

Research Article

Haematologic and Biochemical Parameters to Differentiate Severe Malaria from Uncomplicated Malaria in a Ghanaian Population in Sub-Saharan Africa

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Abstract

Malaria is classified as either uncomplicated (UM) or severe (SM), but the mechanism underlying the progression from uncomplicated to severe is still unclear. This study aimed to assess haematologic and biochemical parameters as potential prognostic biomarkers for differentiating SM from UM in a Ghanaian population. A descriptive cross-sectional study was conducted to sample 166 participants, comprising 42 healthy controls, 78 uncomplicated malaria cases, and 46 severe malaria cases. Blood samples were analysed for full blood count, liver function test, renal function test, and serum angiopoietins. Statistical analyses were carried out using GraphPad Prism 9 software. Median and interquartile ranges, Mann-Whitney U test, and Kruskal-Wallis analysis were done to compare groups. The haemoglobin and platelet counts of SM patients were significantly lower than those of the UM group ($p < 0.05$). However, the White Blood Cell (WBC) counts of severe malaria patients (7.4, IQR: 5.4 - 10.6) were significantly higher than the uncomplicated malaria population (5.7, IQR: 5.0 - 6.5) ($p < 0.001$). Serum levels of bilirubin (total and direct), alanine transaminase (ALT), aspartate transaminase (AST), gamma-glutamyl transferase (GGT), alkaline phosphatase (ALP), and total proteins in severe malaria were significantly higher than uncomplicated malaria group ($p < 0.001$). These findings indicate that haemoglobin, platelet, creatinine, urea, AST, ALT, GGT and bilirubin levels may serve as biomarkers for distinguishing severe from uncomplicated malaria.

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Keywords

Malaria, Haematologic, Biochemical, Prognostic

1. Introduction

Malaria, caused by *Plasmodium* species, is classified as uncomplicated or severe [1]. Based on the severity, the two main types of malaria infection can be differentiated with the aid of a meticulous clinical examination of the patient [2]. Despite several interventions put in place to control malaria, the prevalence of the disease is still a worrying situation among the Ghanaian population [3]. Although it is estimated that about 250 million cases of malaria occur annually [4], only a small percentage of those progress to severe malaria, which is life-threatening [5, 6]. There is no definitive diagnosis for severe malaria because of its non-specific manifestation coupled with confounders such as diarrhoea in places where the infection is very endemic [7]. Numerous clinical symptoms, ranging from asymptomatic to varying degrees of fever, are characteristic of defined malaria. Neurological complications and separate or overlapping dysfunction of the cardiovascular, respiratory, hepatic, renal, haematologic, and metabolic systems are all part of the severity of malaria [8].

Prior research on how malaria infections affect blood parameters has shown that the most significant haematological indicators of malaria infection and clinical severity with fatal outcomes are a large drop in platelet counts, anaemia, leucocytosis, or leucopenia [8]. On the other hand, a study by [9] concluded that haematological alterations are not always accurate laboratory markers of malaria caused by *Plasmodium falciparum*. But depending on the endemicity, pre-existing hemoglobinopathies, environmental factors, nutritional state, and malaria immunity, these characteristics can change to varying degrees [10]. The degree to which these haematologic parameters change needs to be looked at.

The number of promising and appealing candidates of prognostic biomarkers that can distinguish between Uncomplicated malaria (UM) and/or severe malaria (SM), including multi-organ dysfunctions in SM, and the steadily worsening circumstance of SM is quite few. The identification of a reliable prognostic biomarker that can accurately and precisely identify people with or at risk of severe malaria would be useful. Therefore, in this study, we sought to assess haematologic and biochemical parameters as prognostic biomarkers for differentiating severe malaria from uncomplicated malaria in a Ghanaian population.

2. Materials and Methods

2.1. Study Population and Design

A cross-sectional study was employed to recruit 166 participants who attended the Seventh Day Adventist Hospital, Bremang, in the Suame Municipality of Ghana. The institution was selected because it serves as the main healthcare provider for most of the population living in the catchment area. The community inhabitants are primarily artisans and industrious traders. Cases were selected based on the World Health Organization (WHO) categorisation of malaria. For UM, the participants had a present or previous fever and a positive malaria test, and for SM, the participants had a previous or present fever, a positive test and a sign of organ dysfunction.

