% or more and incorrect one "No" if <60%.

Results

Results were in table (1) and figure (1).

Table 1: *Toxoplasma* prevalence questionnaire in the Kingdom of Saudi Arabia from 2020-2025.

Question No.	Yes	No
1- Have you heard about <i>Toxoplasma gondii</i> and/or toxoplasmosis?	76%	29%
2- Do you know that <i>Toxoplasma</i> is a zoonotic infectious parasite?	66%	34%
3- Have you ever had a pet cat?	55%	45%
4- Do you know that cats are the <i>T. gondii</i> definitive host?	61%	39%
5- Do you know that undercooked meat can transmit <i>T. gondii</i> ?	74%	10%
6- Do you think <i>T. gondii</i> can be transmitted from cats to man?	61%	39%
7- Do you think that washing fruits and vegetables can avoid <i>T. gondii</i> infections?	87%	13%
8- Do you know pregnant women must avoid cats to avoid <i>T. gondii</i> infections?	74%	26%
9- Have you any eye problem and/or infection due to <i>T. gondii</i> ?	76%	24%
10- Do you think that <i>T. gondii</i> infected person can be without symptoms?	47%	53%
11- Do you know that people with weakened immune systems are at higher risk to toxoplasmosis?	82%	18%
12- Have you ever eaten raw or undercooked meat?	39%	61%
13- Are you familiar with how <i>Toxoplasma</i> can affect the brain and eyes?	58%	42%
14- Do you know that toxoplasmosis can be asymptomatic in infected people?	68%	32%
15- Have you ever been told to avoid touching cat litter if you're pregnant?	71%	29%
16- Do you know that toxoplasmosis can be risky to babies?	66%	34%
17- Have you ever know that toxoplasmosis can spread by contaminated water?	68%	32%
18- Do you know that toxoplasmosis can be diagnosed by serologically in blood?	74%	26%
19- Have you ever heard that toxoplasmosis can be safely treated with medication?	68%	32%
20- Do you think that all cats carry <i>Toxoplasma</i> parasites?	50%	50%
21- Have you ever been warned about the risks of eating raw fruits or vegetables?	82%	18%
22- Do you know that proper cooked meat can prevent toxoplasmosis?	84%	16%
23- Have you ever heard that <i>Toxoplasma</i> can be transmitted from animals to man?	92%	8%
24- Do you know that toxoplasmosis is more common in certain world countries?	66%	34%
25- Do you know that <i>Toxoplasma</i> oocysts can infect man from contaminated soil?	74%	16%
26- Have you ever considered toxoplasmosis can be linked to other infectious diseases?	68%	32%
27- Have you ever been concerned about the risks of touching cat litter?	63%	37%
28- Have you heard that toxoplasmosis is particularly risky to patients with HIV/AIDS?	74%	26%
29- Have you ever wondered how <i>Toxoplasma</i> is transmitted to humans?	68%	32%
31- Do you know that toxoplasmosis can cause brain and nerve damage in extreme cases?	76%	24%
32- Do you think you are at risk of toxoplasmosis because of your lifestyle?	71%	29%
33- Have you ever heard that toxoplasmosis can be prevented with simple hygiene practices?	61%	39%
34- Have you been told that toxoplasmosis is a concern for pet owners?	47%	53%
35- Do you know that keeping pets clean and avoiding raw food can prevent toxoplasmosis?	76%	24%
36- Have you ever wondered if you could catch <i>Toxoplasmosis</i> without owning a cat?	79%	21%
37- Do you know that people living in rural areas may be at higher risk for toxoplasmosis?	89%	11%
38- Do you know that washing hands regularly can reduce the chance of getting toxoplasmosis?	74%	26%

N.B.: Title useful context, percentage of Yes answers, and percentage of No answers.

Discussion

In the present study, all students were females of them (76%) knew *Toxoplasma gondii* from their university studies, and 66% knew it as a zoonotic disease. As to transmission by undercooked meat, students (74%) gave correct answer, and infection acquired from cat exposure students (61%) gave correct answer. As to washing fruits and vegetables to avoid infection, students (87%) gave correct answer.

In the present study, as to misconceptions and gaps in knowledge, the students (50%) didn't believe that all cats carry *T. gondii* as

a definitive host, and highlighted a common misconception.

In the present study, only 47% of the students were aware that *Toxoplasma* can live in humans asymptomatic. Also, 58% of them understood *T. gondii* pathological effect on the brain and eyes.

