Al-Shatrah Veterinary and Biological Sciences Journal
ISSN (Print): 2958-8952
Volume 2, Issue 2
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Seroprevalence and hematological alterations associated with toxoplasmosis in women of reproductive age in Kirkuk province, Iraq

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Abstract

Toxoplasma gondii infection poses a significant public health risk in women of childbearing age because of the risk of unfavorable pregnancy outcome and possible hematological changes. The purpose of the study was to evaluate the seroprevalence of T. gondii and determine the modifications of hematological and iron status in pregnant and non-pregnant women in Kirkuk Province, Iraq. This cross-sectional study was conducted between January and late June 2025and included 152 women (106 pregnant and 46 non-pregnants). Blood samples were examined using anti-Toxoplasma IgG/IgM ELISA, complete blood count (CBC) and iron biomarkers (serum iron, TIBC, transferrin, and ferritin). The levels of seropositivity higher in non-pregnant women (IgG: 41.3%, IgM: 34.8%) compared to pregnant women (IgG: 20.0%, IgM: 21.0%). Hematological anomalies, such as microcytic anemia, leukocytosis, and thrombocytopenia were also observed in seropositive women. The patterns of iron deficiency particularly evident among Igm-positive cases. These outcomes are significant to the necessity to combine serological and hematological screening into the prenatal care plan to alleviate maternal and fetal complications.

Keywords: Toxoplasmosis, hematology, iron status, IgG, IgM, pregnancy.

الملخص

تُعد عدوى المقوسة الكوندية **(Toxoplasma gondii)** خطراً مهماً على الصحة العامة لدى النساء في سن الإنجاب، نظرًا لما قد تسببه من مضاعفات سلبية على الحمل وما قد يرافقها من تغيرات دموية محتملة. هدفت هذه الدراسة إلى تقييم الانتشار المصلي لطفيلي **T. gondii** وتحديد التغيرات في المؤشرات الدموية وحالة الحديد لدى النساء الحوامل وغير الحوامل في محافظة كركوك، العراق.

أُجريت الدراسة بتصميم مقطعي خلال الفترة من يناير إلى يونيو 2025، وشملت 152 امرأة (106 حوامل و46 غير حامل). تم فحص عينات الدم باستخدام اختبار الإليزا **(ELISA)** للكشف عن الأجسام المضادة **IgG** و **IgM**الخاصة بداء المقوسات، بالإضافة إلى إجراء فحص صورة الدم الكاملة **(CBC)** وقياس مؤشرات الحديد الحيوية) حديد المصل، السعة الكلية لارتباط الحديد**TIBC** ، الترانسفيرين، ومخزون الحديد.**(**

أظهرت النتائج أن معدلات الإيجابية المصلية كانت أعلى لدى النساء غير الحوامل **(IgG** بنسبة 41.3% و **IgM**بنسبة 34.8 **(%**مقارنة بالنساء الحوامل **(IgG** بنسبة 20.0% و **IgM**بنسبة 21.0 **.(%**كما لوحظت اضطرابات دموية لدى النساء ذوات النتائج المصلية الإيجابية، شملت فقر الدم من نوع فقر الدم صغير الكريات ، وارتفاع كريات الدم البيضاء ، ونقص الصفائح الدموية. وكانت أنماط نقص الحديد أكثر وضوحًا لدى الحالات الإيجابية لـ**IgM.**

تؤكد هذه النتائج أهمية دمج الفحوصات المصلية والدموية ضمن برامج الرعاية السابقة للولادة، للحد من المضاعفات المحتملة على الأم والجنين.

الكلمات المفتاحية: داء المقوسات، أمراض الدم، حالة الحديد، IgG، IgM، **الحمل**.

Introduction

Toxoplasma gondii is a ubiquitous, obligatory intracellular protozoan parasite and infects nearly one-third of global population. (Montoya and Liesenfeld, 2004). The parasite has a complex life cycle where felids are definitive hosts and the other warm-blooded animals, including humans, are the intermediate hosts. Human infection is normally contracted through consuming oocysts in contaminated food, water or soil, or by consuming undercooked meat containing tissue cysts (Robert-Gangneux & Dardé, 2012). Toxoplasmosis poses a serious threat during pregnancy, as primary maternal infection can lead to vertical transmission as most of the infections are asymptomatic in immunocompromised persons. Primary maternal infection lead to vertical transmission, resulting in congenital toxoplasmosis intracranial calcifications, or