2.2. Sample Collection and Sample Analysis

5 mL of blood was aseptically collected and aliquoted into Ethylenediaminetetraacetic acid (EDTA) (2 mL) and serum separator tubes (3 mL). The EDTA sample was used for blood films (thin and thick) for the detection of malaria parasites according to the protocol described by Haggaz et al., (2014) and for full blood count (FBC) using a five (5) parts automated haematology analyser, Sysmex XN - 350 (Sysmex Corporation, Kobe, Japan 2019). The serum separator tube was allowed to clot and centrifuged at 3000rpm for 5 minutes and the serum separated into a plain tube, 1mL was used for biochemical analysis (liver and renal function tests) using the LE - Scientific Fully Automated Chemistry Analyzer LE Max - 2000 (LE Scientific Medfuture, Hamburg, Germany, 2021). The rest stored at -20 °C for the measurement of Angiopoietins -1 and -2 (ANG-1 & -2) levels by employing a double sandwich enzyme-linked immunosorbent assay (ELISA) technique according to the manufacturer's instructional manual (Melson Shanghai Chemical Ltd, 2020, ANG-1 KIT10062 ANG 2 -KIT10691) which works on the principle that any antigen present binds to the capture antibody once the sample is put to wells coated with a capture antibody. Before an enzyme-linked secondary antibody is administered and binds to the detecting antibody, an antigen-binding detecting antibody is first added. Following the addition of a substrate, this is changed by an enzyme to a form that can be detected.

2.3. Statistical Analysis

Statistical analyses were carried out using GraphPad Prism 9 software (GraphPad Software, San Diego, CA, USA). Statistically significant differences were set at a p-value <0.05. Mann-Whitney U test was performed to compare two groups, while the Kruskal-Wallis analysis was done to compare three or more groups, followed by Dunn's Multiple Comparison tests. Correlations between two continuous variables of interest were tested using the nonparametric Spearman's rank correlation (ρ). Multiple logistic regression was performed to identify the best predictors of severe malaria. Descriptive analysis was done using tables of means, medians, quartile ranges, and variances.

2.4. Ethics and Consent

The study was approved by the Committee for Human Research, Publication and Ethics (CHRPE) of Kwame Nkrumah University of Science and Technology (KNUST). Reference number CHRPE/AP/129/21.

3. Results

3.1. Description of Study Population

This study recruited a total of 166 participants between the ages of 1 - 70 years, comprising 46 (27.7%) SM cases, 78 (47.0%) UM cases, and 42 (25.3%) healthy controls (HC). The median age of the study participants was 24 (IQR: 5 - 38), and 26 (61.9%) were female, while 16 (38.1%) were male. [Table 1](#) summarises the parasite count of UM and SM based on their demographic characteristics. Among uncomplicated malaria patients, children less than 5 years of age recorded the highest parasitaemia (7346, IQR: 1994-26693); however, this was not statistically different from the other age groups (5-17 and ≥ 18 years) ($p = 0.649$). Sex, marital status, education, and occupation were not associated with parasitaemia in uncomplicated malaria subjects. Conversely, in the severe malaria population, those with basic education significantly recorded higher parasitaemia than their counterpart with secondary education ($p = 0.037$). The rest of the demographic characteristics for the severe malaria population did not affect the parasitaemia level ([Table 1](#)).

Table 1. Comparison of parasitaemia levels of uncomplicated and severe malaria within the various demographic characteristics.

Demographic characteristics	Uncomplicated malaria			Severe Malaria		
	n	Parasitaemia (/ μ L) Median (IQR)	P value	n	Parasitaemia (/ μ L) Median (IQR)	P value
Age range						
<5	6	7346 (1994 - 26693)		16	29589 (17150 - 102905)	
5-17	14	2808 (1397 - 7568)		14	29793 (14542 - 88230)	
≥ 18	58	2670 (1109 - 6716)	0.649	16	5461 (1871 - 32617)	0.075
Sex						
Female	42	2670 (680 - 6716)		22	26823 (2595 - 179603)	
Male	36	3623 (1208 - 8470)	0.190	24	23542 (5856 - 57785)	0.744
Marital status						
Single	26	2670 (1208 - 8470)		10	26823 (6542 - 50000)	
Marriage	30	1275 (787 - 6112)	0.546	4	3079 (1777 - 4380)	0.120
Education ^b						
No education						
Basic	36	2413 (840 - 4400)		14	29793 (9439 - 88705)	
Secondary	18	4208 (2670 - 8676)		14	6542 (2282 - 40296)	0.037
Tertiary	8	1641 (947 - 4531)	0.071	NA		