In the present study, 74% of them knew that pregnant women must be cautious with cats as a definitive host, but 26% were not aware, and 71% of them knew about avoiding cat litter during pregnancy, but 29% were unaware. Moreover, 82% of the students understood the risks of eating raw veget-

ables, and 84% realized that proper cooking can prevent infection, but 39% consumed raw or undercooked.

In Saudi Arabia, *toxoplasmosis* among women ranged from 22.5% (Shoura *et al.*, 1973) up to 37.4% (Abbas *et al.*, 1986). Sarwat *et al.* (1993) detected anti-*Toxoplasma* antibodies in blood donors. Morsy and El Dasouki (1974) in Riyadh reported a febrile toxoplasmosis case. Morsy *et al.* (1994) in Riyadh City detected antibodies against *T. gondii* in domestic rodents. Al-Amari (1994) in Asir area found higher anti-*Toxoplasma* antibodies among blood donors as compared to previous ones. Hilali *et al.* (1995) detected cysts of *Toxoplasma*, *Isospora*, *Hammondia* and *Sarcocystis* in camel's meat. Al Dakhil and Morsy (1996) in the Eastern Region isolated *T. gondii* from the Indian grey mongoose (*Herpestes edwardi*, Greffroy). Amin and Morsy (1997) in Jeddah reported anti-*Toxoplasma* antibodies in butchers and slaughtered sheep and goats. Tabbara *et al.* (1999) reported that the systemic toxoplasmosis was 32.7% among population, and retinochoroiditic scar of suggestive toxoplasmosis was among 2.9% cases. Al-Qurashi *et al.* (2001) in the Eastern Region reported that IgG was 25% among human population, but congenital toxoplasmosis IgM was 5%. Al-Harathi *et al.* (2006) in King Faisal University in Al-Ahssa evaluated the awareness of toxoplasmosis and its preventive behaviors among female students reported that 65.4% were not aware, and 28.2% were aware complications or risk factors. Alqahtani and Hassan (2012) reported high IgG positive among Sharourah inhabitants (47%) followed by Habona Province (37.9%) and least was in Najran City (19.3%), with significant increase with ageing. They added that high number of cats in rural area than urban one especially indoors was responsible for the highest difference in rural localities, and the highest anti-*Toxoplasma* IgG in females in rural areas again emphasize the locality habits in these areas by more responsibilities of females, who were concerned with houses and farms

more than their partners, with more chances to infection exposure. Moussa *et al.* (2015) in Hail studied the awareness and risk of *T. gondii* among 800 basal representative participants of whom (79.25%) knew toxoplasmosis, and (50.25%) the cats' role in transmission, but few (25.1%) knew *T. gondii* infective agent and 22.13%, 22.62%, 17.75% & 24% knew about vulnerable group susceptibility, treatment, availability and modality respectively. They (39.12%) recognized congenital toxoplasmosis anomalies, (38.62%) congenital toxoplasmosis abortion, (64.7%) didn't have pet cats, and the great majority consumed cooked meat, and washed vegetables. Nevertheless, most of them used cat feces as fertilizer. They concluded that knowledge, and preventive measures among Hail population was at low level, and that health education program was indicated in schools, hospitals and other working areas.

Elsafi *et al.* (2015) in Dhahran among 400 pregnant women, reported an overall IgG & IgM positivity rates against *T. gondii* were 28.5 and 3%, respectively. 75.5% of the women never heard about toxoplasmosis and its associated risk factors. Lack of knowledge was associated with higher risk of infection (OR= 4.04, $p < 0.001$). Keeping pet cats was uncommon and poorly associated with infections (OR= 1.15, $p \geq 0.64$). Consumption of undercooked meat was frequently and slightly risk was associated with sheep/goat meat (OR= 1.39, $p = 0.15$). Eating outdoors at restaurants was for the first time reported to be related to a higher infection risk (OR= 2.69, $p < 0.001$). Several possible risk factors were indicated by odds ratios calculation that their overall knowledge toxoplasmosis was poor. They concluded that it was of vital importance to give a formal education about toxoplasmosis risk factors to the childbearing age's women.

Alrashada *et al.* (2016) in Al-Ahssa, reported that female students obtained their information from internet (55.5%), and 25.1% & 50.25% of them, respectively, knew the causative agent and cats' role in toxoplasmo-

sis transmission.

