ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Relationship Between Latent Toxoplasmosis and Thyroid Hormone Levels in Pregnant Women

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A B S T R A C T:
The protozoan parasite *Toxoplasma gondii* is responsible for the causing diseases, including toxoplasmosis (acute and latent), which is one of the most common. Latent toxoplasmosis is a risk factor that may bring about a thyroid disorder when it is present during pregnancy. The goal of the study was to find out if latent toxoplasmosis has anything to do with thyroid problems in pregnant women. Blood samples were taken from two hundred and fourteen pregnant women hospitalized at various hospitals in the governorate of Erbil. ELISA was used for the detection of *Toxoplasma* IgG antibodies as well as the determination of blood thyroid hormone levels. In all, 23.3 % of specimens were *Toxoplasma gondii* IgG positive. The levels of thyroxin (T4) were shown to be positively correlated with latent toxoplasmosis (p=0.026), but those of thyroid stimulating hormone (TSH) and triiodothyronine (T3) were less than 0.05. The characteristics of abortion (p=0.042), age, city, area, blood type, employment, diet, animal interaction, sickness, and vitamin D level were all determined to have no relation to whether or not a person tested positive for *Toxoplasma* IgG. In conclusion, latent toxoplasmosis significantly affected the rate of T4 secretion during pregnancy. T3 and TSH showed no correlation with latent toxoplasmosis. Women who are pregnant need to know more about toxoplasmosis to avoid its harmful effects. This has a significant impact on the number of abortions that are caused by the parasite at hand.

KEY WORDS: Latent toxoplasmosis, Thyroid hormone, ELISA, pregnancy
DOI: http://dx.doi.org/10.21271/ZJPAS.35.SpD.2
ZJPAS (2023) , 35(SpD);11-17 .

1. INTRODUCTION:

Toxoplasma gondii is an important food borne pathogen because it is an obligate parasite of host cells which causes recurrent toxoplasmosis (Mageed et al., 2014). One-third of the population worldwide has been infected with *T.gondii* (Galvan-Ramarez et al., 2014). The Oocyst stage of this parasite can be more dangerous than the tissue cyst stage. Eighty percent of immunocompromised persons may experience occurrences without any symptoms (Wujcicka et al., 2014). Abortion and severe damage to the developing brain system of the fetus are two of the many negative outcomes associated with toxoplasmosis. Toxoplasmosis is more prevalent during the second and third trimesters of pregnancy, and it is also associated with an increase in inflammatory thyroid conditions (Montazeri et al., 2018).When enters the body during pregnancy, the *Toxoplasma* parasite will move via the blood and lymph to various regions of the body including the thyroid gland. Once there, the parasite will alter the function of the thyroid gland as well as the hormones that are released. The normal operation of physiological systems is contingent upon the presence of thyroid hormones. Because of this, it is extremely important to know that there are many factors, including (environmental factors, genetic factors, or intrinsic ones) that influence levels of (TSH) (Babic Leko et al., 2021). Thyroid follicular cells are stimulated to generate thyroxin (T4) and triiodothyronine (T3) by the thyroid-stimulating hormone (TSH). Thyroxin (T4) accounts for 80% of the inactive portion of thyroid hormone, while

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Article History:
Received: 20/12/2022
Accepted: 18/02/2023
Published:01/11/2023

triiodothyronine (T3) accounts for 20% of the active portion of thyroid hormone. The iodothyronine deiodinases are responsible for the removal of iodine, which is the first step in the process that changes inactive T4 to active T3 (Raghuwanshi et al., 2014). The levels of thyroid-stimulating hormone (TSH) and thyroid hormone can vary by up to 65% from person to person owing to hereditary factors; however, many environmental factors can also influence thyroid function (Babić Leko et al., 2021). According to researches carried out by (Cao et al., 2021; Kanková et al., 2014; Valizadeh et al., 2022), T4 and TSH levels, which are significantly predictive of thyroid function, increase and fluctuate as a result of the presence of *Toxoplasma gondii* during pregnancy. It was shown that pregnant women with latent toxoplasmosis had a slight increase in the thyroid hormones levels in their bodies. In mice affected by toxoplasmosis, there has also been evidence of thyroid dysfunction (Shapira et al., 2012). Individuals who had toxoplasmosis had higher levels of all three hormones (TSH, T3, and T4), based on the results of additional research that was conducted by (Saki et al., 2016). These researchers found that healthy controls had lower amounts of each hormone (Wiersinga, 2019).

