

Comparative Analysis of Hematological, Biochemical, and Inflammatory Biomarkers in Malaria and Dengue Patients in an Endemic Setting of Pakistan

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Abstract

Objective

To compare the hematological, biochemical, and selected derived inflammatory biomarker profiles of laboratory-confirmed malaria and dengue patients presenting to secondary-care hospitals in District Swat, Khyber Pakhtunkhwa, Pakistan, and to identify routine laboratory parameters with the greatest potential to support early clinical differentiation of the two infections in resource-constrained endemic settings.

Methods

A hospital-based comparative cross-sectional study was conducted at the Tehsil Headquarter (THQ) and District Headquarter (DHQ) hospitals of District Swat. Fifty-five malaria and 55 dengue laboratory-confirmed cases were enrolled through consecutive sampling after written informed consent. Hematological parameters (hemoglobin, hematocrit, total white blood cell count, platelet count, neutrophils, lymphocytes, monocytes, eosinophils), biochemical markers (blood urea, serum creatinine, total bilirubin, alanine aminotransferase (ALT), and derived inflammatory indices (neutrophil-to-lymphocyte ratio (NLR) and neutrophil-to-monocyte ratio (NMR) were measured on venous blood drawn at presentation. All analyses were performed in SPSS version 26.0, with a two-sided alpha of 0.05.

Results

The 110 enrolled patients comprised 55 malaria (mean age 21.76 ± 16.82 years; 58.2% male) and 55 dengue (mean age 31.71 ± 14.41 years; 61.8% male) cases. Dengue patients were significantly older ($p = 0.001$) and had a marginally higher mean body temperature ($102.98 \pm 0.76^{\circ}\text{F}$ vs $102.64 \pm 0.95^{\circ}\text{F}$; $p = 0.037$); sex distribution did not differ ($p = 0.846$). Hemoglobin (14.81 ± 2.20 vs 12.41 ± 1.70 g/dL; $p < 0.001$; $d = +1.26$) and hematocrit (41.52 ± 6.04 vs $33.99 \pm 4.81\%$; $p < 0.001$; $d = +1.44$) were significantly higher in dengue. Biochemically, dengue patients had significantly higher blood urea (43.25 ± 11.45 vs 29.51 ± 8.12 mg/dL; $p < 0.001$), serum creatinine (1.05 ± 0.28 vs 0.84 ± 0.40 mg/dL; $p = 0.001$), and ALT (119.67 ± 55.32 vs 52.73 ± 27.25 U/L; $p < 0.001$). Total bilirubin ($p = 0.082$), total white cell count, platelet count, leukocyte differentials, NLR ($p = 0.603$), and NMR ($p = 0.928$) did not differ significantly between groups.

Conclusion

Malaria and dengue patients presenting to secondary care in District Swat exhibit distinct hematological and biochemical profiles. Higher hemoglobin, hematocrit, blood urea, serum creatinine, and ALT,

consistent with the plasma-leakage and hepatic/renal tropism of dengue, retained the largest effect sizes and are the most promising routine laboratory candidates for an ancillary differentiation algorithm.

Introduction

Mosquito-borne infectious diseases remain a leading cause of acute febrile morbidity and mortality across tropical and subtropical regions, where sustained warmth, surface water, and peri-domestic container habitats sustain vector breeding throughout much of the year. Among these infections, malaria and dengue fever are the most prominent causes of acute febrile illness globally. Malaria continues to be a significant cause of morbidity and mortality in low- and middle-income countries, while dengue has expanded rapidly over recent decades because of urbanization, climate change, and increased human mobility [1, 2]. Both diseases are endemic in many parts of Asia, Africa, and Latin America, including Pakistan [3].

Malaria is initiated by the bite of an infected female *Anopheles* mosquito, which transmits protozoan parasites of the genus *Plasmodium* (predominantly *P. falciparum* and *P. vivax* in Pakistan). Clinical presentation typically includes fever, chills, anemia, and a range of systemic complications whose severity tracks with parasitaemia and host immunity [4]. Dengue fever, by contrast, is a viral infection caused by dengue virus (family *Flaviviridae*, serotypes DENV-1–4), transmitted primarily by *Aedes aegypti* and secondarily by *Aedes albopictus*. Its clinical spectrum ranges from uncomplicated pyretic illness to severe dengue with plasma leakage, haemorrhage, and shock [5]. In endemic areas, the two diseases share early symptoms: fever, headache, myalgia, and malaise, making clinical differentiation unreliable within the first 48 to 72 hours of presentation [6].

This symptom overlap places laboratory parameters at the center of differential diagnosis. Previous studies have shown that hematological abnormalities such as anemia, hemoconcentration, leukocyte alterations, and thrombocytopenia may help distinguish malaria from dengue [7–9]. Biochemical abnormalities, particularly renal and hepatic derangements, may reflect differing patterns of organ involvement between the two infections [10–12]. In recent years, attention has also turned to derived inflammatory indices calculable from routine blood counts most notably the neutrophil-to-lymphocyte ratio (NLR) and the neutrophil-to-monocyte ratio (NMR), because they may capture host inflammatory response in a simple, low-cost manner and are obtainable from any automated complete blood count. A 2026 meta-analysis found NLR to be elevated in dengue relative to healthy controls but lower in dengue than in malaria, suggesting some discriminatory potential that is, however, sensitive to disease phase and severity [11].

In Pakistan, both malaria and dengue are major seasonal health problems, particularly in Khyber Pakhtunkhwa (KP), where heavy monsoon rains, recurrent floods, and changing climatic conditions facilitate mosquito breeding [13, 14]. KP alone recorded approximately 99,301 confirmed malaria cases by December 2023, representing roughly 90% of the provincial communicable-disease burden [14]. District Swat, in the northern part of the province, has experienced recurrent dengue outbreaks since

2017 and remains a high-burden site for both infections during the post-monsoon months [15]. Despite the local relevance, comparative data on hematological, biochemical, and inflammatory biomarkers measured simultaneously in the two infections that remain scarce for this region. This study was therefore conducted to compare the laboratory profiles of malaria and dengue patients in District Swat and to identify routine markers with the greatest potential to support early clinical differentiation in a resource-constrained endemic setting.