Alzaheb (2018) reviewed Saudi Arabia published data between January 2000 and December 2017, reported that *T. gondii* positivity among 13,597 reproductive aged women between 15 & 49 years was 27.8% (95% CI=20.6%-36.3%), with significant association between age and positivity. Mohammed *et al.* (2019) in Riyadh district reported that *T. gondii* oocysts were among 12/100 fecal samples from both stray and pet cats. Mohamed (2020) reviewed published data between 2000 and 2018 on man or pregnant women or children as well as animals or any particular species, found that about one-third of the population had IgG seropositivity and 6.4% had IgM seropositivity. He added that in Riyadh chronic toxoplasmosis prevalence in sheep was 68%, and in Najran acute one was 19% in sheep, goats, and camels. Also, Mahfouz *et al.* (2019) conducted a cross-sectional study on 440 random samples of female students at Jazan University using semi-structured, self-administered questionnaire. They found that 79.1% of them had insufficient knowledge about toxoplasmosis. Students from healthcare faculties had higher knowledge scores (28.5%) than students from arts and humanities (20.6%) and science (18.9%) faculties, but, without significant differences. They concluded that a substantial proportion of Jazan University's female students had insufficient knowledge on toxoplasmosis, and that health educational programs are necessary to increase their awareness and knowledge about toxoplasmosis and its clinical manifestations.

Al-Yami *et al.* (2021) in the Eastern Province for gestational/congenital toxoplasmosis reported the dire need to develop and implement preventive programs against *T. gondii* and a health education program on how to avoid toxoplasmosis for pregnant women.

Hassanein *et al.* (2022) in based retrospective study between January 2019 and March 2021 at three governmental hospitals in Jeddah Region: King Fahad, King Abdulaziz, and East Jeddah Hospital, found that the ov-

erall *T. gondii* seropositivity rate of 18.53% (93/502) subscribed as 90 babies (17.9%)

with IgG seropositive and 3 babies (0.60%) with IgM seropositivity. The highest IgG seropositivity rate was among 0-6 month old babies (7.17%); followed by 5.38%, and 4.98% in 7-12, and 13-18 months old babies, respectively, but three babies with IgM positivity were 13-18 months old.

Alharazi *et al.* (2023) in the northwestern region hospitals females, the overall anti-*T. gondii* antibodies were 8.3%. Higher (9.9%) prevalence of positive results among patients aged 30 years and above, with statistical significance. They added that females have increased (8.1%) seroprevalence, and *T. gondii* incidence (8.2%) occurred particularly among those lived in rural areas.

Moafa *et al.* (2024) in retrospective studies published from 1994 to 2023 on 20,699 patients from different Saudi Arabian regions found that the IgG prevalence of toxoplasmosis was lower than the global average, with significant variations across different age groups, water sources, and dietary habits.

Aldali *et al.* (2024) in Riyadh used a bilingual Google form, a cross-sectional online survey distributed in both Arabic and English from 11 January 2024 to 4 March 2024. They reported that of 533 participants aged 18-25 years old constituted the largest group (70.4%), with those aged 26-40 years old were (14.4%) and aged 41-60 years old were (15.2%). Of whom (76.4%) were unmarried. Of them (79.2%) were unaware of toxoplasmosis and only (9.0%) obtained awareness from doctors and (3.6%) from awareness campaigns, and knowing toxoplasmosis severity and causative factors was (15.9%). Others variables as social status, pet-cats, hand-washing before meals, and washing fruits & vegetables didn't show significant correlations. They concluded that there was insufficient toxoplasmosis knowledge among them. But, despite low knowledge, there was a slightly positive attitude and learning willing, and adopt preventive measures when infor-

med, and the well education, attitudes to toxoplasmosis could improve due to a desire to learn and act.

Alghafari (2025) in Jeddah assessed toxoplasmosis knowledge and preventive behaviors among 135 pregnant Saudi women. By face-to-face interviews, reported that 45.2% of them had a poor knowledge, but those aged 31-40 years had significantly higher knowledge compared to < 30 years. The author added that 90.4% of them practiced effective preventive behaviors and 86.7% reported habitually hand-washing after handling raw meat, and didn't eat raw meat. The author concluded that the overall poor toxoplasmosis knowledge among pregnant women indicated the importance of implementing targeted antenatal health education campaigns and interventions to protect them and to minimize the congenital toxoplasmosis risk.