2. MATERIALS AND METHODS

The current study was performed at Koya University's science and health research center (SHRC) between September 1, 2021, and July 1, 2022.

2.1. Study design

The design of the investigational research is a series of processes that are classified into four categories. One ofthese groups is the collection of blood samples in pregnant women, which is two hundred fourteen samples of blood collected from pregnant women. Testing employing (ELISA) technology was used in tests of the immunological parameter to identify *Toxoplasma* IgG. And tests of biochemical are performed to determine the number of thyroid hormone levels in the body.

2.2. Study participants

A population of the study consisted of 214 pregnant women aged between (18-45) year's old attending four hospitals in Erbil governorate. A questionnaire was designed to collect demographic information including: age, city, area, blood type, employment, diet, animal interaction, sickness, and vitamin D level from the study participants.

2.3. Sample collection

During the second and third trimesters of their pregnancies, 214 pregnant women were taken to the Public Hospital in Erbil and Hospitals in Koya, during 1/7/ 2021 to 1/1/ 2022 had an entire of 6 ml of whole blood collected from them using the standard venipuncture method. This included women who were in the control group as well as those who were in the patient group. After separating the serum from the whole blood samples by centrifuging them at three thousands r/min for 10 minutes, the serum was placed in sterile tubes, where they were aliquoted and frozen at -80 degrees Celsius until used.

2.4.diagnosis Methods

2.4.1 Detection of IgG antibody against *Toxoplasma gondii*

The indirect ELISA approach was used, and *Toxoplasma*-IgG 96 well plates that had been coated with *Toxoplasma* antigen were included in the analysis were utilized as the testing platform.

2.4.2 Detection of biochemical parameter

Sandwich enzyme-linked immunosorbent assay is often applied for thyroid stimulating hormone (TSH), whereas competitive ELISA is utilized for screening for (T4 and T3). These examinations were carried out on a total of ninety samples of *T. gondii*-IgG, of which 50 were found to be positive and 40 were found to be negative.

2.5. Statistical Analysis

Using Graph Pad prism, the concentration of each ELISA test was estimated (Version8.0.2). Moreover, the application SPSS (kind 26, Inc., Chicago, Illinois, United States) was employed to evaluate the data and the Chi-square test was applied to compare the nominal values of the negative and positive groups of *T.gondii* IgG. In addition, the t-test was used to compare the means of continuous data.

Aimed at the goal of determining the risk factors of *T. gondii* infection in pregnant women, binary logistic regression analysis was utilized, and the association between serological parameters and *T. gondii* IgG was determined by using Pearson's correlation coefficient. By evaluating the ROC curve, Results from serological tests were analyzed for determining specificity and sensitivity.

3. RESULTS

Overall (23.36%) of all blood samples analyzed from pregnant women were positive for *T. gondii* IgG, while (76.63%) of samples were seronegative of *T. gondii* IgG. 47.70% of samples were taken from the second trimester and 52.3% were taken from the 3rd trimester.

Using the chi-square test, results showed that there were no statistically significant differences between the *T.gondii* IgG seropositive and seronegative groups about the following parameters: trimester, age, city, location, blood group, employment, dietary habits, animal contact, race, disease, and vitamins, except for the criterion of abortion (p = 0.040), none of the characteristics were significant. According to the findings, pregnant women who are infected with toxoplasmosis are at a higher risk of having an abortion than pregnant women without the infection (OR= 1.0, p = 0.0310). Even though blood groups A positive and O positive were extra numerous than others in seropositive samples, these differences were not statistically significant. Regarding the animal contact trait, the fact that 66.0% of patients with toxoplasmosis had no animal interaction is statistically insignificant. Using the Independent T-test, the mean difference in blood thyroid hormone levels between confirmed infected pregnant women with toxoplasmosis and healthy controls was calculated. The average mean of TSH, T3, and T4 levels of patient groups, plus standard deviation, were 2.79±1.805, 2,13±0.629, and 13.03±3.35 respectively, which were statically no-significant(Figure1).