Methodology

Study Design and Setting

A hospital-based comparative cross-sectional study was conducted in District Swat, in the northern region of Khyber Pakhtunkhwa, Pakistan, between April and December 2025. The district is characterised by seasonal rainfall and prolonged monsoon conditions favourable for mosquito breeding and the transmission of both malaria and dengue. Data were collected from the Tehsil Headquarter (THQ) and District Headquarter (DHQ) hospitals, both of which manage a high volume of acute febrile illness during the post-monsoon transmission season. Ethical approval was obtained from the institutional ethics review committee (reference number to be inserted on acceptance), and written informed consent (or parental/guardian consent for minors) was obtained from all enrolled participants.

Inclusion and Exclusion Criteria

Patients presenting with acute febrile illness during the study period were enrolled through consecutive sampling. All age groups and both sexes were eligible if they had laboratory-confirmed malaria (peripheral blood smear microscopy or a rapid diagnostic test) or laboratory-confirmed dengue (NS1 antigen and/or IgM antibody-based testing). Patients with documented co-infections were excluded, as were those with chronic hematological disease, chronic liver disease, chronic kidney disease, or current medications known to affect hematological parameters. Recommendation for the next iteration: dengue cases should additionally be stratified by the 2009 WHO/TDR severity classification (dengue without warning signs / with warning signs / severe dengue), and malaria cases should be stratified by *Plasmodium* species (*vivax* / *falciparum* / mixed).

Laboratory Procedures

Venous blood samples were drawn from all enrolled patients under aseptic conditions at the time of presentation, before any volume resuscitation where possible. Blood collected in EDTA anticoagulant was used for the complete blood count (hemoglobin, hematocrit, total white blood cell count, platelet count, and the differential including neutrophils, lymphocytes, monocytes, and eosinophils) on a calibrated automated haematology analyser. Serum samples were used for biochemical investigations: blood urea, serum creatinine, total bilirubin, and alanine aminotransferase (ALT), measured by standard

enzymatic/colorimetric methods. The derived inflammatory ratios, neutrophil-to-lymphocyte ratio (NLR) and neutrophil-to-monocyte ratio (NMR) were calculated from the absolute differential counts. The timing of phlebotomy relative to symptom onset (in days) was recorded for each patient to support phase-stratified analysis in a subsequent phase of work.

Statistical Analysis

Data were cleaned in Microsoft Excel and analysed in SPSS version 26.0. Continuous variables were summarised as mean $\pm$ standard deviation and compared between groups using the independent-samples t-test; categorical variables were summarised as frequencies and percentages and compared using the chi-square test. In addition to p-values, Cohen's d effect sizes and approximate 95% confidence intervals for the between-group difference are reported to convey the magnitude of separation. A two-sided p-value of less than 0.05 was deemed statistically significant. Given the 9.95-year mean age gap between the two arms, the between-group differences in the most age-sensitive parameters (hemoglobin, hematocrit, serum creatinine, ALT) are flagged as potentially confounded; a multivariable logistic regression adjusting for age (and, in a second model, for sex and days-of-illness) is planned as a follow-on analysis and is discussed in Section 2.5. A receiver-operating-characteristic analysis for the five largest-effect parameters is also planned to quantify diagnostic utility before any clinical-decision rule is proposed.

Results

A total of 110 patients were included in the final analysis 55 malaria and 55 dengue cases. The demographic and clinical characteristics of the two arms are summarised in Fig. 1. Dengue patients were significantly older than malaria patients (mean 31.71 ± 14.41 years vs 21.76 ± 16.82 years; $p = 0.001$). Males were slightly more frequent in both groups (58.2% and 61.8%, respectively), but the gender distribution did not differ significantly ($p = 0.846$). Mean body temperature was significantly higher in dengue patients ($102.98 \pm 0.76^\circ\text{F}$ vs $102.64 \pm 0.95^\circ\text{F}$; $p = 0.037$); however, this difference (0.34°F) is unlikely to be clinically meaningful on its own.

Figure 1 Demographic and clinical characteristics. (A) Age in years; (B) Body temperature in $^\circ\text{F}$. Error bars represent one standard deviation. ** $p < 0.01$, * $p < 0.05$ (independent-samples t-test).

Hematological comparison revealed that dengue patients had significantly higher hemoglobin and hematocrit values than malaria patients (Table 1, Fig. 2). Mean hemoglobin was 14.81 ± 2.20 g/dL in dengue versus 12.41 ± 1.70 g/dL in malaria ($p < 0.001$; Cohen's $d = +1.26$, large effect), and mean hematocrit was $41.52 \pm 6.04\%$ in dengue versus $33.99 \pm 4.81\%$ in malaria ($p < 0.001$; $d = +1.44$, large effect). In contrast, the two groups did not differ significantly in total white blood cell count, platelet count, or any leukocyte differential parameter (neutrophils, lymphocytes, monocytes, eosinophils). Eosinophil percentages showed a trend toward higher values in malaria ($0.62 \pm 0.91\%$ vs $0.33 \pm 0.67\%$; $p = 0.059$), which did not reach the conventional threshold for statistical significance.

Table 1
Comparison of hematological parameters between malaria and dengue patients.

Parameter	Malaria (n = 55)	Dengue (n = 55)	p-value	Cohen's d
Hemoglobin (g/dL)	12.41 ± 1.70	14.81 ± 2.20	< 0.001	+ 1.26
Hematocrit (%)	33.99 ± 4.81	41.52 ± 6.04	< 0.001	+ 1.44
WBC count (/cmm)	6098.18 ± 1958.22	5485.45 ± 2287.44	0.134	-0.29
Platelet count (/cmm)	133327.27 ± 37021.04	134436.36 ± 36422.30	0.874	+ 0.03
Neutrophils (%)	70.76 ± 10.29	70.87 ± 10.61	0.956	+ 0.01
Lymphocytes (%)	20.04 ± 8.14	19.27 ± 7.96	0.620	-0.10
Monocytes (%)	8.40 ± 3.72	9.44 ± 4.90	0.214	+ 0.24
Eosinophils (%)	0.62 ± 0.91	0.33 ± 0.67	0.059	-0.37

Biochemical analysis showed significant differences between the two infections (Table 2, Fig. 3). Dengue patients had significantly higher blood urea (43.25 ± 11.45 mg/dL vs 29.51 ± 8.12 mg/dL; $p < 0.001$; $d = + 1.40$), serum creatinine (1.05 ± 0.28 mg/dL vs 0.84 ± 0.40 mg/dL; $p = 0.001$; $d = + 0.62$), and ALT (119.67 ± 55.32 U/L vs 52.73 ± 27.25 U/L; $p < 0.001$; $d = + 1.55$). Total bilirubin did not differ significantly between the groups (1.39 ± 0.51 mg/dL in malaria vs 1.26 ± 0.27 mg/dL in dengue; $p = 0.082$; $d = - 0.32$).

