

ISSN Print: 1813-176x
ISSN Online: 1994-4624

International Journal of Molecular Medicine and Advance Sciences
https://ijmmas.com/

Research Article

Trends in Hematological and Liver Function Parameters Among Malaria-Positive Patients: A Half-Decade Retrospective Study from Karachi, Pakistan

Muhammad Yasir Rishi[1]*, Saad Ullah[2], Midhat Iqbal[2], Laiba Nazir[2], Sadia Hayat[2], Saad Umer Qaisrani[2], Muhammad Uzair[1], Maria Rishi[3]

[1]Department of Pathology, Baqai Medical College, Baqai Medical University, Karachi, Pakistan
[2]4th-year MBBS students, Baqai Medical College, Baqai Medical University, Karachi, Pakistan
[3]Baqai Institute of Pharmaceutical Sciences, Baqai Medical University, Karachi, Pakistan

Correspondence:
Muhammad Yasir Rishi.

Email: yasirrishi@yahoo.com

Received: 18-09-2026
Revised: 05-10-2026
Accepted: 18-10-2026
Published: 02-11-2026

DOI: 10.61336/ijmmas.22-04-24

Abstract: Background: Malaria remains a major public health problem in Pakistan, causing hematological abnormalities and liver dysfunction. Local evidence on laboratory differences among Plasmodium species is limited. Objective: To evaluate hematological and liver function parameters among malaria-positive patients and to compare laboratory findings across Plasmodium species and over time. ***Methods***: This retrospective cross-sectional study used laboratory records (2021–2025) of malaria-positive patients at Fatima Teaching Hospital, Baqai Medical University, Karachi. Demographic data, hematological indices and liver function parameters were extracted and analyzed in IBM SPSS Statistics version 26. Species groups were compared using the Kruskal-Wallis test with Dunn's post-hoc test and Bonferroni correction. Temporal trends were assessed using the Kruskal-Walli's test across calendar years and Spearman's rank correlation between year and each parameter. Associations between laboratory parameters were assessed with Spearman's correlation. ***Results***: A total of 118 malaria-positive patients were included (mean age 30.86 ± 14.57 years; 60.2% male). Plasmodium vivax predominated (73.7%), followed by P. falciparum (17.8%) and mixed infection (8.5%). Mild anemia (median hemoglobin 11.6 g/dL) and thrombocytopenia (median platelet count 110 $\times 10^9$/L) were the commonest abnormalities. Hemoglobin was significantly lower in P. falciparum than in P. vivax infection (10.9 vs 12.0 g/dL; $p = 0.009$), and aspartate aminotransferase (AST) was significantly higher (23 vs 18 U/L; $p = 0.013$). Platelet count correlated inversely with total bilirubin ($\rho = -0.316$, $p < 0.001$). AST rose over the study period ($\rho = 0.364$, $p = 0.006$; median 16 U/L in 2021–2022 to 27 U/L in 2024), whereas hemoglobin, platelet count, white blood cell count, bilirubin and alanine aminotransferase (ALT) showed no significant temporal change. ***Conclusion***: Anemia and thrombocytopenia are common laboratory findings in malaria. P. falciparum infection was associated with lower hemoglobin and higher AST than P. vivax, supporting species-specific clinical monitoring. The upward AST trend suggests that hepatic involvement may be increasing at this center and warrants continued surveillance.

Keywords: malaria; Plasmodium falciparum; Plasmodium vivax; anemia; thrombocytopenia; liver function; temporal trends; Karachi.

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INTRODUCTION

The World Health Organization estimated 263 million malaria cases worldwide in 2023, an incidence of 60.4 cases per 1000 population at risk, up from 58.6 per 1000 in 2022 [1]. Malaria is endemic across Pakistan, and Plasmodium vivax is consistently the most prevalent species, followed by P. falciparum and mixed infections; Karachi has been reported to carry a particularly high share of national cases [2].

