Original Article

Correlation Between Maternal Iron Status and Susceptibility to Malarial Infection in Pregnant Women.

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ABSTRACT

Background: Malaria and anemia especially iron-deficiency anemia are two primary maternal health complications in areas where malaria is endemic. During pregnancy changes in the immune and blood systems potentially predispose women to different infections. The complex interplay between the parasite and host influences the relationship between iron deficiency and malaria infection in hosts. Recognizing the relationship between malaria infections and iron deficiency is crucial for refining antenatal care.

Objectives: To determine the impact of maternal iron levels on the risk of malaria infection in women of childbearing age residing in malaria-endemic areas.

Methodology: this cross sectional study at department Community Medicine Department Khyber Medical College Peshawar 150 pregnant women was obtained using non-probability sampling techniques. The study assessed the iron status of pregnant women which included checking their haemoglobin serum ferritin serum iron concentration and transferrin saturation levels. Malaria was diagnosed using peripheral smear and rapid diagnostic tests. The population was then analyzed to determine their iron sufficiency status and the respective group to which they belonged. The data were analyzed using SPSS version 24.0.

Results:80 of 150 patients. The patients had Mean age of 26.4 years with a standard deviation of 4.8 years. The results indicated that malaria was present in 58 of the 120 iron-deficient female patients which constituted 48.3% with a statistical significance of 0.003. In contrast only 22 of the 80 iron-sufficient females had malaria resulting in an infection rate of 27.5% with a statistical significance of 0.003. The mean haemoglobin concentration of patients with malarial infection was 9.1 ± 1.2 g/dL while that of infected patients without malarial infection was 10.6 ± 1.4 g/dL showing a statistically significant difference of less than 0.001. The analysis revealed a negative correlation between the amount of serum ferritin and the level of parasitemia with a correlation coefficient of r = -0.41 and a p-value of 0.01.

Conclusion: During iron deficiency pregnant women have an elevated risk of malaria infection indicating that iron supplementation strategies must be developed and tailored accordingly. Antenatal care that monitors and corrects iron deficiency will reduce the complications of malaria particularly in areas with high malaria transmission.

Keywords: Malaria Pregnancy Iron deficiency Anemia.

Article Metadata

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Article History

Received: 22th Jan, 2025

Revised: 20th Feb, 2025

Accepted:24th March,2025

Published 05th April,2025

DOI: https://doi.org/10.64911/1nn0ar22

This article may be cited as:

Khan HM, Hussan J, Nargis J. Correlation between maternal iron status and susceptibility to malarial infection in pregnant women. J Pak Int Med Coll. 2025;2(2):44-49.

INTRODUCTION

The Diseases presents substantial public health challenges particularly in widespread areas of developing nations that threaten vulnerable maternal communities including pregnant women. The World Health Organization documented that sub-Saharan African pregnant women faced malaria infection in 2021 which produced 819 000 newborns with low birth weight among 11 million exposed females [1]. The most destructive strain affecting pregnant women is Plasmodium falciparum though P. Vivax infections have been recorded in specific regions. The disease course of malaria during pregnancy produces maternal Anemia and miscarriages as well as stillbirths together with limited fetal growth and premature births [2]. WHO data indicates that Anemia affects 40 percent of pregnant women throughout the world as iron deficiency causes most of these cases [3]. The maternal body requires substantial increases in iron during pregnancy to support fetal development along with an increase in blood volume. Studies have yielded conflicting opinions on the interaction between iron deficiency and malaria-related issues. Studies indicate that low iron levels can protect against malaria because parasites lack the necessary iron to grow [4]. The investigation of immune system function in iron deficiency has yielded results indicating a reduced ability to combat infections such as malaria and other diseases along with disrupted immune function [5]. Study indicates that both supplementation and prophylaxis combination are essential for protecting pregnant women against malaria infection particularly in regions with proven high levels of both diseases [6]. The current national and global health guidelines recommend that healthcare providers provide iron supplements to pregnant mothers during antenatal care [7]. The implementation of iron supplements in malaria-endemic areas necessitates further continuous investigation regarding suitable dosages along with safety assessments of these interventions. Several studies have investigated the impact of iron supplements on the risk of malaria. A Zanzibar trial with randomized subjects revealed that all-patient iron supplementation elevated the risk of severe malaria in children dwelling in regions with high transmission rates [8]. The study indicates incomplete findings regarding this concern for pregnant women. The study must determine whether iron deficiency in pregnant mothers leads to different malaria susceptibility compared to non-anaemic expectant mothers. The study investigates whether iron deficiency status is associated with malaria infection risks among pregnant women visiting antenatal care services at a tertiary care hospital in an endemic malaria area [9]. This study seeks to reveal the connection between iron levels and malaria exposure in pregnant women to establish better customized antenatal treatment approaches particularly when malaria and IDA coexist in endemic territories [10].