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even fetal death (Dubey, 2020; Bobić et al., 2019). Women in childbearing age, therefore, constitute a demographic at a high risk of toxoplasmosis, especially in regions with considerable seroprevalence. Even in Kirkuk Province, seroprevalence levels showed a high rate among women, but the overall clinical outcomes, particularly the hematological changes, are under-researched (Salman et al., 2021).Toxoplasmosis has been associated with multiple hematological abnormalities, which can be detected using complete blood count (CBC) tests. There are decreased hemoglobin, disturbed red blood cell indices (MCV, MCH, MCHC), leukocytosis, neutrophilia, and thrombocytopenia all of which may cause active infection (Daryani et al., 2017; ElMahallawy et al., 2014). Such alterations are especially worrying during pregnancy, a physiologically immunomodulated state characterized by expanded plasma volume, making it prone to hematologic stress. The toxoplasmosis is usually treated using pyrimethamine, sulfadiazine and folinic acid, especially in acute and congenital toxoplasmosis. Nonetheless, these medications do not have no negative consequences. A folic acid antagonist, pyrimethamine may inhibit the process of DNA synthesis, resulting in bone marrow suppression which can be expressed in the form of anemia, leukopenia, and thrombocytopenia among pregnant or immunocompromised patients (Gavrilov et al., 2022). Consequently, hematologic surveillance is advised in the course of treatment to prevent iatrogenic conditions, including pancytopenia or neutropenic infections (Yera et al., 2018).

In addition to hematologic effects, T. gondii infection can also impair iron homeostasis, which is a vital physiologic process among women in the reproductive age bracket as a result of menstruation and increased nutritional demands. Serum iron reflects the amount of circulating iron bound primary to transferrin are the important biomarkers that are used to determine iron status. Serum iron indicates the ratio of the iron bound to transferrin in blood whereas TIBC indicates the ability of the blood to bind iron. According to the emerging data, T. gondii uses host iron to further its intracellular multiplication (Abbaspour et al., 2014; Ganz and Nemeth, 2015).Transferrin is a liver-produced glycoprotein and the main iron transport protein; the transferrin concentration is regulated by the iron levels and the presence of inflammatory cues (Abbaspour et al., 2014; Ganz and Nemeth, 2015). This intestinal iron consumption can cause distorted iron levels and result in functional iron deficiency or anemia, especially in pregnant women who are infected (de Sousa et al., 2021; Antunes et al., 2022). Besides, the host immune phenotype, characterized by release of cytokines and the synthesis of acute-phase iron-binding proteins such as hepcidin, also interferes with iron availability by lowering intestinal iron absorption and enhancing iron sequestrition by macrophages (Ganz & Nemeth, 2015).

Serological testing especially (ELISA) is gold standard in the diagnosis of toxoplasmosis in clinical practice with IgM and IgG respectively denoting recent and

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previous exposure respectively. High specificity of the PCR-based method of detecting parasite DNA makes it useful, its roution use is limited by cost , infrastructure requirements and invasiveness (Robert-Gangneux and Dardé, 2012). To provide a practical and non-invasive method of identifying infections and their presence in the system, serological testing should be combined with markers of the hematologic and iron status in areas with limited access to molecular diagnostics, like Kirkuk Province.

To conclude, the assessment of hematological parameters, iron biomarkers in women with toxoplasmosis provides a good clue to the interaction between parasitic infection, host response, and physiological stress during this period of pregnancy. These tests are essential to the prompt identification of the disease, proper treatment planning, and reduction of risks of adverse maternal and fetal consequences.

Materials and Methods:

Ethical Approval:

The present study was conducted following the international and national ethical standards. Ethical approval was obtained from the Community of ethical board in Kirkuk Health Directorate (Approval No: 53 in 22 August 2025)– Republic of Iraq

1. Study Design and Setting

The cross-sectional study was carried out in the Kirkuk Province, in Northern Iraq, between January and 30 th of July, 2025. The objective of the study was to determine the seroprevalence of *Toxoplasma gondii* and its effect of the amoeba on the hematology of a group of women of reproductive age The number of hospitals such as Genernal Hopital in Kirkuk , The Azaddi Hospital and The private labrotary of Ibn Al-Nafes, that were in three areas and a few privatized gynecological clinics that included urban and rural areas were sampled.

2. Study Population

The study involved 152 women (106 pregnant women receiving routine antenatal care (referred to as the test group),46 non-pregnant women with the history of miscarriage or congenital fetal anomalies (referred to as a case control roup) gave written informed consent. Women who had known hematological disease, autoimmune disease or were taking antibiotics were excluded.

3. Data Collection: Data were gathered by means of a structured questionnaire and included:

(Age, Residency (urban/rural), Reproductive and obstetrical history).Questionnaire data were coded and kept in a laboratory database, which was confidential.

4. Blood Sample Collection

Each participant was sampled using 5 ml venous blood stander using standard aseptic venipuncture techniquestechniques. Two blood samples were collected One in EDTA tube to perform complete blood count (CBC).One in plain tube to perform serum separation. The separation of serum samples was done through centrifugation at 3000 rpm in 10 minutes and kept at 20 c until the expermeint was conducted (Kodym et al., 2007).

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5. Hematological Analysis

CBC was preformed on a Sysmex XN-350 hematology analyzer (Japan) including the following measurements:

Red blood cell indices: MCV, MCH, MCHC, PCV.White blood cell (WBC) count and differential neutrophils, lymphocytes, monocytes, eosinophils), Platelet count (PLT).