Because the parasite develops within red blood cells, hematological change is the most frequent complication of malaria. Anemia and thrombocytopenia are the classic findings, arising from hemolysis of parasitized and non-parasitized cells, splenic sequestration, marrow suppression and immune-mediated platelet destruction [3]. Hepatic involvement is also recognized, particularly in falciparum malaria, where sequestration of parasitized erythrocytes in the hepatic sinusoids and hemolysis can produce raised transaminases and hyperbilirubinemia, and jaundice is the most visible sign of hepatic dysfunction [4,5].

Pakistani reports have described the hematological profile of malaria in Khyber Pakhtunkhwa, Dera Ismail Khan, Multan and southern Pakistan [6–9]. Far fewer have looked at liver function alongside blood counts, and few have examined how these laboratory parameters change over several years in a single center. Such information is useful because laboratory values guide early suspicion, risk stratification and monitoring in a setting where parasite density is often not quantified.

We therefore evaluated hematological and liver function parameters in malaria-positive patients presenting to a teaching hospital in Karachi over five years (2021–2025), compared these parameters between P. vivax, P. falciparum and mixed infections, examined correlations between hematological and hepatic markers, and assessed temporal trends.

MATERIALS AND METHODS

2.1 Study design, setting and period

This was a retrospective cross-sectional study of laboratory records of malaria-positive patients at Fatima Teaching Hospital, Baqai Medical University, Karachi, Pakistan. Records covered 2021–2025. Data were collected from December 2025 to March 2026 after approval from the Institutional Review and Ethics Board (IREB) of Baqai Medical University.

2.2 Participants

Consecutive sampling was used: all laboratory records of malaria-positive patients of any age who met the inclusion criteria were included. Records had to contain hematological parameters (WBC, RBC, hemoglobin, MCV, MCH, platelets, neutrophils, lymphocytes, eosinophils, monocytes) and liver function tests (ALT, AST, ALP, GGT, total, direct and indirect bilirubin). Records with incomplete or missing values were excluded. A total of 118 records were analyzed. Malaria was diagnosed by rapid immunochromatographic test (MP ICT).

2.3 Data collection

A structured extraction sheet captured patient identifier, report date, age, sex, infecting species, complete blood count parameters (WBC, RBC, hemoglobin, hematocrit, MCV, MCH, MCHC, platelets and differential counts) and liver function parameters (ALT, AST, ALP, GGT and bilirubin fractions). Coded identifiers were used and no personal identifying information entered the analysis dataset.

2.4 Statistical analysis

Data were analyzed using IBM SPSS Statistics version 26. Categorical variables are reported as frequencies and percentages and age as mean ± SD. The Shapiro-Wilk test showed that all continuous laboratory variables departed significantly from normality, so they are reported as median (interquartile range, IQR) and analyzed with non-parametric methods. Hemoglobin, platelet count, WBC count, total bilirubin, ALT and AST were compared across the three species groups with the Kruskal-Wallis test; significant results were followed by Dunn's post-hoc test with Bonferroni correction. Temporal trends were assessed with the Kruskal-Wallis test across calendar years and Spearman's rank correlation between year and each parameter. Associations between hematological and hepatic parameters were assessed with Spearman's ρ. A two-sided p-value < 0.05 was considered significant. A chi-square test of species by year was not performed because more than 20% of expected cell counts were below 5.

RESULTS

3.1 Patient characteristics

Of 118 patients, 71 (60.2%) were male and 47 (39.8%) female, with a mean age of 30.86 ± 14.57 years. *P. vivax* was identified in 87 patients (73.7%), *P. falciparum* in 21 (17.8%) and mixed *P. vivax*/*P. falciparum* infection in 10 (8.5%) (Table 1).

Table 1. Baseline characteristics of the study population (N = 118)

Variable	Category	n	%
Age (years)	Mean ± SD	30.86 ± 14.57	—
Sex	Male	71	60.2
	Female	47	39.8
Species	*P. vivax*	87	73.7
	P. falciparum	21	17.8
	Mixed	10	8.5

3.2 Overall laboratory profile

Median hemoglobin was 11.6 g/dL, below the reference limit and consistent with mild anemia, and median platelet count was 110 $\times 10^9$/L, consistent with thrombocytopenia. Median WBC count, total bilirubin, ALT and AST were within reference ranges, although the wide ALT interquartile range indicates marked variability in a minority of patients (Table 2).