MATERIAL AND METHODS

This Study Conducted In Department Of Community Medicine Department Khyber Medical College Peshawar From Jan 2023 To Jan 2024. A non-probability consecutive sampling technique was employed to include 150 pregnant women who attended antenatal clinics at various trimesters. Participants provided their consent for the study before it was conducted and their evaluations for iron status and malaria infection were then conducted. Laboratory technicians performed standard tests to evaluate both iron parameters and haemoglobin levels as well as serum iron and ferritin levels and transferrin saturation levels. Malaria diagnosis requires evaluation through peripheral blood smears together with rapid diagnostic tests. The study participants were categorized into two groups: iron-deficient and iron-sufficient based on their iron levels. A structured proforma supported documentation of clinical information as well as laboratory results and malaria infection diagnoses. Approval from the institutional review board served as the basis for ethical permission.

INCLUSION CRITERIA

Clinic patients aged 18–40 years who consented to participation and received standard iron and malaria tests were included in the study regardless of their trimester or pregnancy order.

EXCLUSION CRITERIA

hematology disorders and liver disease with chronic renal disease as well as recent malaria treatment and long-term iron therapy exceeding four weeks resulted in patient exclusion.

DATA COLLECTION

A pre-established questionnaire was used for data collection and structured laboratory evaluations were conducted. A team recorded both the clinical history and physical examination findings as well as malaria diagnostic results and iron status indices. The hospital's central laboratory utilized trained technicians who performed testing following completion checks to ensure data correctness.

STATISTICAL ANALYSIS

The data analysis was conducted using SPSS version 20.0. The study reported categorical variables in terms of frequencies along with percentages. The mean value is accompanied by standard deviation as a method for presenting continuous variables. The study employed the Chi-square test to examine the relationship between iron status and malaria diagnosis. Pearson correlation was used to analyze the relationship between serum ferritin and parasitemia severity. P-value <0.05 was considered significant.

RESULTS

The study included 150 pregnant women throughout its investigation. All participants were 26.4 ± 4.8 years old on average. The study group consisted of 120 participants who were iron-deficient while 80 patients had a normal iron balance. Results from the study showed malaria infection present in 80 patients (40%) among the total study sample. Women with iron deficiency showed a substantial association with malaria infection at 58 (48.3%) while women with sufficient iron showed only 22 (27.5%) cases (p = 0.003). The inverse relationship between blood parasitic levels and serum ferritin counts became statistically significant with a correlation value of -0.41 (p = 0.01). The frequencies of infection remained similar throughout all pregnancy trimesters. The study indicates that iron deficiency makes pregnant women more vulnerable to acquiring malaria. The risk of infection increased significantly when female patients had both low ferritin levels and low haemoglobin levels simultaneously. The study results verify that changes in iron homeostasis affect how hosts interact with pathog by demonstrating the importance of personalized approaches treating to pregnancy anent specifically in malaria-endemic zones.

Figure 1. Malaria Distribution in Iron-Deficient Women

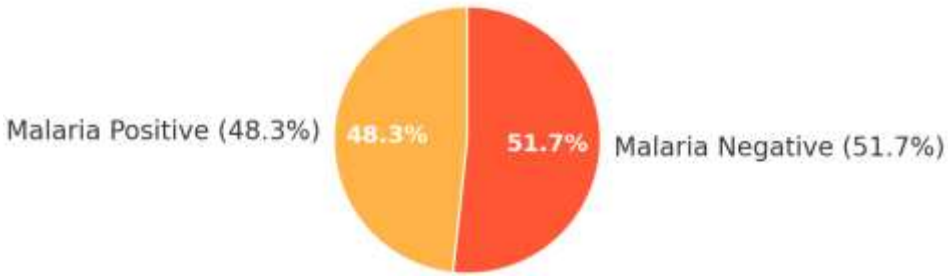

Figure 1 (left) malaria status among iron-deficient women. Malaria positivity was observed in 48.3% of participants while 51.7% were malaria negative.