In other countries, Al-naggar *et al.* (2010) in Yemen reported that 50% of the students sample knew about toxoplasmosis via the internet, and that cat as definitive host 64%. Ebrahimi *et al.* (2015) in Iran reported that the most important source of information for the university students (55.8 %) was books, more male students were aware of toxoplasmosis than females, 72.5% believed that consumption of undercooked meat is an important route of infection, and cats are the definitive host (50.25%). Senosy (2020) in Beni-Suef University, Egypt assessed toxoplasmosis-related knowledge, attitudes and preventive practices among 1079 female undergraduate students of them only 35 (3.2%) had good knowledge. The author added that 67.1% of them always ate fast food, while 70.7%, 72% and 78.2% of female students reported hand washing after gardening, cleaning areas where cats were and cooking with meat, respectively. Author concluded that the toxoplasmosis knowledge was deficient among female university students, with negative attitude, many students correctly avoided risk behaviors, without realizing what to avoid. Thus, there was a critical need for satisfactory educational programs to increase

their toxoplasmosis awareness.

Hamou *et al.* (2021) in Morocco, Rabat among 230 university students reported that 55.2% were females and 44.8% were males and (42.6%) of them have heard of toxoplasmosis; during their faculty studies in classrooms with 75.8%, and 3.2% were from the internet. They added that only 36.5% knew the correct causative agent of toxoplasmosis, 32.1% were aware of the definitive host and (33%) knew that cats are the main source of environmental contamination.

Conclusion and Recommendations

Toxoplasmosis is a global zoonotic disease with a complex epidemiology and multiple clinical manifestations even fatal in immunosuppressed people

- 1- Avoid feeding pets' unpasteurized milk or other unpasteurized dairy products.
- 2- Proper washing fruits and vegetables under running water before eating, especially those grown in backyard gardens.
- 3- Cook meat to considerable temperatures capable to destroy *Toxoplasma* infective stage and other infectious organisms.
- 4- Avoid stray and pet cat whenever possible, but is a must during pregnancy.
- 5- Hand-washing is a must and strict hygiene measures and pregnancy screening program.
- 6- There is an importance need to improve community knowledge towards toxoplasmosis, particularly among the general population, particularly the females.

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References

- Abbas, IE, Villena, I, Dubey, JP, 2020: A review on toxoplasmosis in humans and animals from Egypt. *Parasitology* 147, 2:135-59.
- Abbas, SA, Basalamah, A, Serebour, F, Alfonso, M, 1986: The prevalence of *Toxoplasma gondii* antibodies in Saudi women and the outcome of congenital infection among Newborns in Saudi Arabia. *Saudi Med. J.* 7:346-54.
- Abdel-Motagaly, AME, Ibrahim, AMA, Mor-