Table 2. Overall laboratory parameters (N = 118), median (IQR)

Parameter	Median (Q1–Q3)	Reference range
WBC ($\times 10^9$/L)	5.45 (3.92–7.00)	4.0–11.0
Hemoglobin (g/dL)	11.6 (10.53–12.88)	12.5–15.5
Platelets ($\times 10^9$/L)	110 (76.5–165.0)	150–400
Total bilirubin (mg/dL)	0.7 (0.46–1.31)	0.1–1.2
ALT (U/L)	29 (20.25–52.0)	< 34
AST (U/L)	19.5 (14.0–24.0)	3–40

3.3 Comparison by *Plasmodium* species

Hemoglobin differed significantly across species (H = 9.34, p = 0.009): median 12.0 g/dL in *P. vivax*, 10.9 g/dL in *P. falciparum* and 11.5 g/dL in mixed infection, with post-hoc testing confirming the *P. vivax* versus *P. falciparum* difference. AST also differed significantly (H = 8.61, p = 0.013), being higher in *P. falciparum* (23 U/L) than in *P. vivax* (18 U/L) on post-hoc testing. Platelet count (p = 0.242), WBC count (p = 0.851), total bilirubin (p = 0.199) and ALT (p = 0.291) did not differ significantly between species (Table 3). Median platelet count was below 150 $\times 10^9$/L in *P. vivax* and mixed infection; the *P. falciparum* median (161 $\times 10^9$/L) was higher, although the groups did not differ significantly.

Table 3. Laboratory parameters by *Plasmodium* species, median (IQR)

Parameter	*P. vivax* (n = 87)	*P. falciparum* (n = 21)	Mixed (n = 10)	p
Hemoglobin (g/dL)	12.0 (10.75–13.25)	10.9 (8.27–11.05)	11.5 (10.51–12.36)	**0.009***
Platelets ($\times 10^9$/L)	110 (78.0–146.5)	161 (128.05–233.38)	94 (69.91–148.09)	0.242
WBC ($\times 10^9$/L)	5.2 (5.22–6.66) †	6.0 (4.91–8.05)	6.05 (3.59–11.29)	0.851
Total bilirubin (mg/dL)	0.64 (0.56–1.18)	0.70 (0.56–1.37)	1.10 (0.68–1.32)	0.199
ALT (U/L)	31 (11.73–63.10)	26 (10.91–26.81)	31.5 (16.09–25.11) †	0.291
AST (U/L)	18 (17.89–20.21)	23 (20.19–33.43)	21.5 (16.09–25.11) †	**0.013***

Kruskal-Wallis p-value; significant difference between P. vivax and P. falciparum on Dunn's post-hoc test with Bonferroni correction (hemoglobin and AST). † IQR inconsistent with the median in the source output; recheck against SPSS before submission.

3.4 Temporal trends, 2021–2025

Case numbers rose from 5 in 2021 to 35 in 2025 (31 in 2022, 29 in 2023, 16 in 2024), reflecting the sampling window rather than a true epidemiological trend. AST differed significantly across years (H = 12.79, p = 0.012): the median increased from 16 U/L in 2021 and 2022 to 27 U/L in 2024 and 22 U/L in 2025, and AST correlated positively with calendar year (ρ = 0.364, p = 0.006). AST data were sparse in 2022 (n = 17) and 2023 (n = 4) because of missing values. Hemoglobin showed a non-significant tendency toward lower values in later years (H = 8.15, p = 0.086; ρ = −0.078, p = 0.403), with the lowest median in 2023 (10.8 g/dL). Platelet count, WBC count, total bilirubin and ALT did not differ across years (p = 0.432, 0.319, 0.872 and 0.511) and none correlated with year (all $|\rho| \leq 0.11$, $p > 0.25$) (Table 4).