Table 2
Comparison of biochemical parameters between malaria and dengue patients.

Parameter	Malaria (n = 55)	Dengue (n = 55)	p-value	Cohen's d
Blood urea (mg/dL)	29.51 ± 8.12	43.25 ± 11.45	< 0.001	+ 1.40
Serum creatinine (mg/dL)	0.84 ± 0.40	1.05 ± 0.28	0.001	+ 0.62
Total bilirubin (mg/dL)	1.39 ± 0.51	1.26 ± 0.27	0.082	-0.32
ALT / SGPT (U/L)	52.73 ± 27.25	119.67 ± 55.32	< 0.001	+ 1.55

The derived inflammatory ratios did not differ significantly between the groups (Fig. 4). The neutrophil-to-monocyte ratio (NMR) was 10.39 ± 4.97 in malaria and 10.50 ± 7.22 in dengue ($p = 0.928$; $d = + 0.02$, negligible effect), and the neutrophil-to-lymphocyte ratio (NLR) was 4.48 ± 2.69 in malaria and 4.76 ± 3.03 in dengue ($p = 0.603$; $d = + 0.10$, negligible effect). These null findings are interpreted in Section 2.5 in light of prior Pakistani and international literature suggesting variable NLR behaviour across disease phases and severity strata.

To synthesise the comparative profile across all fourteen parameters, two additional visualisations are provided. Figure 5 presents a radar chart in which each parameter is normalised to the malaria value (= 1.0), so that the dengue profile traces the relative deviation from the malaria reference. Figure 6 ranks all fourteen parameters by Cohen's d effect size with approximate 95% confidence intervals, providing a

single-image summary of discriminatory value. The five parameters with the largest absolute effect sizes ALT ($d = +1.55$), hematocrit ($d = +1.44$), blood urea ($d = +1.40$), hemoglobin ($d = +1.26$), and serum creatinine ($d = +0.62$) are precisely the five that achieved statistical significance, and all are positive (i.e., higher in dengue). All non-significant parameters cluster near $d = 0$, confirming that the null findings are not artefacts of small sample size but reflect genuine distributional overlap.

Figure 6 Ranking of discriminatory value across all fourteen biomarkers by Cohen's d effect size with approximate 95% confidence intervals. Positive values indicate higher mean in dengue; negative values indicate a higher mean in malaria. Filled markers indicate statistical significance ($p < 0.05$); grey markers indicate non-significance.

Discussion

This study compared the hematological, biochemical, and selected derived inflammatory biomarker profiles of malaria and dengue patients presenting to secondary-care hospitals in District Swat, Pakistan. Several routine laboratory parameters differed significantly between the two diseases and may provide useful adjunctive information for clinical differentiation in this endemic setting. The discussion that follows interprets each cluster of findings, engages directly with the prior literature (including the discrepant Pakistani NLR evidence), and addresses the confounding introduced by the age imbalance between arms.

Hemoglobin and Hematocrit

The most clinically meaningful findings are the significantly higher hemoglobin and hematocrit values in dengue relative to malaria ($d = +1.26$ and $d = +1.44$ respectively; both $p < 0.001$). This pattern is both biologically plausible and consistent with the pathophysiology of each disease. An elevated hematocrit in dengue is the laboratory signature of hemoconcentration resulting from endothelial plasma leakage; an increase of greater than 20% from baseline (or an absolute value above approximately 40% in adult males) is a recognised warning sign in the 2009 WHO/TDR classification and a trigger for closer monitoring and judicious fluid therapy [7, 8, 16]. Conversely, the lower hemoglobin and hematocrit observed in malaria are consistent with the well-described hemolysis of parasitised erythrocytes, the accelerated clearance of both parasitised and unparasitised red cells, and the marrow suppression that characterises acute malarial infection and that may progress to malarial anemia [9, 17]. The size of the effect (a 7.5-percentage-point absolute hematocrit difference) suggests that red-cell indices have genuine discriminatory value at the bedside, although the absolute thresholds will require local validation.

Leukocyte and Platelet Parameters

No significant differences were observed in total white blood cell count, platelet count, or any of the leukocyte differential parameters between malaria and dengue patients. This is at odds with some previous reports in which dengue presented more frequently with leukopenia and in which thrombocytopenia differed in magnitude between the two infections. The most likely explanation is that, in our cohort, both arms presented with comparable degrees of thrombocytopenia and leukocyte perturbation a pattern that has been reported when hospital-based enrolment captures patients at a relatively advanced stage of illness [18–21]. In other words, by the time a patient reaches secondary care in Swat, both infections have produced platelet and white-cell changes that converge toward a similar range, eroding the early discriminatory value of these parameters. The marginal trend toward higher eosinophil percentages in malaria ($p = 0.059$) is intriguing and deserves exploration in a larger study, as eosinophilia is more typically a feature of convalescent or chronic parasitaemia than of acute presentation.

Inflammatory Ratios Engaging the Discrepant Literature

NLR and NMR, the derived inflammatory ratios assessed here, did not differ significantly between malaria and dengue patients ($p = 0.603$ and $p = 0.928$, respectively), and the corresponding effect sizes were negligible ($d = +0.10$ and $d = +0.02$). This null finding deserves explicit comparison with the prior Pakistani literature. Muhammad et al. (2025), in a study published in the Pakistan Journal of Pathology, reported that NLR had “strong discriminatory value” between dengue and malaria and proposed it as a cost-effective diagnostic and prognostic marker [10]. A 2026 meta-analysis similarly reported NLR to be lower in dengue than in malaria [11]. Our null result therefore diverges from the prevailing direction of literature. Three non-exclusive explanations should be considered. First, the phase of illness at sampling is a strong determinant of NLR, and our hospital-based enrolment may have captured patients at a point in the disease course where the neutrophil and lymphocyte responses of the two infections have converged. Second, the local disease mix in Swat (*P. vivax* predominance, dengue serotype composition, prior exposure history) may differ from the populations in which NLR performed well. Third, the absence of severity stratification, particularly the absence of a severe-dengue subgroup may have attenuated any between-group NLR signal that would have been visible had severe cases been analysed separately. The inflammatory ratios, while inexpensive and easily calculable, therefore cannot be recommended for malaria-versus-dengue differentiation in this setting without further, severity-stratified evidence.