6. Iron Profile Analysis

Iron metabolism was assessed by automated clinical chemistry analysis with the DCR automated detector (Netherlands) and ferritin determination. Although other biochemical tests are done by direct spectrophotometry, they are done according to standardized operating procedures and quality assurance. Clotted blood samples were centrifuged to obtain serum at 3000 rpm in 10 minutes. The separated serum was tested on the following parameters, serum iron, total iron binding capacity (TIBC), transferrin, serum ferritin.

6.1 Serum Iron and TIBC

The colorimetric method based on ferrozine was employed in the measurement of both serum iron and TIBC because it is a popular technique due to its sensitivity and specificity. Under this technique, transferrin is dissociated in an acidic solution with serum iron after which the results are reacted with ferrozine to create a violet complex. The photometric absorption is done at 560 nm. In the case of TIBC, the serum is saturated with excessive iron, and the unbound iron is then eliminated; the rest of iron is then determined back with the same ferrozine reaction (Tietz et al., 2006; Burtis et al., 2012).

6.2 Transferrin

The concentration of transferrin was identified by immunoturbidimetric methods, where the transferrin of serum is mixed with the particular anti-transferrin antibodies and the turbidity of the mixture is measured. The turbidity of the solution at a wavelength of 340 nm is directly proportional to the concentration of transferrin. It is a very precise method that can be used on a routine basis in clinical practice (Thomas, 2014).

6.3 Serum Ferritin

The serum ferritin was also analyzed using chemiluminescent microparticle immunoassay (CMIA) or electrochemoluminescense immunoassay (ECLIA) based on the analyzer. These techniques employ ferritin specific monoclonal antibodies coupled with chemiluminescent label. The light intensity released, which is measured by photomultiplier tubes is related to the concentration of ferritin in the sample. This test can be regarded as a sensitive and specific measure of iron stores, especially useful in identifying a case of early iron deficiency or iron overload (Camaschella, 2015; Tietz et al., 2006).

Biochemical analyses were done twice and proper calibration and controls were done to facilitate inter assay and intra assay reliability.

7. Serological Testing

Serum samples were tested for anti-Toxoplasma IgG and IgM antibodies using ELISA kits from DRG International, Germany, based on a sandwich ELISA principle:

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Wells pre-coated with *T. gondii* antigen were incubated with serum samples. HRP-conjugated secondary antibodies were added. Color development was measured at **450 nm** using a microplate reader. Results >1.0 IU/mL were considered **positive**, per manufacturer guidelines.

8. Statistical Analysis

Data were analyzed using **IBM SPSS Statistics Version 26**:

Descriptive statistics summarized demographics and lab findings. Chi-square test compared categorical variables (e.g., seroprevalence by group and age). An independent samples t-test compared CBC parameters between groups. .**p < 0.05** was considered statistically significant.

Table 1. Study Population Characteristics in pregnancy and non-pregnancy

This table presents the age distribution and demographic details of both study groups. The age difference is statistically significant (p = 0.0078).

Group	Mean Age (years)	p-value
Pregnant (n=106)	28.9 ± 6.3	0.0078
Non-Pregnant (n=46)	31.4 ± 6.9	

Group	IgG Positive (%)	IgM Positive (%)	Significance
Pregnant (n=106)	20.0	21.0	Yes
Non-Pregnant (n=46)	41.3	34.8	Yes

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Table 2. Seroprevalence of *Toxoplasma gondii* antibodies, involving both IgM and IgG, throughout the gestational period

Gestational Period	Total	IgM_Positive	IgG_Positive	IgM Rate (%)	IgG Rate (%)	Toxoplasma Rate (%)
First	69.00	22.00	15.00	31.88%	21.74%	44.93%
Second	18.00	2.00	3.00	11.11%	16.67%	16.67%
Third	18.00	4.00	6.00	22.22%	33.33%	33.33%

Seropositivity rates were significantly elevated in the control group, indicating a possible association with previous foetal loss or abnormalities. The table *displays* the number of women screened along with the level of positivity for *Toxoplasma* IgM, IgG, and combined positivity (>0.9 IU/mL) across each gestational period. The Toxoplasma-IgM rate was 31.88% in the sera of women during the first trimester, followed by 22.22% in the third trimester, in contrast to a higher IgG rate of 33.33% in the third trimester and 21.74% in the first trimester, respectively. Overall, women in the second trimester exhibited low levels of both IgM and IgG Toxoplasma antibodies, $P<0.05$

Table 3: IgM Positivity by Age Group

Age Group (years)	IgM Positive (%)
18–25	15.0%
26–35	23.5%
36–45	28.1%

The IgM positive rate increased with age, peaking at 28.1% in the 36–45 age group. There is a statistically significant difference ($P<0.05$) between this rate and the rates of 23.5% for women aged 26 to 35 and 15% for those aged 18 to 25.