Figure 2. Malaria Infection by Iron Status in Women

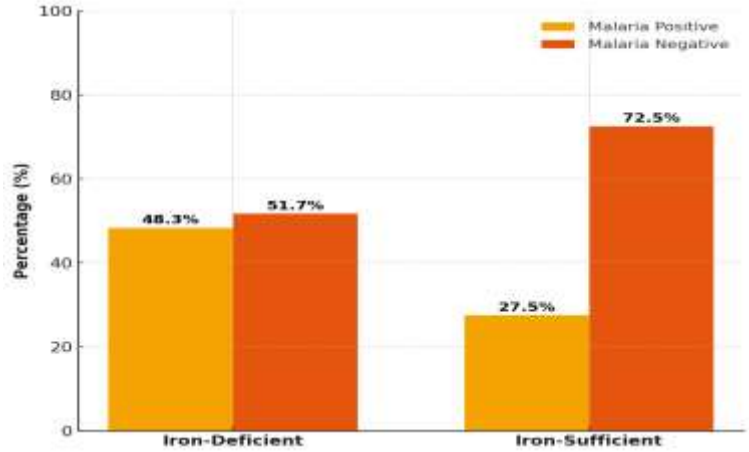

Figure 2 (right) shows malaria infection stratified by iron status. Among iron-deficient women 48.3% were malaria positive compared with 27.5% in iron-sufficient women. Conversely 51.7% of iron-deficient women and 72.5% of iron-sufficient women were malaria negative. Percentages represent proportions within each subgroup.

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	Value	Statistical Test Used
Mean Age (years)	26.4 ± 4.8	Independent *t*-test
Gravidity ≥2 n (%)	110 (55%)	Chi-square test
Trimester (1st) n (%)	50 (25%)	Chi-square test
Trimester (2nd) n (%)	80 (40%)	Chi-square test
Trimester (3rd) n (%)	70 (35%)	Chi-square test

Table 1 presents demographic and clinical characteristics of pregnant women included in the study. The mean age was 26.4 years. Distribution across gravidity and pregnancy trimesters was assessed using Chi-square tests.

Table 2. Iron Status and Malaria Infection Rates

Iron Status	Total Women (n)	Malaria Positive (n %)	Malaria Negative (n %)	Statistical Test Used	*p*-value
Iron-Deficient	120	58 (48.3%)	62 (51.7%)	Chi-square test	0.01
Iron-Sufficient	80	22 (27.5%)	58 (72.5%)	Chi-square test	0.01

Table 2 demonstrates malaria infection rates by iron status. Malaria prevalence was significantly higher among iron-deficient women (48.3%) compared with iron-sufficient women (27.5%). Group differences were tested using Chi-square analysis ($p = 0.01$).

Table 3. Haematological Parameters by Malaria Status

Parameter	Malaria Positive	Malaria Negative	Statistical Test Used	*p*-value
Haemoglobin (g/dL)	9.1 ± 1.2	10.6 ± 1.4	Independent *t*-test	<0.001
Serum Ferritin (ng/mL)	18.4 ± 6.1	27.9 ± 7.4	Independent *t*-test	0.01
Serum Iron (µg/dL)	42.6 ± 12.3	62.8 ± 15.1	Independent *t*-test	0.003
Transferrin Saturation (%)	14.2 ± 5.5	21.6 ± 6.2	Independent *t*-test	0.007

Table 3 compares hematological parameters by malaria status. Malaria-positive women had significantly lower hemoglobin serum ferritin serum iron and transferrin saturation levels compared to malaria-negative women. All variables were analyzed using independent *t*-tests with statistical significance defined as $p < 0.05$.

DISCUSSION

The our study analysis revealed a significant relationship between the rates of iron deficiency and the degree of exposure to malaria among pregnant women[10-11]. This has been noted in previous literature stressing the intricate interplay between iron deficiency and malaria. Several previous studies have reported that iron deficiency may protect against malaria due to the parasite Plasmodium not having sufficient iron to complete its lifecycle [12]. In a study of Tanzanian children those with lower iron stores had reduced cases of clinical malaria compared to children with normal iron levels [13-14]. In our study malaria-infected iron-deficient pregnant women had lower levels of

haemoglobin and ferritin which according to our findings resulted in higher parasite loads [15-16]. Okafor et al. in Nigeria reported that pregnant women with iron deficiency anemia had increased occurrences of P. falciparum and adverse pregnancy outcomes [17]. Ekvall et al. stated that pregnant women in Mozambique with low serum ferritin suffered from worsened anemia and were more likely to have placental malaria [18]. This situation calls for the development of complex strategies that will provide protection against iron deficiency and also prevent malaria especially in resource-poor settings.As noted in this study women with normal iron levels lower infection risks and better blood test results experienced a reduced risk of infection. Results suggest that balanced iron levels provide the ideal relationship between immune function and parasite control compared to excessive supplementation and deficiency states [19]. The WHO states that in regions with malaria transmission iron supplementation should be accompanied by additional malaria control measures such as insecticide-treated nets and intermittent preventive malaria treatment [20-21]. In our study the results of the correlation between serum ferritin and parasitemia severity support the concept that iron storage influences the mechanisms of malaria disease. Findings from Gera and Sachdev's meta-analytic study confirmed an increased susceptibility to malaria among untreated individuals when iron levels were elevated. The criteria for determining individualized iron treatment in pregnancy must be tailored to use patient-specific elements and the intensity of malaria transmission in the region. Our study contributes to the body of research detailing the complex interaction of iron and malaria in pregnant women. There is a need for longitudinal studies to demonstrate direct positive causation and evaluate the effect of iron with strong malaria preventive measures and highly integrated iron administration.