Biochemical Parameters Renal and Hepatic Involvement

Marked biochemical differences were observed between the dengue and malaria groups, all in the direction of higher values in dengue. Blood urea ($d = +1.40$), serum creatinine ($d = +0.62$), and ALT ($d = +1.55$) were all significantly elevated in dengue, while total bilirubin was not ($p = 0.082$). The renal findings most plausibly reflect prerenal compromise dehydration from reduced oral intake, intravascular volume depletion from plasma leakage, and systemic inflammatory stress during the acute dengue phase [23, 24]. The hepatic findings are consistent with the well-recognised hepatic tropism of dengue; hepatocyte injury and the release of transaminases are common in dengue fever, and ALT elevations several-fold

above the upper limit of normal are not unusual [12, 25]. Bilirubin, by contrast, did not distinguish the two infections in our cohort, suggesting that haemolysis-related jaundice in malaria and hepatic-related cholestasis in dengue converge on a similar bilirubin range by the time of hospital presentation; bilirubin alone is therefore not a useful differentiator.

Demographic and Confounding Considerations

A notable finding was that dengue patients were significantly older than malaria patients (mean 31.71 vs 21.76 years; $p = 0.001$). The 9.95-year age gap is a genuine confounder for several of the parameters that differed significantly between arms: hemoglobin, hematocrit, and creatinine all rise modestly but measurably with adult age, and ALT exhibits an age-dependent trend. It is therefore possible that a portion of the observed between-arm difference in these parameters reflects demographic imbalance rather than (or in addition to) the underlying infectious syndrome. The bivariate analysis reported here cannot disentangle these two contributions; the planned multivariable logistic regression adjusting for age (and in a second model for sex and days-of-illness) is required before the differences can be unambiguously attributed to dengue versus malaria pathophysiology. In the interim, the effect sizes are large enough ($d = +1.26$ to $+1.55$ for the top five parameters) that a substantial component is very likely disease-specific, but the precise magnitude of the disease effect remains to be estimated. The age gap itself may reflect differences in exposure history (occupational and peri-domestic exposure to *Aedes* versus *Anopheles*), differences in health-seeking behaviour, or epidemiological differences in the local transmission of the two infections in Swat, and merits a focused epidemiological inquiry.

Synthesis Discriminatory Hierarchy

Combining the effect-size ranking (Fig. 6) with the statistical significance results yields a clear discriminatory hierarchy. Hemoglobin, hematocrit, blood urea, serum creatinine, and ALT occupied the top five positions and were the only parameters to achieve statistical significance, all in the direction of higher values in dengue. Total white cell count, platelet count, the leukocyte differentials, NLR, NMR, and total bilirubin occupied the lower ranks, all with negligible effect sizes and non-significant p -values. This hierarchy provides a transparent, evidence-based shortlist for the next phase of work, which should construct and validate a multivariable diagnostic score built around the five top-ranked parameters, with age as a covariate.

Strengths and Limitations

A major strength of the present study is the simultaneous comparison of a broad panel of routinely available hematological and biochemical parameters between malaria and dengue patients in a real-world endemic setting, supplemented by an exploratory assessment of two derived inflammatory ratios. The study's clinical relevance is enhanced by the ease of availability of all tests performed; the panel is reproducible in any secondary-care hospital with a basic laboratory.

The limitations are several and are stated candidly. First, the cross-sectional design cannot capture the temporal evolution of any parameter, which is particularly relevant for hematocrit (which rises as plasma

leakage progresses) and for platelets (which fall before clinical presentation and recover during convalescence). Second, the study did not stratify dengue cases by the 2009 WHO/TDR severity classification, nor did it stratify malaria cases by Plasmodium species; both stratifications are necessary to attribute differences to pathophysiology rather than to severity or species composition. Third, the timing of phlebotomy relative to symptom onset was not recorded for the present analysis, introducing potential phase-of-illness bias. Fourth, the hospital-based enrolment likely oversamples patients with more severe disease and undersamples those with milder illness who do not present to secondary care, limiting generalizability to primary-care or community settings. Fifth, the 9.95-year mean age gap between arms is a material confounder that the bivariate analyses do not address; an age-adjusted (and ideally severity-stratified) multivariable model is required before any between-group difference is attributed to the infectious syndrome. Sixth, the sample size of 110 is modest, and the study is statistically underpowered for the smaller between-group differences (e.g., eosinophils, $p = 0.059$). A larger, multi-site study ideally across multiple districts of Khyber Pakhtunkhwa is recommended to validate and extend these findings.

Conclusion

This study demonstrates that patients with malaria and dengue fever presenting to secondary care in District Swat, Pakistan, exhibit distinct and clinically meaningful laboratory profiles. Dengue patients had significantly higher hemoglobin, hematocrit, blood urea, serum creatinine, and ALT, a constellation consistent with plasma leakage, hepatic tropism, and prerenal-renal compromise characteristic of dengue, with effect sizes ranging from large to very large (Cohen's $d = +0.62$ to $+1.55$). Total white blood cell count, platelet count, leukocyte differential, NLR, NMR, and total bilirubin did not differ significantly between groups and are unlikely to be useful differentiators in this setting. Together, these findings indicate that routine hematological and biochemical investigations, particularly red-cell indices and renal and hepatic function markers, may prove useful adjuncts in differentiating malaria from dengue at the bedside.

Declarations

Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

Ethical approval for the study was granted by the Research Ethics Committee of KMU-Institute of Health Sciences, Swat, Pakistan (No: KMU/HIS/REC/0005).