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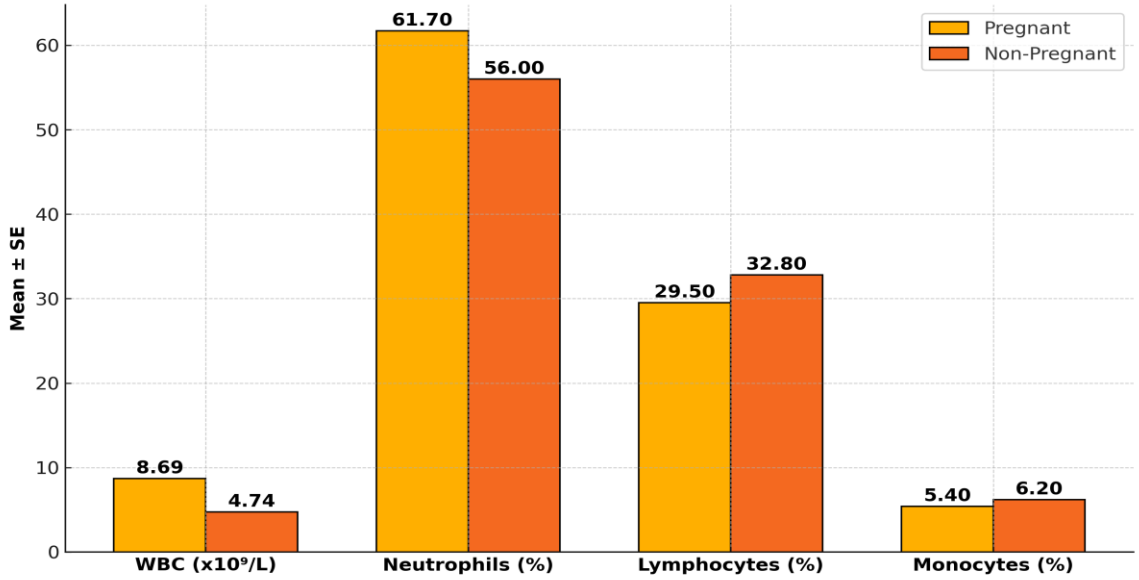
Table 4. Red Blood Cell Indices Comparison

Parameter	Pregnant (mean ± SE)	Non-Pregnant (mean ± SE)	p-value
MCV (fL)	81.03 ± 0.63	86.11 ± 0.59	<0.0001
MCH (pg)	27.75 ± 0.26	29.50 ± 0.39	0.0019
Hb (g/dL)	11.78 ± 0.16	12.34 ± 0.19	NS
PCV (%)	34.97 ± 0.43	36.17 ± 0.52	NS

Significant decreases in mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) were seen in the pregnant group, with a p-value of less than 0.01, in comparison to the non-significant reductions in haemoglobin and peripheral blood volume (PCV).



ıre 1. Comparison of WBC and differential counts between pregnant and non-pregnant won

Figure-1.Comparison of WBC and differential counts between pregnant and non-pregnant women.

Total white blood cell (WBC) counts and leukocyte properties in pregnant and non-pregnant women are shown in Figure 1. The bar chart shows a significant increase in WBC counts (8.69 $\times 10^9$/L) in pregnant individuals compared to non-pregnant controls (4.74 $\times 10^9$/L), indicating leukocytosis during pregnancy due to immunomodulation or infection-related reactions. In addition, pregnant women had greater neutrophil percentages (61.7%) than non-pregnant women (56.0%), indicating increased innate immunological activity. In contrast, the control group had greater

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lymphocyte counts (32.8% vs. 29.5%), probably due to adaptive immune suppression throughout pregnancy to preserve foetal tolerance. Non-pregnant women saw a moderate but substantial increase in monocytes (6.2% vs. 5.4%). These findings emphasise immunological changes throughout pregnancy and the significance of monitoring haematological markers, especially in rubella infected women.