- sy, TA, 2017: An intervention program on blood protozoa acquired by needle stick injury and infection control. *JESP* 47, 2: 309-22
- Al Dakhil, MA, Morsy, TA, 1996: Natural *Toxoplasma* infection sought in the Indian grey mongoose (*H. edwardi*, Greffroy, 1818) trapped in the Eastern Region, Saudi Arabia. *J. Egypt. Soc. Parasitol.* 26, 3:645-52.
- Al-Agroudi, MA, Ahmad, GMS, Kondo, MK, Morsy, TA, 2017: An overview of congenital toxoplasmosis: Clinical features, diagnosis, treatment and prevention. *JESP* 47, 3:523-40.
- Al-Amari, OM, 1994: Prevalence of antibodies to *Toxoplasma gondii* among blood donors in Abha, Asir Region, South Western Arabia. *J. Egypt. Publ. Hlth. Assoc.* 69:77-88.
- Al-Harhi, SA, Jamjoom, MB, Ghazi, HO, 2006: Seroprevalence of *Toxoplasma gondii* among pregnant women in Makkah, Saudi Arabia, Umm Al-Qura Univ. *J. Sci. Med. Eng.* 18, 2: 217-27.
- Al-Qurashi, A, Ghandour, AM, Obied, OE, Al-Mulhim, A, Makki, SM, 2001: Seroepidemiological study of *Toxoplasma gondii* infection in the human population in the Eastern Region. *Saudi Med. J.* 22, 1:13-18
- Al-Yami, FS, Dar, FK, Yousef, AI, Al-Qurouni, BH, Al-Jamea, LH, et al, 2021: A pilot study on screening for gestational/congenital toxoplasmosis of pregnant women at delivery in the Eastern Province of Saudi Arabia. *Saudi Pharm. J.* 29:343-50
- Aldali, JA, Aljehani, AM, Elsokkary, EM, Alkhamis, FL, Bin Khathlan, NM, et al, 2024: Assessment of knowledge, attitude, and preventive behavior regarding toxoplasmosis among females in Riyadh, Saudi Arabia: A cross-sectional study. *Int. J. Environ. Res. Public Hlth.* Aug 14;21(8):1065. doi: 10.3390/ijerph21081065.
- Alqahtani, J, Hassan, MM, 2012: Incidence of toxoplasmosis *gondii* in Najran region, KSA. *J. Egypt. Soc. Parasitol.* 42, 2:253-60.
- Alrashada, N, Alqarash, Z, Alshehri, F, Alkhamies, L, Alshqaqeeq, A, 2016: Toxoplasmosis among Saudi female students in Al-Ahssa, Kingdom of Saudi Arabia: Awareness and risk factors. *Open J. Prevent. Med.* 6:187-95.
- Alzaheb, RA, 2018: Seroprevalence of *Toxoplasma gondii* and its associated risk factors among women of reproductive age in Saudi Arabia: A systematic review and meta-analysis. *Int. J. Women Hlth.* 10:537-44.
- Amin, AM, Morsy, TA, 1997: Anti-*Toxoplasma* antibodies in butchers and slaughtered sheep and goats in Jeddah Municipal abattoir, Saudi Arabia. *J. Egypt. Soc. Parasitol.* 27, 3:913-8.
- Bigna, JJ, Tochie, JN, Tounouga, DN, Bekolo, AO, Ymele, NS, et al, 2020: Global, regional, and country seroprevalence of *Toxoplasma gondii* in pregnant women: a systematic review, modeling and meta-analysis. *Sci. Rep.* Jul. 21; 10 (1):12102. doi:10.1038/s41598-020-69078-9.
- CDC, 2024: About Toxoplasmosis. <https://www.cdc.gov/parasites/toxoplasmosis/biology.html>.
- CDC, 2024b: Clinical Care of Toxoplasmosis. <https://www.cdc.gov/toxoplasmosis/hcp/clinicalcare/index.html>
- CDC, 2025: Treatment of toxoplasmosis: <https://www.cdc.gov/toxoplasmosis/treatment/index.html>.
- Coster, LO, 2013: Parasitic infections in solid organ transplant recipients. *Infect. Dis. Clin. North Am.* 27:395-427
- Desmots, G, Couvreur, J, 1974: Congenital toxoplasmosis: A prospective study of 378 pregnancies. *N. Engl. J. Med.* 290:1110-6
- Dubey, JP, 2010: *Toxoplasmosis of Animals, and Humans* 2nd Ed. CRC Press, Boca Raton.
- Dunay, IR, Gajurel, K, Dhakal, R, Liesenfeld, O, Montoya, JG, 2018: Treatment of toxoplasmosis: Historical perspective, animal models, and current clinical practice. *Clin. Microbiol. Rev.* 31, 4: e00057-17.
- Ebrahimi, M, Ahmadi, A, Yaghfoori, S, Rassouli, M, 2015: Evaluating the prior knowledge of toxoplasmosis among students of Ferdowsi University of Mashhad. *Med. J. Islamic Republic of Iran* 29, 163:1-3.
- Elsafi, SH, Al-Mutairi, WF, Al-Jubran, KM, Abu Hassan, MM, Al Zahrani, EM, 2015: Toxoplasmosis seroprevalence in relation to knowledge and practice among pregnant women in Dhahran, Saudi Arabia. *Pathog. Glob. Hlth.* 109, 8:377-82.
- Hamou, SA, Lamhamdi, B, Hayah, I, Belbacha, I, Sadak, A, et al, 2021: The level of knowledge about toxoplasmosis among university students in Rabat in Morocco. *J. Parasit. Res.* Jul 26; 2021: 5553977. doi:10.1155/2021/5553977.
- Hassanein, RAM, El-Shemi, AG, Alkurbi, M O, Alahmadi, AA, Almatery, WS, 2022: Seroprevalence of *Toxoplasma gondii* infection among babies in Jeddah Province, Saudi Arabia: A retrospective study. *Pan Afr. Med J.* May 26; 42: 72. doi: 10.11604/pamj.2022.42.72.32877.
- Hilali, M, Fatani, A, Al-Atiya, S, 1995: Isolat-

ion of tissue cysts of *Toxoplasma*, *Isospora*, *Hammondia* and *Sarcocystis* from camel *Camelus dromedarius* meat in Saudi Arabia. *Vet. Parasitol.* 58:353-8.