LIMITATIONS

The study was limited by the cross-sectional design which does not allow for the establishment of cause-and-effect relationships. The single-center nature of the study also affects the generalizability of the findings. The lack of clear parasite concentration measurements and the analysis of seasonal malaria transmission may also explain some of the relationships studied.

CONCLUSION

The implications of anemia in pregnant women include increased vulnerability to malaria infections. Optimal management of anemia would improve patient outcomes and reduce the associated risks. Integrated approaches to managing anemia and preventing malaria are most needed in endemic regions.

FUTURE FINDINGS

The study community should conduct systematic follow-up studies to elucidate the pathway by which iron concentration levels influence the severity of malaria disease. During studies in diverse regions with varying malaria prevalence and nutritional status the interaction of specifically formulated iron supplementation and malaria prophylactic drugs in pregnant women should be prioritized.

Disclaimer: **Nil**

Conflict of Interest:**Nil**

Funding Disclosure: **Nil**

Authors Contribution

Concept & Design of Study: Hayat Muhmmad Khan

Data Collection:Jehan Hussan

Drafting: Jalwa Nargis

Data Analysis:Jalwa Nargis

Critical Review:Jalwa Nargis

Final Approval of version: All Authors Approved The Final Version.

REFERENCES

1. Al Khaja KAJ Sequeira RP. Drug treatment and prevention of malaria in pregnancy: a critical review of the guidelines. Malaria journal. 2021;20(1):62. doi: https://doi.org/10.1186/s12936-020-03565-2.

2. Costanza A Placenti V Amerio A Aguglia A Serafini G Amore M et al. Chloroquine/Hydroxychloroquine Use and Suicide Risk:Hypotheses for Confluent Etiopathogenetic Mechanisms? Behavioral sciences (Basel Switzerland). 2021;11(11)doi: https://doi.org/10.3390/bs11110154.

3. Crider K Williams J Qi YP Gutman J Yeung L Mai C et al. Folic acid supplementation and malaria susceptibility and severity among people taking antifolate antimalarial drugs in endemic areas. The Cochrane database of systematic reviews. 2022;2(2022)doi: https://doi.org/10.1002/14651858.cd014217.

4. Cutts JC Agius PA Zaw L Powell R Moore K Draper B et al. Pregnancy-specific malarial immunity and risk of malaria in pregnancy and adverse birth outcomes: a systematic review. BMC medicine. 2020;18(1):14. doi: https://doi.org/10.1186/s12916-019-1467-6.

5. Helvacioglu C Baghaki S Bibata BB Yıldırım Karaca S Doğan K. Can platelet indices be of value in pregnant women with malaria? Journal of obstetrics and gynaecology : the journal of the Institute of Obstetrics and Gynaecology. 2022;42(6):2046-50. doi: https://doi.org/10.1080/01443615.2022.2080533.

6. Kayiba NK Yobi DM Tchakounang VRK Mvumbi DM Kabututu PZ Devleesschauwer B et al. Evaluation of the usefulness of intermittent preventive treatment of malaria in pregnancy with sulfadoxine-

pyrimethamine in a context with increased resistance of Plasmodium falciparum in Kingasani Hospital Kinshasa in the Democratic Republic of Congo. Infection genetics and evolution : journal of molecular epidemiology and evolutionary genetics in infectious diseases. 2021;94:105009. doi: https://doi.org/10.1016/j.meegid.2021.105009.

7. Koko DC Maazou A Jackou H Eddis C. Analysis of attitudes and practices influencing adherence to seasonal malaria chemoprevention in children under 5 years of age in the Dosso Region of Niger. Malaria journal. 2022;21(1):375. doi: https://doi.org/10.1186/s12936-022-04407-z.

8. Koladjo BF Yovo E Accrombessi M Agbota G Atade W Ladikpo OT et al. Malaria in the First Trimester of Pregnancy and Fetal Growth: Results from a Beninese Preconceptional Cohort. The Journal of infectious diseases. 2022;225(10):1777-85. doi: https://doi.org/10.1093/infdis/jiac012.