The personal correlation was used to investigate and examine the connection between toxoplasmosis and thyroid hormones. In the situation where *Toxoplasma*-IgG were positive for the patient, the p-values for TSH and T3 were not significant. (0.60 And 0.68) respectively, but the p-value for T4 (0.02) was significant.

The examination of ROC curves provided a detailed look into the disparities that were discovered between thyroid hormones. The AUC value for T4 is the highest (0.60), and it has a sensitivity of 56% while maintaining a specificity of 32%. In addition, the area under the curve (AUC) for TSH was 0.46, while the AUC for T3 was 0.51 (Figure 3).

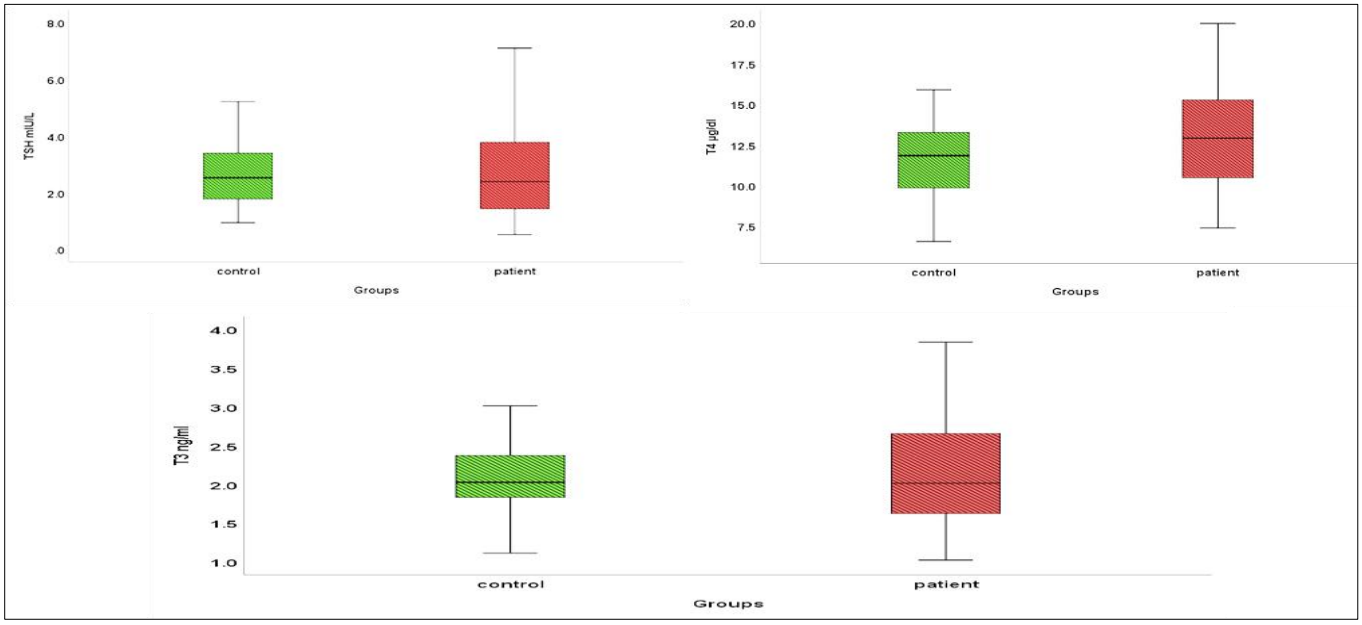

Figure 1: Box plots illustrating the differences in the distributions of blood TSH, T3, and T4 levels between patient groups and control groups