Mahfouz, MS, Elmahdy, M, Bahri, A, Mobaraki, YM, Altalhi, AA, et al, 2019: Knowledge and attitude regarding toxoplasmosis among Jazan University Female Students. *Saudi J. Med. Med. Sci.* 7, 1:28-32.

Medscape, 2022: Toxoplasmosis Differential Diagnose: <https://medicine.medscape.com/229969-differential>.

Milne, G, Webster, JP, Walker, M, 2020: *Toxoplasma gondii*: An underestimated threat? *Trend. Parasitol.* 36, 12:959-69.

Mittal, V, Ichhpujani, RL, 2011: Toxoplasmosis: An update. *Trop. Parasitol.* 1, 1:9-14.

Moafa, HN, Altemani, AH, Alaklabi, A, Ghailan, KY, Alshabi, A, et al, 2024: The prevalence of *Toxoplasma gondii* in Saudi Arabia (1994-2023): A systematic review and meta-analysis. *J. Epidemiol. Glob. Hlth.* 14:1413-54.

Mohamed, K, 2020: Toxoplasmosis in humans and animals in Saudi Arabia: A systematic review. *J. Infect. Dev. Ctries* 14, 8:800-81.

Mohammed, OB, Omar, OI, Elamin, EA, Bushara, HO, Omer, SA, Alagaili, AN, 2019: Prevalence of *Toxoplasma gondii* in household and stray cats of Riyadh, Saudi Arabia. *Vet. Ital.* 55, 3:241-5.

Montoya, JG, 2002: Laboratory diagnosis of *Toxoplasma gondii* infection and toxoplasmosis. *J. Infect. Dis.* 185, 1:S73-82.

Moussa, S, Al-Bluwe, AJ, Albalawi, GA, Alghafees, GA, Alharbi, R, et al, 2015: Awareness and risk behaviors of toxoplasmosis among Hail population, Kingdom of Saudi Arabia. *Inter. J. Sci. Res.* 6, 4:830-40.

Morsy, TA, El Dasouki, IT, 1974: A case of toxoplasmosis manifesting as a febrile illness in-

Saudi Arabia. *J. Pakis. Med. Ass. (Central)* 24, 12:289-91.

Morsy, TA, Sabry, AA, Habib, KSM, Arafa, MAS, El Bahrawy AFA, 1994: Antibodies against *Toxoplasma* in commensal rodents trapped in Riyadh Region, Saudi Arabia. *J. Egypt. Soc. Parasitol.* 24, 2:279-84.

Morsy, TA, Sabry, AH, Habib, KS, Arafa, M A, El-Bahrawy AF, Al-Dakhel MM, 2001: Antibodies against *Toxoplasma* in commensal rodents trapped in Riyadh Region, Saudi Arabia. *J. Egypt. Soc. Parasitol.* 24: 279-84.

Morsy, TA, Hussein, HE, Morsy, ATA, 2022: TORCH infections, pathogenicity & mortality assessments. *JESP* 52, 1:53-70.

Rostami, A, Riahi, SM, Gamble, HR, Fakhri, Y, Shiadeh, MN, et al, 2022: Global prevalence of latent toxoplasmosis in pregnant women: A systematic review and meta-analysis. *Clin. Microbiol. Infect.* 26:673-83

Sarwat, MA, Ahmed, AB, Zamzami, OM, Fawzy, AFA, Morsy, TA, 1993: *Toxoplasma gondii* in Saudi blood donors: A serological study using 3 tests. *J. Egypt. Soc. Parasitol.* 23, 3: 751-7.

Shoura, MI, Morsy, TA, El-Dasougi, J, 1973: Toxoplasmin skin test in Riyadh Saudi Arabia. *J. Trop. Med. Hyg.* 76:254.

Tabbara, KF, Al-Omar, OM, Tawflk, AI, Al-Shaiinary, F, 1999: Toxoplasmosis in Saudi Arabia. *Saudi Med. J.* 20, 1:46-9.

Wehbe, K, Pencole, L, Lhuire, M, Sibiude, J, Mandelbrot, L, et al, 2022: Hygiene measures as primary prevention of toxoplasmosis during pregnancy: A systematic review. *J. Gynecol. Obstet. Hum. Reprod. Mar;* 51(3):102300. doi: 10.1016/j.jogoh.2021.102300.

WHO, 1991: Adequacy of Sample Size in health Studies, Geneva, Switzerland

Explanation of figure

Fig. 1: Spreading of toxoplasmosis in the Kingdom of Saudi Arabia from 2020-2025.