Figure 2: Platelet Count Comparison

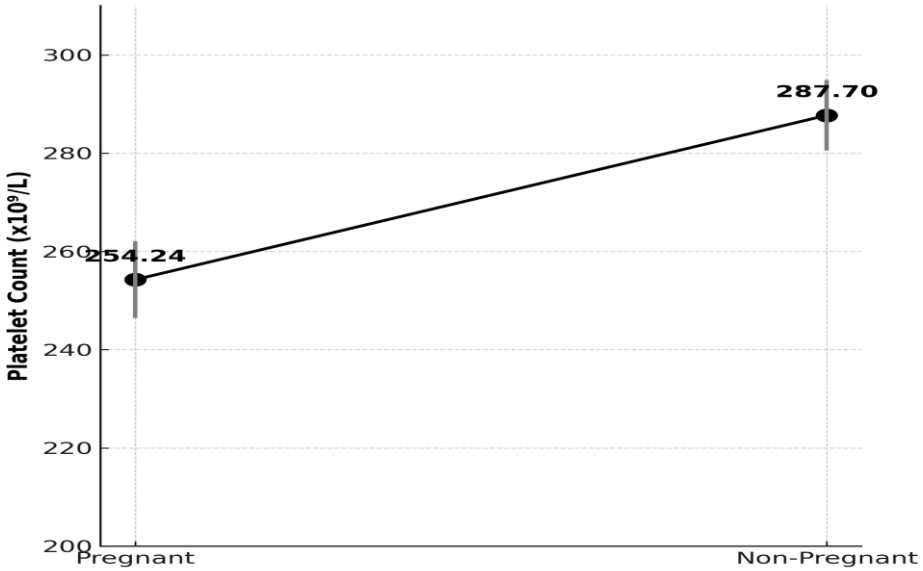

Figure 2 and Table 6 show that the number of the platelets in the pregnant women (254.24 ± 7.82 ×10⁹/L) has significantly decreased compared to the non-pregnants (287.70 ± 7.17 × 10⁹/L) with a p-value of 0.002. This significant thrombocytopenia can be a physiological alteration related to pregnancy perhaps through the hypertrophic plasma volume or underlying inflammatory reactions linked with viral infections like rubella. The decline in the level of the platelets should be an object of concern since it can predispose pregnant women to higher risks of bleeding or reflect minor changes in the hematological homeostasis.

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Table 5. CBC Comparison Between IgM-Positive and IgG-Positive Women

IgM positive women showed higher inflammatory markers; IgG positive women had more stable hematologic profiles.

Parameter	IgM Positive	IgG Positive	p-value
MCV (fL)	82.5 ± 0.6	85.0 ± 0.5	0.002
MCH (pg)	28.1 ± 0.3	29.3 ± 0.4	0.008
WBC ($x10^9$/L)	9.1 ± 0.2	5.1 ± 0.2	<0.0001
Neutrophils (%)	62.4 ± 0.8	57.1 ± 0.6	0.001
Lymphocytes (%)	26.3 ± 0.7	30.9 ± 0.6	0.005
Monocytes (%)	6.2 ± 0.2	6.9 ± 0.2	0.047
Platelets ($x10^9$/L)	252.0 ± 7.5	280.4 ± 6.8	0.003

CBC Trends of Parameters over Gestational Periods:

The three parameters are all contained within or marginally less than reference ranges indicating the slightest hematologic changes occurring during pregnancy.

Figure 3- Red blood cells (RBCs), Packed cell volume(PCV), and hemoglobin (Hb) according to gestational periods

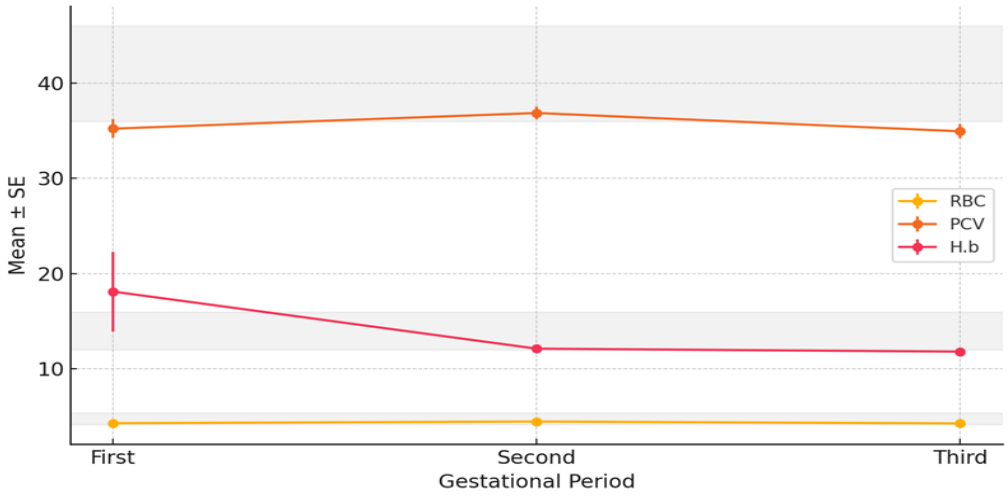

Figure-4. Blood color indices (MCV, MCH, and MCHC) levels cross trimesters.

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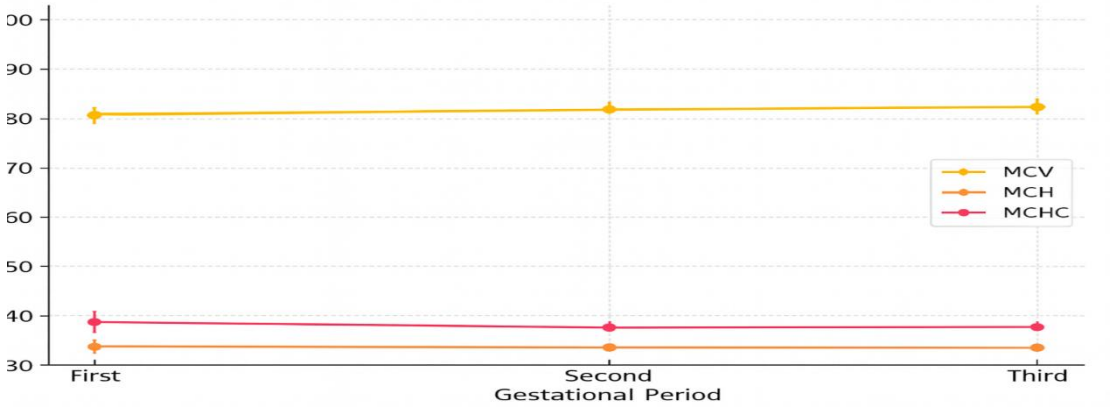

Values appear stable across pregnancy, with MCHC notably elevated in the third trimester.