Table 4. Year-wise median (IQR) of laboratory parameters

Parameter	2021 (n = 5)	2022 (n = 31)	2023 (n = 29)	2024 (n = 16)	2025 (n = 35)	H	p
Hb (g/dL)	12.0 (10.9–12.0)	12.3 (11.4–13.4)	10.8 (10.0–12.2)	11.4 (9.7–12.2)	11.8 (9.8–13.4)	8.15	0.086
PLT ($\times 10^9$/L)	89 (89–175)	111 (77–146)	98 (71–127)	128 (81–323)	115 (81–167)	3.81	0.432
WBC ($\times 10^9$/L)	4.3 (3.3–6.3)	5.7 (4.7–8.2)	4.4 (3.7–6.4)	5.7 (3.4–6.7)	5.5 (4.2–7.9)	4.71	0.319
T. bilirubin (mg/dL)	0.75 (0.70–1.10)	0.80 (0.38–1.11)	0.68 (0.50–1.18)	0.55 (0.30–1.25)	0.62 (0.50–1.48)	1.24	0.872
ALT (U/L)	34 (24–42)	33 (23–54)	35 (21–43)	24 (17–32)	26 (19–60)	3.29	0.511
AST (U/L)	16 (16–18)	16 (12–21)	19 (17–20)	27 (20–32)	22 (18–26)	12.79	**0.012**

n varies slightly by parameter because of missing values.

3.5 Species distribution by year

P. vivax accounted for all cases in 2021 (100%), fell to 65.5% in 2023 (with *P. falciparum* 20.7% and mixed infection 13.8%) and rose to 94.3% in 2025 (Table 5). Because yearly subgroups were small (minimum expected count 0.43), no formal test was possible and the pattern is descriptive only.

Table 5. *Plasmodium* species distribution by year, n (%)

Year	*P. vivax*	*P. falciparum*	Mixed	Total
2021	5 (100.0)	0 (0.0)	0 (0.0)	5
2022	24 (77.4)	2 (6.5)	5 (16.1)	31
2023	19 (65.5)	6 (20.7)	4 (13.8)	29
2024	13 (81.2)	2 (12.5)	1 (6.2)	16
2025	33 (94.3)	2 (5.7)	0 (0.0)	35

3.6 Correlations

Platelet count showed a moderate inverse correlation with total bilirubin (ρ = −0.316, p < 0.001). ALT and AST were weakly but significantly positively correlated (ρ = 0.186, p = 0.044). Hemoglobin was not significantly correlated with indirect bilirubin (ρ = 0.081, p = 0.381) (Table 6).

Table 6. Spearman correlations between hematological and hepatic parameters

Variables	ρ	p
Hemoglobin vs indirect bilirubin	0.081	0.381
Platelet count vs total bilirubin	−0.316	**< 0.001**
ALT vs AST	0.186	**0.044**

DISCUSSION

In this five-year retrospective series of 118 malaria-positive patients from Karachi, anemia and thrombocytopenia were the most consistent hematological abnormalities, liver function parameters were largely within reference limits, hemoglobin and AST differed by infecting species in a direction indicating greater involvement in falciparum malaria, platelet count was inversely related to bilirubin, and AST increased over the study period.

Demographic profile. The cohort comprised mainly young adult men and was dominated by *P. vivax* (73.7%). Similar male predominance has been reported in Khyber Pakhtunkhwa [7], a Karachi series likewise found *P. vivax* far more common than *P. falciparum* [6], and a Dera Ismail Khan cohort described cases concentrated in young working-age adults [8]. The male excess most plausibly reflects greater occupational and outdoor exposure to *Anopheles* vectors rather than a biological difference in susceptibility.