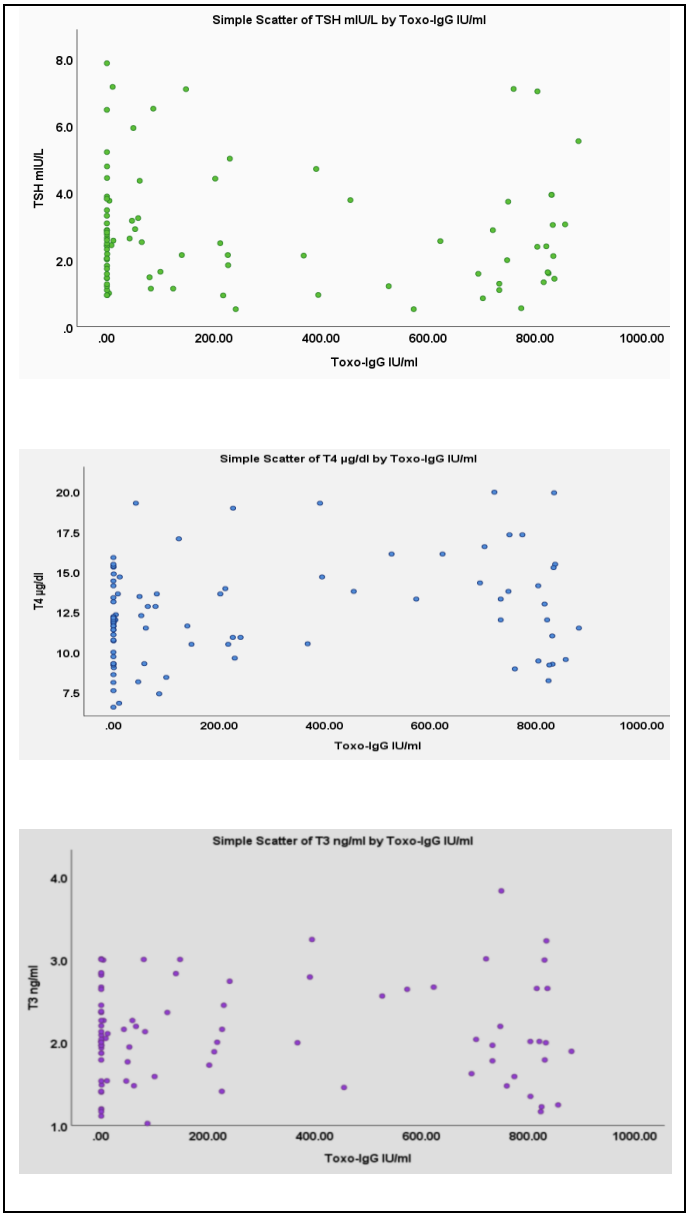

Figure 2: The relationship that exists between *T.gondii* IgG and thyroid hormones (TSH, T4, and T3)