WBC and Differential Count Analysis by Gestational Period

Table 6: WBC and Differential Counts with Interpretation

Parameter	1st Trimester	2nd Trimester	3rd Trimester	Reference Range	Remarks
WBC ($\times 10^9$/L)	8.96 ± 0.46	9.07 ± 0.51	8.11 ± 0.52	4.0 – 11.0	Within normal range
Neutrophils (%)	61.6 ± 1.37	59.7 ± 2.15	60.7 ± 2.18	40 – 60	Slightly elevated in 1st trimester
Lymphocytes (%)	28.1 ± 1.52	30.4 ± 1.99	29.0 ± 2.03	20 – 40	Stable and within normal range
Monocytes (%)	6.4 ± 0.41	6.1 ± 0.52	6.2 ± 0.50	2 – 8	Normal across all trimesters
Eosinophils (%)	2.65 ± 0.30	3.56 ± 1.05	2.78 ± 0.47	1 – 4	Slight elevation in 2nd trimester
Basophils (%)	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	0 – 1	At upper normal limit in all

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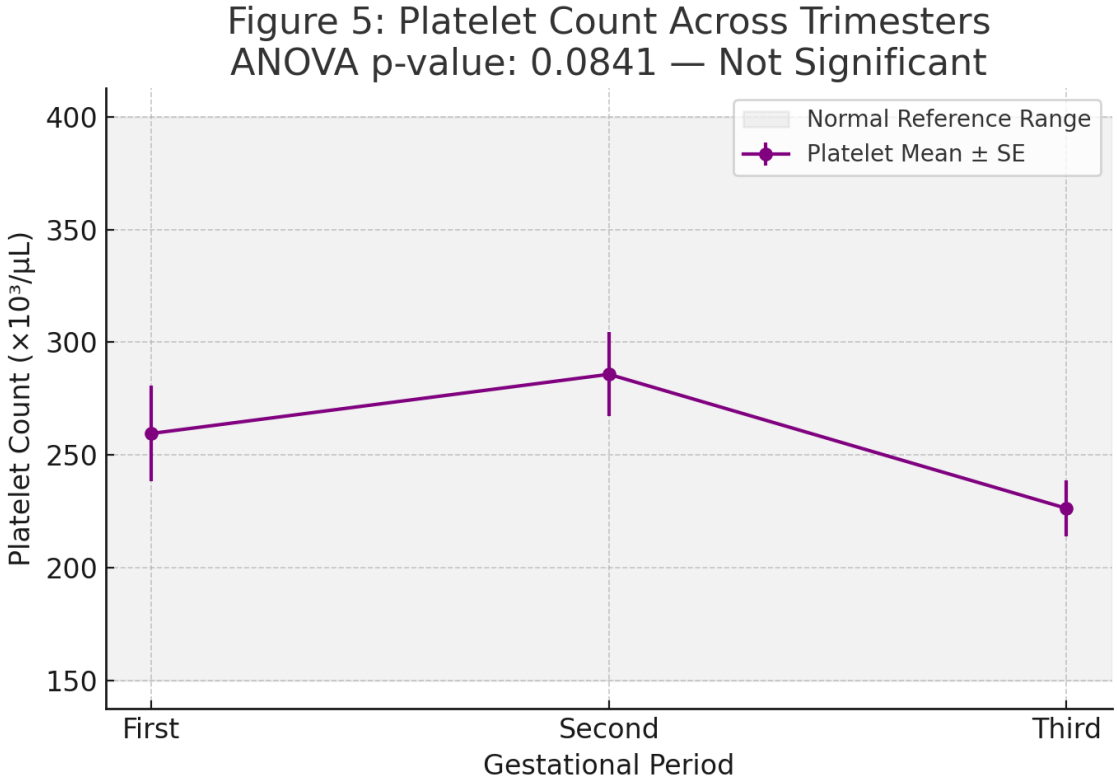
Table 7: ANOVA Results for WBC and Differential Parameters

Parameter	F-statistic	p-value	Interpretation
WBC	1.103	0.3394	Not Significant
Neut	0.263	0.7697	Not Significant
Lymph	0.417	0.6612	Not Significant
Mono	0.141	0.8686	Not Significant
Eosino	0.539	0.5863	Not Significant
Baso	Nan	Nan	Not Significant

Figure 5: Platelet Count Across Trimesters

The following chart shows the average number of platelets in the three gestation periods. All the values are within the normal range (150-400 $\times 10^3$/uL). This trend decreases in the third trimester, although ANOVA analysis demonstrates that this tendency is statistically insignificant (p = 0.0841).