Financial Disclosure

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Author Contribution

Muhammad Asif Zeb, Ahsan Saidal, and Aftab Tahir Khan conceived the idea and designed the study. Muhammad Asif Zeb, Saifullah, Ismail, and Shahi Zeb performed the laboratory investigations and validated the experiments. Tariq Aziz and Aftab Tahir Khan contributed to clinical data collection and patient enrolment. Statistical analysis and data interpretation were performed by Muhammad Asif Zeb, Ahsan Saidal, and Tariq Aziz. Ahsan Saidal and Aftab Tahir Khan provided overall supervision and critically revised the manuscript. All authors read and approved the final manuscript.

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Figures

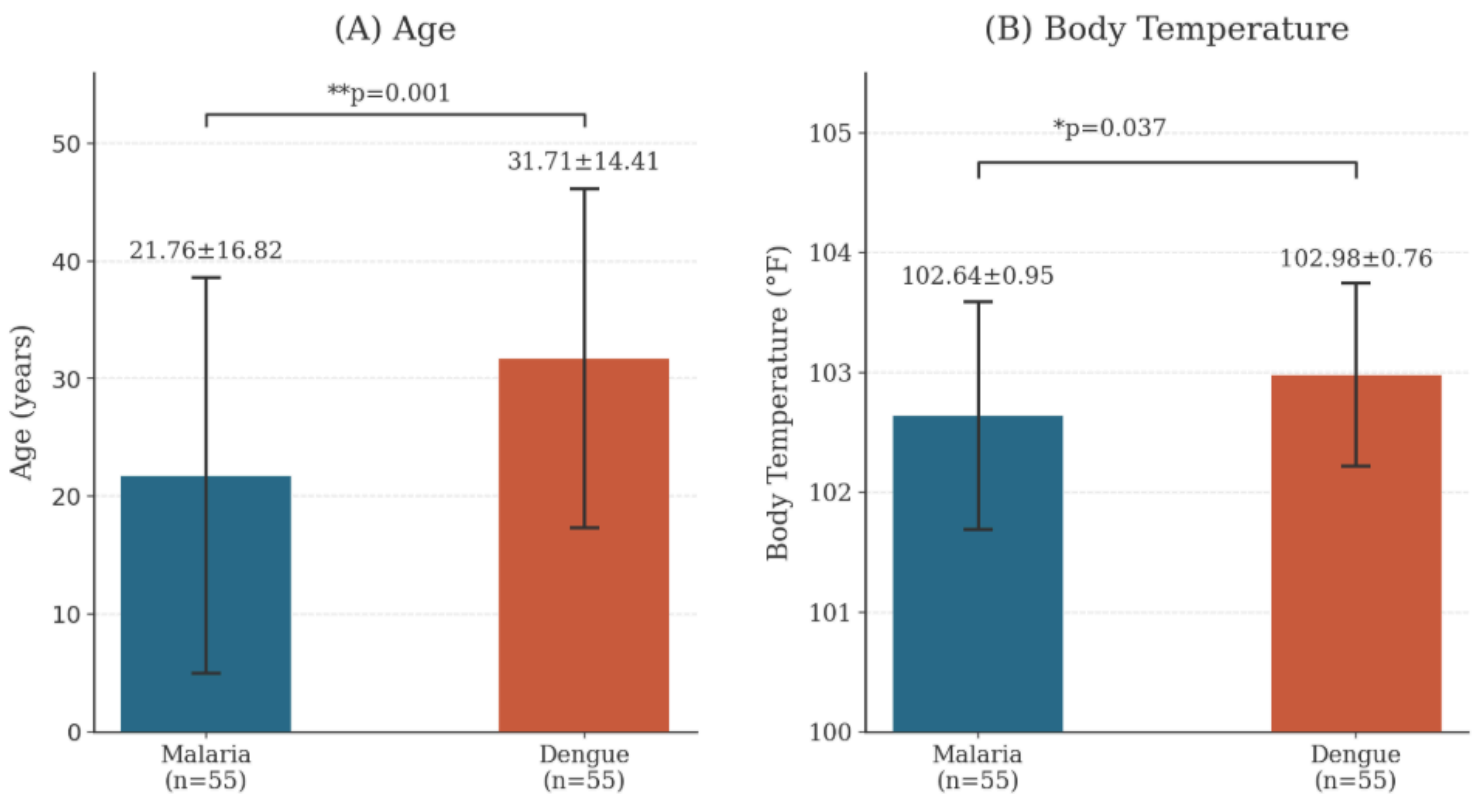


Figure 1

Demographic and clinical characteristics. (A) Age in years; (B) Body temperature in °F. Error bars represent one standard deviation. **p < 0.01, *p < 0.05 (independent-samples t-test).