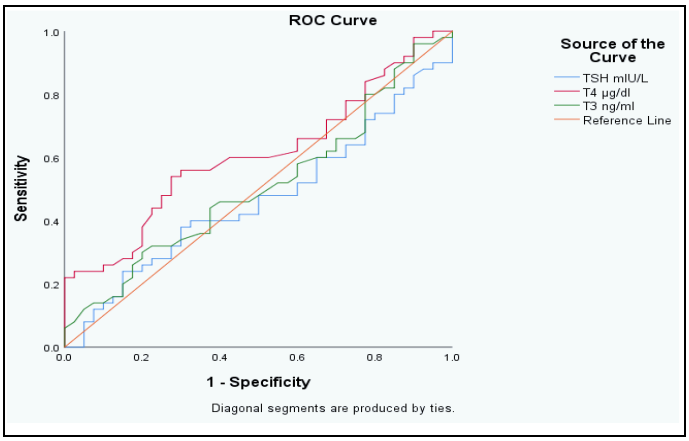

Figure 3: ROC Curve of TSH, T3, and T4 with Specificity and Sensitivity

4. DISCUSSION

The estimation of *T. gondii* seropositivity in pregnant women raises the risk of infection in both the fetus and the infant, as well as the risk of reactivation of infection in people with weakened immune systems. Toxoplasmosis is more prevalent in other countries, such as Jordan has a prevalence of 47.10%, Iran has a prevalence of 75.70%, Yemen has a prevalence of 45.40%, Malaysia has a prevalence of 13%, and Brazil has a prevalence of 24.1% (Ait Hamou et al., 2021; Gelaye et al., 2015). The prevalence of toxoplasmosis was found to be 12.3% in Iraq, which is lower than the reported prevalence in those other countries (Barzinji, 2021). There was a wide range of variation in the frequencies of *T.gondii* seropositivity because of the differences in the geographical distribution of the parasite, the climatic conditions, and the eating habits of the participants (Odeniran et al., 2020; Tarekegn et al., 2020). In addition, the genetic history of both the parasite and the host, as well as the kind of immune response that is generated by the parasite, have a role in the transmission of the infection (Bamba et al., 2017; Negero et al., 2017). Concerning the age group component, the findings of research by Laboudi (Laboudi et al., 2021) were not consistent with our findings. It was shown that the different age groups as well as the seropositivity of *T.gondii* in pregnant women were statistically significant (p = 0.027). (Dubey et al., 2012) found that there is no significant link between the presence of *T.gondii* antibodies and age groups at this stage. This conclusion is in line with our findings. The lack of a significant correlation between age and *T. gondii* infection is probably attributable to the fact that the current study only included a small number of pregnant women. The results of the study conducted by (Barzinji, 2021) are in agreement with our findings this is consistent with our study findings in the blood groups, whereby although blood type (O) had a higher prevalence of *Toxoplasma*-IgG seropositive samples (42% of total samples), these results were not statistically significant (p>0.05). Concerning the nature of patients' interactions with animals, 66% of seropositive patients had no contact with animals, although this finding was statistically insignificant. There were other reports of non-significant *T.gondii* seropositivity with animal interaction (Amin and Merdaw, 2021). On

the other hand, (El-Shqanqery et al., 2017; Negero et al., 2017) found a significant relationship between *Toxoplasma* seropositivity and contact with cat because cat feces play a significant role in the transmission of *T.gondii* due to their high Oocyst load. However, other researches (Agmas et al., 2015; Awoke et al., 2015) have demonstrated a substantial correlation between owing cats and *T. gondii* seropositivity. The results indicated that 56% of pregnant women who are *Toxoplasma*-seropositive consume vegetables; however, these results were not statistically significant. Raw meat and vegetable diet was not associated with toxoplasmosis seroprevalence, according to (Bamba et al., 2017; Negero et al., 2017). In the same setting, substantial associations were discovered between abortion history and *Toxoplasma*-IgG positive. This is consistent with (Kalantari et al., 2021) studies that indicated a substantial association between frequent abortions in pregnant women and toxoplasmosis. However, contrary to the findings of (Laboudi et al., 2021), IgG seropositivity was greater among pregnant women with a history of abortion. As connected to the risk factor of Vitamin D insufficiency and seropositivity to *T.gondii*, our results were consistent with those of (Ghaffarifar et al., 2010) in that there was no significant difference between verified pregnant women with *Toxoplasma* and controls in terms of vitamin D deficit. (Rasheed et al., 2021) agreed with our findings; nevertheless, their data revealed that there was no significant link between the risk factor of vitamin D insufficiency and *T.gondii* IgG seropositivity in Saudi pregnant women. In addition, (Soltani et al., 2022) found that 66.6% of infected people living in urban areas tested positive for *T. gondii* IgG, while 72.7% of people living in rural areas did so. This difference was statistically significant, and it was attributed to the risk factor of coming into contact with oocysts at their places of employment. According to our study latent bradyzoites in the tissues cyst might change to tachyzoites and enter blood circulation blood, and reach the organs including thyroid glands through cysts development, which would then deregulate T4 and T3 release. There haven't been a lot of studies done on the link between having a *T. gondii* infection and having a thyroid issue. The results of a study that was conducted by (Alvarado-Esquivel et al., 2019; Valizadeh et al., 2022), It included participants who had been diagnosed with thyroid problems and tested positive for *Toxoplasma* IgG indicated that there were no statistically significant differences detected among *T. gondii* IgG positivity and thyroid disorders. In addition, the findings of (Dubey et al., 2014; Kanková et al., 2014) were consistent with our findings and demonstrated that there is a significant difference between latent toxoplasmosis and thyroid dysfunction in pregnancy, with a p-value of less than 0.05. Differences in the findings might be due to a variety of factors, such as the quantity of the samples, the techniques used in the laboratory, and the study site, which comprised *Toxoplasma*-infected and healthy controls.