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Statistical Interpretation

The t-test values show statistically significant changes of Iron ($p < 0.001$), TIBC ($p = 0.027$) and Ferritin ($p = 0.005$), which point to a change in iron metabolism in the cases of IgG-positive toxoplasmosis. There were no significant differences in the levels of transferrin ($p = 0.498$). These findings imply sub clinical or resolved iron changes that are carried over after acute infection.

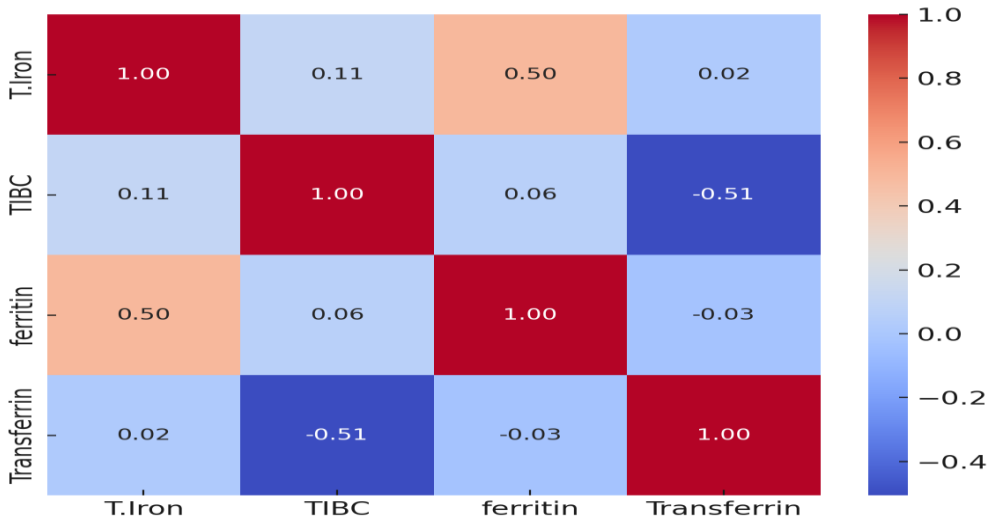
Correlation Analysis of Iron Markers During Toxoplasmosis.

This report provides the Pearson correlation analysis of iron status biomarkers (Iron, TIBC, Ferritin and Transferrin) in two groups of toxoplasmosis patients (positive by IgM (recent infection) and IgG (past or chronic infection)

IgM-Positive Cases

Figure 6: Iron Markers Correlation in Cases of IgM-Positive Toxoplasmosis.

The moderate positive relationship between Iron and Ferritin was found in IgM-positive patients ($r = 0.50$) which demonstrates that iron levels are inclined to rise with stored iron. There was also moderate negative relationship between TIBC and Transferrin ($r = -0.51$), which may be an indicator of iron transportation and its regulation in acute infection.



IgG-Positive Cases

Figure 7: Correlation Between Iron Markers in IgG-Positive Toxoplasmosis Cases.

In IgG positive cases, there was moderate positive relationship between Iron and Transferrin ($r = 0.34$) and it indicates the presence of the transport activity after infection. There was also mildly significant

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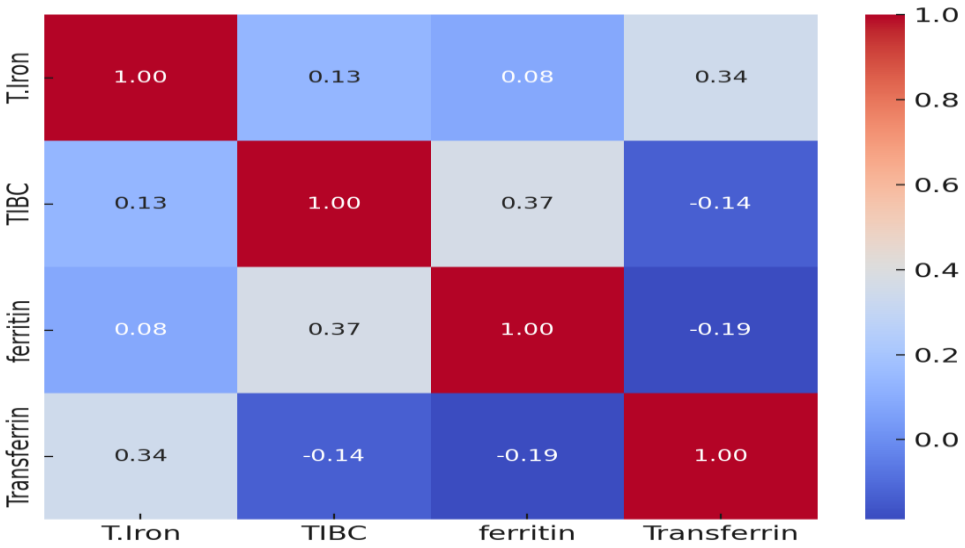
correlation between TIBC and Ferritin (r = 0.37). All in all, the correlations were less than those of IgM, which demonstrated more stable iron homeostasis during recovery or in chronic stages of infection.