9. Ngwenya S Mhlanga S Moyo S Lindow SW. Reducing maternal mortality: a 10-year experience at Mpilo Central Hospital Bulawayo Zimbabwe. Journal of perinatal medicine. 2023;51(2):208-12. doi: https://doi.org/10.1515/jpm-2022-0399.

10. Ota E da Silva Lopes K Middleton P Flenady V Wariki WM Rahman MO et al. Antenatal interventions for preventing stillbirth fetal loss and perinatal death: an overview of Cochrane systematic reviews. The Cochrane database of systematic reviews. 2020;12(12):Cd009599. doi: https://doi.org/10.1002/14651858.CD009599.pub2.

11. Piccioni MG Del Negro V Vena F Capone C Merlino L Moore JM et al. Diagnosis & management of imported malaria in pregnant women in non-endemic countries. The Indian journal of medical research. 2020;152(5):449-55. doi: https://doi.org/10.4103/ijmr.IJMR_851_18.

12. Quanquin NM Barres LG Aliyari SR Day NT Gerami H Fisher SJ et al. Gravidity-dependent associations between interferon response and birth weight in placental malaria. Malaria journal. 2020;19(1):280. doi: https://doi.org/10.1186/s12936-020-03351-0.

13. Seijas-Chávez JA Nolan MS Lynn MK da Rocha MJF da Costa Araújo M Fonseca FLA et al. Causal effects on low Apgar at 5-min and stillbirth in a malaria maternal-fetal health outcome investigation: a large perinatal surveillance study in the Brazilian Amazon. Malaria journal. 2021;20(1):444. doi: https://doi.org/10.1186/s12936-021-03981-y.

14. Singh A Mohan K Omar BJ Chacham S Chaturvedi J Basu S et al. Congenital Malaria in Newborns Delivered to Malaria-infected Mothers in the Hilly Region of Northern India: Is it Deadly? Current pediatric reviews. 2022;18(1):53-8. doi: https://doi.org/10.2174/1573396317666211102093324.

15. Suliman MA Tamomh AG Younis OY Magboul AM Mohammed HY Hassan IM et al. Malaria infection and associated risk factors in pregnant women attending antenatal care clinics in Al Jabalian Locality White Nile state Sudan. Annals of parasitology. 2021;67(3):499-504. doi: https://doi.org/10.17420/ap6703.363.

16. Tassi Yunga S Siriwardhana C Fouda GG Bobbili N Sama G Chen JJ et al. Characterization of the primary antibody response to Plasmodium falciparum antigens in infants living in a malaria-endemic area. Malaria journal. 2022;21(1):346. doi: https://doi.org/10.1186/s12936-022-04360-x.

17. Topazian HM Moser KA Ngasala B Oluoch PO Forconi CS Mhamilawa LE et al. Low Complexity of Infection Is Associated With Molecular Persistence of Plasmodium falciparum in Kenya and Tanzania. Frontiers in epidemiology. 2022;2:852237. doi: https://doi.org/10.3389/fepid.2022.852237.

18. Unger HW Laurita Longo V Bleicher A Ome-Kaius M Karl S Simpson JA et al. The relationship between markers of antenatal iron stores and birth outcomes differs by malaria prevention regimen-a prospective cohort study. BMC medicine. 2021;19(1):236. doi: https://doi.org/10.1186/s12916-021-02114-1.

19. Waltmann A McQuade ETR Chinkhumba J Operario DJ Mzembe E Itoh M et al. The positive effect of malaria IPTp-SP on birthweight is mediated by gestational weight gain but modifiable by maternal carriage of enteric pathogens. EBioMedicine. 2022;77:103871. doi: https://doi.org/10.1016/j.ebiom.2022.103871.

20. Wiebe MC Yanow SK. Do Antibodies to Malaria Surface Antigens Play a Role in Protecting Mothers From Maternal Anemia? Frontiers in immunology. 2020;11:609957. doi: https://doi.org/10.3389/fimmu.2020.609957.

21. Yang D He Y Wu B Deng Y Li M Yang Q et al. Drinking water and sanitation conditions are associated with the risk of malaria among children under five years old in sub-Saharan Africa: A logistic regression model analysis of national survey data. Journal of advanced research. 2020;21:1-13. doi: https://doi.org/10.1016/j.jare.2019.09.001.

22. Zhang J Li Q Song Y Fang L Huang L Sun Y. Nutritional factors for anemia in pregnancy: A systematic review with meta-analysis. Frontiers in public health. 2022;10:1041136. doi: https://doi.org/10.3389/fpubh.2022.1041136.