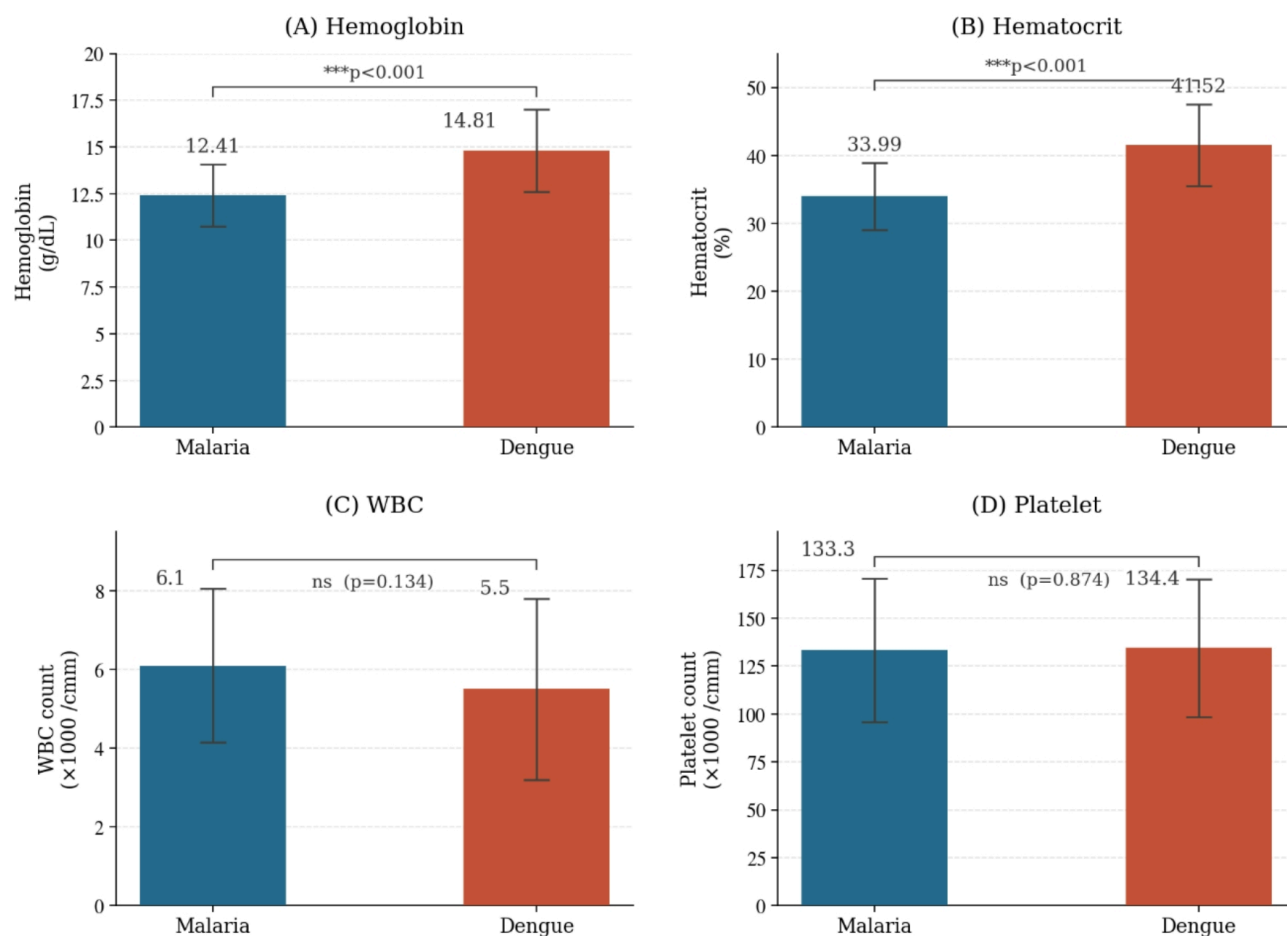


Figure 2

Comparison of hematological parameters between malaria and dengue patients. (A) Hemoglobin (g/dL); (B) Hematocrit (%); (C) Total white blood cell count (x1000 /cmm); (D) Platelet count (x1000 /cmm). Error bars represent one standard deviation. ***p < 0.001; ns = not significant.

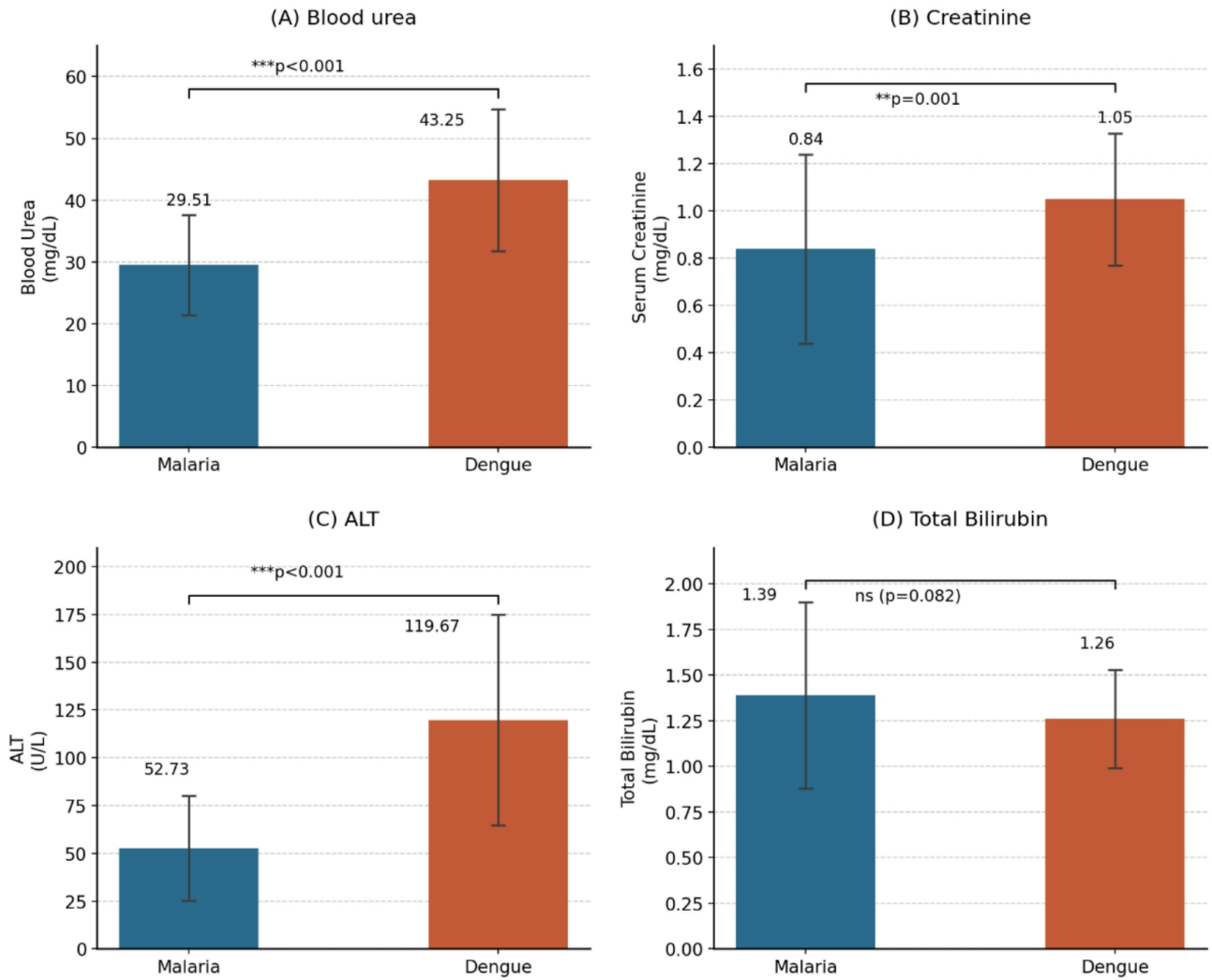


Figure 3

Comparison of biochemical parameters between malaria and dengue patients. (A) Blood urea (mg/dL); (B) Serum creatinine (mg/dL); (C) ALT (U/L); (D) Total bilirubin (mg/dL). Error bars represent one standard deviation. ***p < 0.001, **p < 0.01; ns = not significant.