5. CONCLUSIONS

During pregnancy, latent toxoplasmosis has a great effect on the hormone level of (T4) hormone. Except for abortion, an adverse link was found between latent toxoplasmosis and the demographic features of the patient. Most women who were pregnant and had *T. gondii* had more than one abortion.

Acknowledgements

I would like to acknowledge and give my warmest thanks to my supervisor Dr. Sarmad who made this work possible. I would also like to thank Ms. Alla k. Mohammed for helping me throughout my project.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Agmas, B., Tesfaye, R., & Koye, D. N. (2015). Seroprevalence of Toxoplasma gondii infection and associated risk factors among pregnant women in Debre Tabor, Northwest Ethiopia. *BMC Research Notes*, *8*(1), 107. https://doi.org/10.1186/s13104-015-1083-2

Ait Hamou, S., Lamhamdi, B., Hayah, I., Belbacha, I., Sadak, A., & Laboudi, M. (2021). The Level of Knowledge about Toxoplasmosis among University Students in Rabat in Morocco. *Journal of Parasitology Research, 2021*,p 1-7. https://doi.org/10.1155/2021/5553977

Alvarado-Esquivel, C., Ramos-Nevarez, A., Guido-Arreola, C. A., Cerrillo-Soto, S. M., Pérez-Álamos, A. R., Estrada-Martínez, S., Gutierrez-Martinez, V. D., Sifuentes-Alvarez, A., Ramírez-Valles, E. G., and Contreras-Cisneros, E. (2019). Association

between Toxoplasma gondii infection and thyroid dysfunction: A case-control seroprevalence study. *BMC Infectious Diseases*, *19*(1), 826. https://doi.org/10.1186/s12879-019-4450-0

Amin, S. S., and Merdaw, M. A. (2021). Relationship Between Toxoplasma Gondii Antibodies and Blood Group Inuniversity students. *-NATURAL VOLATILES & ESSENTIAL OILS Journal*, 3804–3811. https://www.nveo.org/index.php/journal/article/view/974

Awoke, K., Nibret, E., and Munshea, A. (2015). Sero-prevalence and associated risk factors of Toxoplasma gondii infection among pregnant women attending antenatal care at Felege Hiwot Referral Hospital, northwest Ethiopia. *Asian Pacific Journal of Tropical Medicine*, *8*(7), 549–554. https://doi.org/10.1016/j.apjtm.2015.06.014

Babic Leko, M., Gunjača, I., Pleić, N., and Zemunik, T. (2021). Environmental Factors Affecting Thyroid-Stimulating Hormone and Thyroid Hormone Levels. *International Journal of Molecular Sciences*, *22*(12), Article 12. https://doi.org/10.3390/ijms22126521

Bamba, S., Cissé, M., Sangaré, I., Zida, A., Ouattara, S., and Guiguemdé, R. T. (2017). Seroprevalence and risk factors of Toxoplasma gondii infection in pregnant women from Bobo Dioulasso, Burkina Faso. *BMC Infectious Diseases*, *17*(1), 482. https://doi.org/10.1186/s12879-017-2583-6

Barzinji, A. (2021). Seroprevalence and risk factors of toxoplasmosis among University of Kirkuk female students. *Annals of Parasitology*, *67*, 175–186. https://doi.org/10.17420/ap6702.327

Cao, J.-M., Wang, N., Hou, S.-Y., Qi, X., and Xiong, W. (2021). Epigenetics effect on pathogenesis of thyroid-associated ophthalmopathy. *International Journal of Ophthalmology*, *14*(9), 1441–1448. https://doi.org/10.18240/ijo.2021.09.22

Dubey, J. P., Lago, E. G., Gennari, S. M., Su, C., and Jones, J. L. (2012). Toxoplasmosis in humans and animals in Brazil: High prevalence, high burden of disease, and epidemiology†. *Parasitology*, *139*(11), 1375–1424. https://doi.org/10.1017/S0031182012000765