Anemia and thrombocytopenia. The median hemoglobin (11.6 g/dL) and platelet count (110 $\times 10^9$/L) indicate mild anemia and thrombocytopenia. A tertiary-care series from Multan reported thrombocytopenia in 89% and anemia in 70% of malaria cases [9], and comparable reductions have been described in Ethiopia [10]. Anemia reflects hemolysis of parasitized and uninfected red cells, splenic sequestration and marrow suppression; thrombocytopenia arises mainly from immune-mediated destruction, splenic pooling and consumption [3]. Platelet medians were below 150 $\times 10^9$/L in *P. vivax* and mixed infection, and the higher *P. falciparum* median (161 $\times 10^9$/L) did not differ significantly from the others, but with only 21 falciparum cases this group is too small to say whether thrombocytopenia is truly species-independent. Platelet count is nevertheless an accessible pointer to malaria in febrile patients in endemic settings [15].

Species differences in hemoglobin. Hemoglobin was significantly lower in *P. falciparum* (10.9 g/dL) than in *P. vivax* (12.0 g/dL), with mixed infection intermediate. This agrees with reports that falciparum malaria produces more marked anemia [11,16]. A plausible explanation is that *P. falciparum* invades red cells of all ages and reaches higher parasite densities, whereas *P. vivax* prefers reticulocytes.

Liver function and species. Total bilirubin, ALT and AST were mostly within reference ranges, so overt hepatic dysfunction was uncommon. AST was nonetheless higher in *P. falciparum* (23 U/L) than in *P. vivax* (18 U/L). This fits the recognized link between falciparum malaria and hepatic involvement through sinusoidal sequestration and ischemia [4,12]. Transaminase elevations in malaria are usually mild, tend to follow parasite density and rarely progress to clinically significant liver dysfunction without other complications [5,12]. The preserved bilirubin and ALT here suggest mild, largely subclinical hepatic involvement rather than frank malarial hepatopathy.

Hematological–hepatic correlations. The inverse correlation between platelet count and total bilirubin (ρ = −0.316) is biologically coherent: thrombocytopenia and hyperbilirubinemia both tend to intensify with parasite burden and disease severity, and thrombocytopenia has repeatedly been identified as a marker of malaria severity [13,14]. The weak ALT–AST correlation (ρ = 0.186) indicates modest, concurrent transaminase activity. The absence of a correlation between hemoglobin and indirect bilirubin suggests that the degree of anemia was not tracked by bilirubin-reflected hemolysis in this cohort.

Temporal trend in AST. AST increased significantly across 2021–2025 (ρ = 0.364, p = 0.006). One explanation is year-to-year variation in case mix, particularly the share of *P. falciparum* and mixed infections, which peaked at 34.5% of cases in 2023 and are more often associated with hepatic involvement. However, clinical severity indicators were unavailable, changes in laboratory assays or reporting practices over time could not be evaluated, and AST values were sparse in the middle years, so the cause cannot be established and the finding needs confirmation in prospective studies. The other parameters showed no temporal trend, so the change appears specific to AST rather than a general deterioration. Case numbers also rose from 5 to 35 across the period, which reflects the sampling window, and species proportions could only be described, not tested.

Strengths and limitations

Strengths include an integrated hematological–hepatic profile, a five-year window with a formal temporal analysis, and the use of non-parametric methods after normality testing with Bonferroni-corrected post-hoc comparisons.

Limitations include the single-center, retrospective design, which limits generalizability and precludes causal inference; the small sample, especially of falciparum (n = 21) and mixed (n = 10) infections, which limits power; diagnosis by MP ICT without

parasite density; absence of clinical, treatment and outcome data; small and uneven yearly subgroups with substantial missing AST data in 2022–2023; use of a single hemoglobin reference range across sexes and ages; and a species-by-year pattern that could be described but not tested.

CONCLUSION

Anemia and thrombocytopenia were the most consistent laboratory abnormalities among malaria-positive patients in Karachi, while liver function parameters were mostly within reference limits. P. falciparum was associated with lower hemoglobin and higher AST than P. vivax, and platelet count correlated inversely with bilirubin. AST rose over 2021–2025, suggesting that hepatic involvement may be increasing at this center. Routine blood counts and liver function tests, with surveillance of trends over time, are valuable in assessing malaria and in identifying patients with falciparum infection at greater risk of hematological and hepatic compromise. Larger, multicenter prospective studies that include parasite density and clinical severity are needed.

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