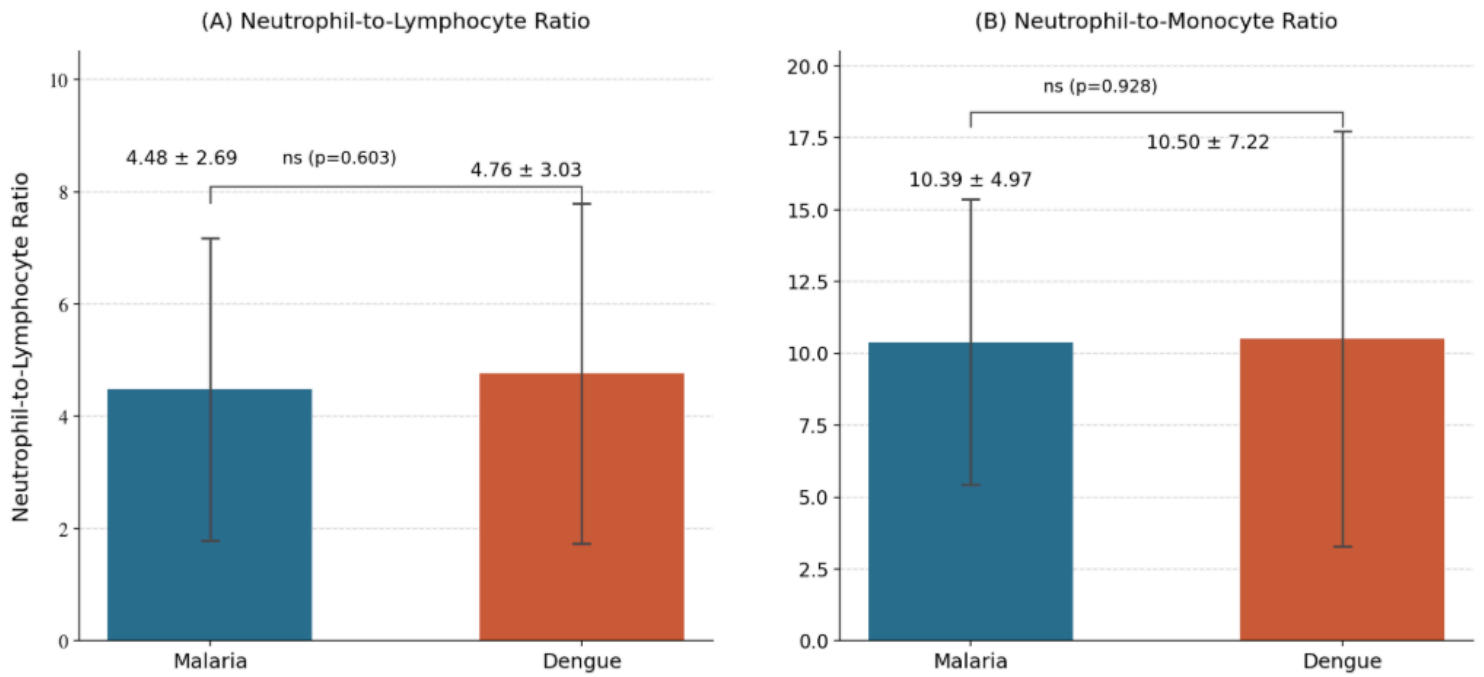


Figure 4

Comparison of derived inflammatory ratios between malaria and dengue patients. (A) Neutrophil-to-lymphocyte ratio (NLR); (B) Neutrophil-to-monocyte ratio (NMR). Error bars represent one standard deviation. ns = not significant.