Dubey, J. P., Newell, T. K., Verma, S. K., Calero-Bernal, R., and Stevens, E. L. (2014). Toxoplasma gondii infection in llama (Llama glama): Acute visceral disseminated lesions, diagnosis, and development of tissue cysts. *The Journal of Parasitology*, *100*(3), 288–294. https://doi.org/10.1645/13-427.1

El-Shqanqery, H. E., Ibrahim, H. M., Mohamed, A. H., and El-Sharaawy, A. A. (2017). SEROPREVALENCE OF TOXOPLASMA GONDII INFECTION AND ASSOCIATED RISK FACTORS AMONG ASYMPTOMATIC PREGNANT FEMALES IN EGYPT. *Journal of the Egyptian Society of Parasitology*, *47*(1), 93–100. https://doi.org/10.21608/jesp.2017.77989

Galvann-Ramarez, M. de la L., GutiÃ©rrez-Maldonado, A. F., Verduzco-Grijalva, F., and JimÃ©nez, J. M. D. (2014). The role of hormones on Toxoplasma gondii infection: A systematic review. *Frontiers in Microbiology*, *5*. https://doi.org/10.3389/fmicb.2014.00503

Gelaye, W., Kebede, T., and Hailu, A. (2015). High prevalence of anti-toxoplasma antibodies and absence of Toxoplasma gondii infection risk factors among pregnant women attending routine antenatal care in two Hospitals of Addis Ababa, Ethiopia. *International Journal of Infectious Diseases: IJID: Official Publication of the International Society for Infectious Diseases*, *34*, 41–45. https://doi.org/10.1016/j.ijid.2015.03.005

Ghaffarifar, F., Abdolah Pour, M., Sharifi, Z., Dalimi Asl, A., and Al-Kawaz, E. (2010). The Effect of Vitamin D3 Alone and Mixed With IFN-γ on Tachyzoites of Toxoplasma gondii (RH Strain) Proliferation and Nitric Oxide (NO) Production in Infected Macrophages of BALB/C Mice. *Iranian Journal of Parasitology*, *5*(3), 48–56. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3279842/

Kalantari, N., Gorgani-Firouzjaee, T., Moulana, Z., Chehrazi, M., and Ghaffari, S. (2021). Toxoplasma gondii infection and spontaneous abortion: A systematic review and meta-analysis. *Microbial Pathogenesis*, *158*, P 398-401. https://doi.org/10.1016/j.micpath.2021.105070

Kanková, S., Flegr, J., Calda, P., Springer, D., and Potlukova Horakova, E. (2014). Effects of Latent Toxoplasmosis on Autoimmune Thyroid Diseases in Pregnancy. *PLoS ONE*, *9*, e110878. https://doi.org/10.1371/journal.pone.0110878

Laboudi, M., Taghy, Z., Duieb, O., Peyron, F., and Sadak, A. (2021). Toxoplasma gondii seroprevalence among pregnant women in Rabat, Morocco. *Tropical Medicine and Health*, *49*(1), 21. https://doi.org/10.1186/s41182-021-00311-5

Mageed, S. N., Cunningham, F., Hung, A. W., Silvestre, H. L., Wen, S., Blundell, T. L., Abell, C., andMcConkey, G. A. (2014). Pantothenic acid biosynthesis in the parasite Toxoplasma gondii: A target for chemotherapy. *Antimicrobial Agents and Chemotherapy*, *58*(11), 6345–6353.