Discussion

This study provides will offer current information on the seroprevalence of *Toxoplasma gondii* in women of reproductive age in Kirkuk Province, Iraq, and its hematological consequences. The findings revealed a notably high seroprevalence that the rate of both IgM and IgG seropositivity is relatively high, especially in non-pregnant women with history of miscarriage or congenital abnormalities. The results are consistent with the local literature, which supports the clinical importance of regular Toxoplasma screening among pregnant women (Al-Mudhaffar et al., 2020; Salman et al., 2022). The high prevalence of the IgG in the control group indicates previous exposure and reflecting the lifelong persistence of latent infection. The IgM rate is high especially in women aged between 26 and 45 years, suggesting an ongoing risk of transmission and there is a possibility of acute infection(Ahmed, P. B.,and Mero, W. 2025).. The same trends have been reported in the previous research in Iraq and the neighboring countries, which has been associated with the exposure to the environment and the lack of knowledge about preventive measures (**Mustafa et al. 2024).** In our results, our findings demonstrated that hematological changes showed asignificant association with toxoplasmosis. The MCV and MCH values of pregnant women were lower, may indicate microcytic anemia, and can be explained by the effect of the parasite on iron metabolism or the nutritional condition of the pregnant. These observations are in line with the previous reports indicating toxoplasmosis to be associated with dysregulated erythropoiesis (Jenum et al., 2015).

Additionally, the increase in the number of WBCs and neutrophils in the pregnant groupmay reflect an immune respon to acute infection, which is consistent with asystemic consistent with a systemic inflammatory response Conversely, IgM-positive women showed more pronounced leukocytosis and thrombocytopenia, which is a pattern

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commonly reported a pattern commonly reported in other acute parasite or viral infections (Elhag et al., 2016). The fact that the number of platelets in pregnant women who are infected reduces is worrisome because thrombocytopenia can expose them to bleeding complications. This is either an immune mediated effect or direct parasitic invasion of bone marrow activity.

The high hematological differences between the positive cases of IgM and IgG also supports the diagnostic and clinical usefulness of CBC. Although ELISA remains the most practical screening tool of screening as it is the least costly test, and helps differentiate between the acute and chronic stages, the hematological profile provides additional clinical insight gives on the disease activity and complications.

Along with hematological changes, The present study evaluated iron metabolism in Toxoplasma-infected women by measuring serum iron, total iron-binding capacity (TIBC), transferrin and ferritin. The findings demonstrated an increase in the level of serum iron and higher TIBC in a large percentage of pregnant women with recent (IgM-positive) infection, which suggests a tendency with functional iron deficiency anemia. This iron disturbance can be explained by various processes including iron sequestration through parasites and inflammatory cytokines-mediated control of hepcidin concentration a major control of iron uptake and allocation (Bjørn and Stefan2025).

Recent research has shown that *T. gondii* utilizes host utilizes host intracellular iron to support its replication, therefore, limiting the supply of iron to erythropoiesis, and causing anemia in individuals with the infection (Antunes et al., 2022; de Sousa et al., 2021). Moreover, this effect can be worsened by the immune response of the host that increases the expression of hepcidin that limits the absorption of iron and promotes iron in sequestration within macrophages (Camaschella, 2015). The high TIBC results can be attributed to compensatory response increase in transferrin synthesis as a result of iron deficiency (Abbaspour et al., 2014). Although the serum transferrin level was within the reference range in the majority of the cases, the reduced level of serum ferritin was observed in some participants with positive IgM results, suggesting subclinical iron depletion.

Such a biochemical profile is consistent with the results of other similar studies in Iraq and other neighboring regions that have also associated latent or active toxoplasmosis cases with iron dysregulation and a higher risk of pregnancy-related complications (Yassin and Rahi, 2020; Farhan and Al-Taie, 2021). Since these changes occur under the influence of the immunomodulatory and metabolic changes during the course of pregnancy, they may affect both the health of the mother and the development of the fetus, which underscores the necessity of combined iron screening and supplementation levels in the pregnancy programs of high-risk groups.

To conclude, the research results substantiate the idea that Toxoplasma serology should be used in combination with CBC assessment in the context of antenatal procedures. Measures of public health such as education, hygiene promotion and specific screening of high-risk groups are imperative in alleviating the burden of congenital toxoplasmosis in Iraq and similar settings .

Conflict of Interest

The author declare no conflict of interest.

Funding

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgment

The author gratefully acknowledge the support of the private Ibn-nafess medical Lab,and the College of Food Science at Tikrit University for

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their facilities.

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