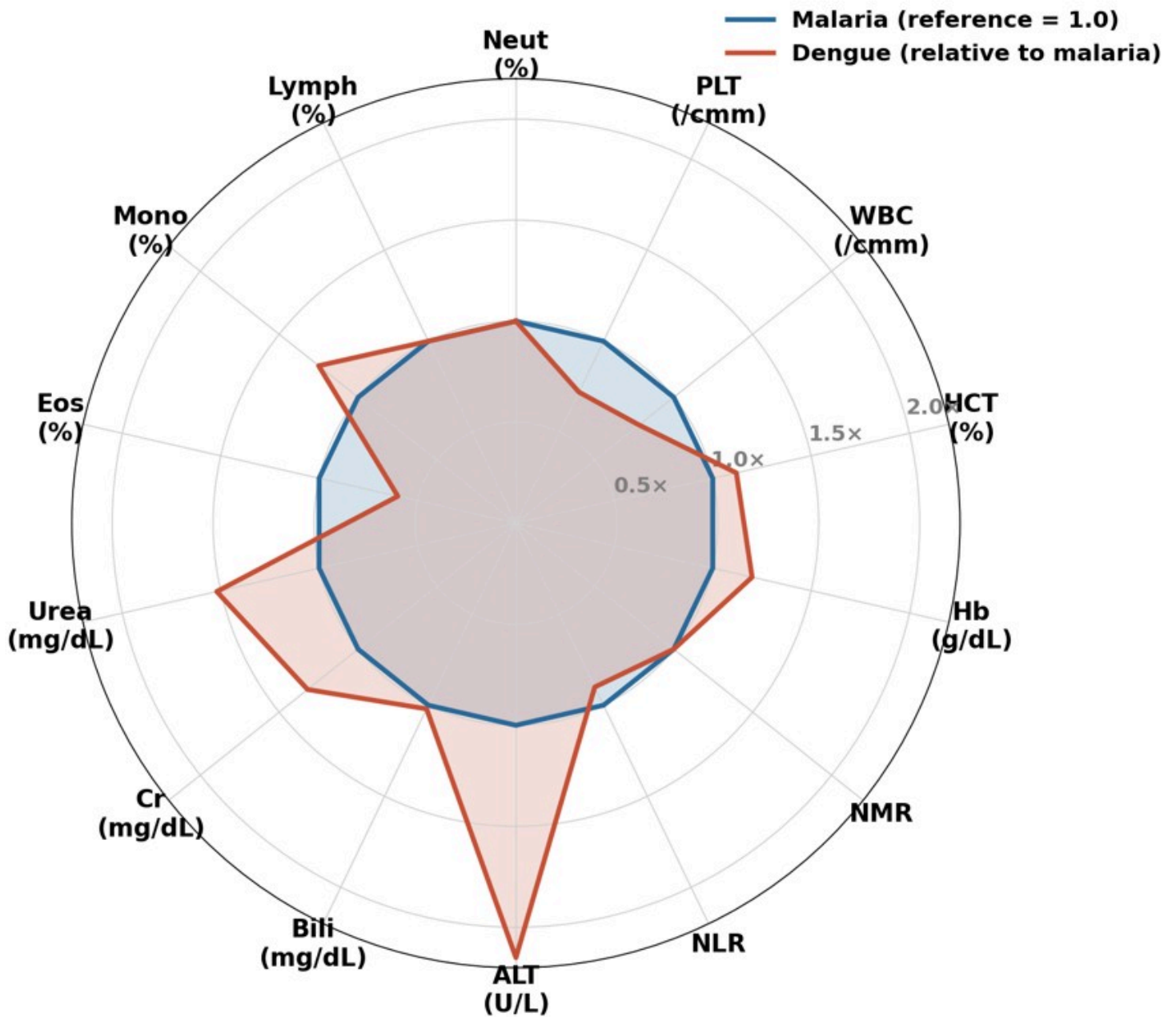


Figure 5

Relative biomarker profile. Each parameter is normalised to the malaria value (reference = 1.0); the dengue trace shows the relative deviation. Values > 1.0 indicate higher mean in dengue; values < 1.0 indicate higher mean in malaria. The dashed ring marks parity between the two groups.

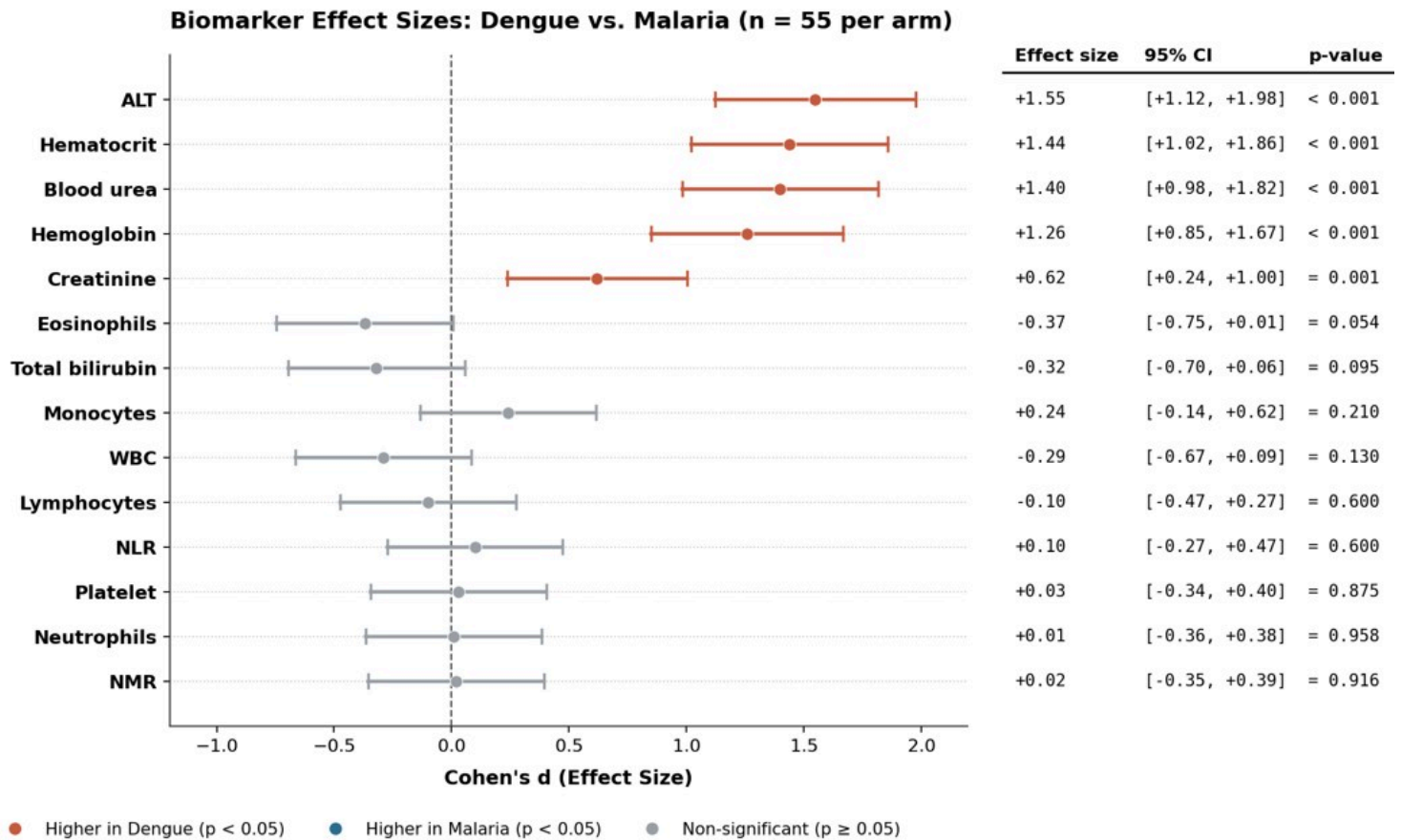


Figure 6

Ranking of discriminatory value across all fourteen biomarkers by Cohen's d effect size with approximate 95% confidence intervals. Positive values indicate higher mean in dengue; negative values indicate a higher mean in malaria. Filled markers indicate statistical significance ($p < 0.05$); grey markers indicate non-significance.