Montazeri, M., Mehrzadi, S., Sharif, M., Sarvi, S., Tanzifi, A., Aghayan, S. A., and Daryani, A. (2018). Drug Resistance in Toxoplasma gondii. *Frontiers in Microbiology*, *9*. https://doi.org/10.3389/fmicb.2018.02587

Negero, J., Yohannes, M., Woldemichael, K., and Tegegne, D. (2017). Seroprevalence and potential risk factors of T. gondii infection in pregnant women attending antenatal care at Bonga Hospital, Southwestern Ethiopia. *International Journal of Infectious Diseases: IJID: Official Publication of the International Society for Infectious Diseases*, *57*, 44–49. https://doi.org/10.1016/j.ijid.2017.01.013

Odeniran, P. O., Omolabi, K. F., and Ademola, I. O. (2020). Risk factors associated with seropositivity for Toxoplasma gondii in population-based studies among immunocompromised patients (pregnant women, HIV patients and children) in West African countries, Cameroon and Gabon: A meta-analysis. *Acta Tropica*, *209*, 33-37. https://doi.org/10.1016/j.actatropica.2020.105544

Raghuwanshi, P. K., Rajput, D., Ratre, B., Jain, R., Patel, N., and Jain, S. (2014). *Evaluation of thyroid dysfunction among type 2 diabetic patients*. https://doi.org/10.3126/AJMS.V6I3.10814

Rasheed, Z., Shariq, A., AlQefari, G. B., Alwahbi, G. S., Aljuaythin, A. I., Alsuhaibani, F. S., Alotaibi, D. F., Aljohani, S. S., Alghasham, R., Alsaeed, T., Alharbi, N. A., Rugaie, O. A., Abdulmonem, W. A., and Sharaf, O. F. (2021). Toxoplasmosis in immunocompetent Saudi women: Correlation with vitamin D. *Women's Health*, *17*, 95-101. https://doi.org/10.1177/17455065211043844

Saki, J., Shafieenia, S., and Foroutan-Rad, M. (2016). Seroprevalence of toxoplasmosis in diabetic pregnant women in southwestern of Iran. *Journal of Parasitic Diseases*, *40*(4), 1586–1589. https://doi.org/10.1007/s12639-015-0735-4

Shapira, Y., Agmon-Levin, N., Selmi, C., Petríková, J., Barzilai, O., Ram, M., Bizzaro, N., Valentini, G., Matucci-Cerinic, M., Anaya, J.-M., Katz, B. P., and Shoenfeld, Y. (2012). Prevalence of anti-Toxoplasma antibodies in patients with autoimmune diseases. *Journal of Autoimmunity*, *39*(1–2), 112–116. https://doi.org/10.1016/j.jaut.2012.01.001

Soltani, S., Tavakoli, S., Sabaghan, M., Kahvaz, M. S., Pashmforosh, M., and Foroutan, M. (2022). The Seroprevalence of Toxoplasma gondii and Associated Risk Factors Among Type 1 Diabetes Mellitus Patients in Abadan, Southwest Iran. *Journal of Archives in Military Medicine*, *10*(1), Article 1. https://doi.org/10.5812/jamm.117842

Tarekegn, Z. S., Dejene, H., Addisu, A., and Dagnachew, S. (2020). Potential risk factors associated with seropositivity for Toxoplasma gondii among pregnant women and HIV infected individuals in Ethiopia: A systematic review and meta-analysis. *PLOS Neglected Tropical Diseases*, *14*(12), p .1-19. https://doi.org/10.1371/journal.pntd.0008944

Valizadeh, G., Голамреза, B., Khamseh, M.-E., Мохаммад-Эбрахим, X., Kashaniyan, M., Марьям, K., Rafiei-Sefiddashti, R., Рахеле, P.-C., Hadighi, R., and Рамтин, X. (2022). Role of Toxoplasma gondii in Thyroiditis of Pregnant Women. *Russian Journal of Infection and Immunity*. https://doi.org/10.15789/2220-7619-ROT-1772

Wiersinga, W. M. (2019). Graves' Disease: Can It Be Cured? *Endocrinology and Metabolism (Seoul, Korea)*, *34*(1), 29–38. https://doi.org/10.3803/EnM.2019.34.1.29

Wujcicka, W., Wilczyński, J., and Nowakowska, D. (2014). Do the placental barrier, parasite genotype and Toll-like receptor polymorphisms contribute to the course of primary infection with various Toxoplasma gondii genotypes in pregnant women? *European Journal of Clinical Microbiology & Infectious Diseases*, *33*(5), 703–709. https://doi.org/10.1007/s10096-013-2017-3