Demographic characteristics	Uncomplicated malaria			Severe Malaria		
	n	Parasitaemia (/µL) Median (IQR)	P value	n	Parasitaemia (/µL) Median (IQR)	P value
Occupation ^a						
Student	18	2670 (1208 - 8470)		8	28271 (5250 - 53455)	
Informal sector	32	3623 (1103 - 6586)		8	3141 (1871 - 9991)	0.253
Formal sector	6	2041 (1441 - 9510)	0.937	NA		-

^a only participants ≥ 18 years were included; ^b only participants ≥ 6 years were included; n = sample size; IQR = 1st-3rd quartile

3.2. Evaluation of Haematological and Biochemical Parameters as Biomarkers in Malaria Patients and Healthy Controls

Table 2 shows the comparison of clinical parameters as biomarkers in malaria patients (UM and SM) and HC. The parasite counts of the SM (24615, IQR: 3943 - 60541) population were significantly higher than UM (2808, IQR: 1090 - 8189). The haemoglobin and platelet count of SM patients were significantly lower than the UM group ($p < 0.05$). However, the white blood cells (WBC) of SM patients (7.4, IQR: 5.4 - 10.6)

were significantly higher than the UM population (5.7, IQR: 5.0 - 6.5) ($p < 0.001$). Serum levels of bilirubin (total and direct), alanine transaminase (ALT), aspartate transaminase (AST), gamma-glutamyl transferase (GGT), alkaline phosphatase (ALP), and total protein in the SM were significantly higher than the uncomplicated malaria group ($p < 0.001$) (Table 2).

The median Ang-1 levels in SM were lower (3.8 ng/L, IQR: 2.2 - 12.7) in comparison to UM (6.3 ng/L, IQR: 3.3 - 8.0) and HC (9.6 ng/L, IQR: 3.5 - 15.3). Ang-2 levels were higher in SM (19.1 ng/L, IQR: 9.0 - 25.8) compared to UM (15.7 ng/L, IQR: 2.6 - 27.4), but this was not statistically significant ($p = 0.152$).

Table 2. Comparison of clinical parameters and biomarkers in malaria patients and healthy controls.

Variable	Healthy controls (HC), n= 42	Uncomplicated malaria (UM), n=78	Severe malaria (SM), n = 46	P value for UM vs. SM
Haemoglobin	11.8 (11.3 - 12.4)	11.8 (10.8 - 13.1)	10.9 (9.2 - 12.5)	0.003
WBC	6.22 (5.0 - 8.1)	5.7 (5.0 - 6.5)	7.4 (5.4 - 10.6)	<0.001
Platelet count	270 (229 - 342)	149 (117 - 196)	108 (46 - 130)	<0.001
NEUT	41.6 (37.8 - 60.7)	69.8 (55.2 - 78.1)	71.5 (61.9 - 82.7)	0.124
LYMP	46.5 (30.3 - 53.3)	23.5 (14.9 - 33.5)	19.0 (12.1 - 29.9)	0.249
MXD	8.8 (7.2 - 10.2)	7.7 (6.1 - 12.1)	7.9 (4.7 - 8.9)	0.012
Total Bilirubin	5.2 (3.8 - 6.2)	8.1 (5.4 - 10.7)	11.2 (7.4 - 24.3)	<0.001
Direct Bilirubin	2.1 (1.2 - 3.2)	3.4 (1.9 - 4.3)	6.6 (4.1 - 16.1)	<0.001
ALT	7 (6 - 8)	9 (5.3 - 11.8)	12 (10 - 18.7)	<0.001
AST	21 (13 - 26)	17 (12 - 23.3)	26 (16.3 - 50)	<0.001
GGT	18 (11 - 22)	20 (13.3 - 28.8)	40 (18.3 - 49.5)	<0.001
ALP	80 (66 - 97)	66 (49.3 - 107.5)	92 (67.8 - 126.8)	0.054
Total protein	69.2 (64.9 - 70.7)	64.1 (60 - 69.4)	68.3 (66.2 - 72.7)	0.002
Albumin	38.6 (37.1 - 41.6)	37.6 (35.9 - 39.7)	35.9 (31.7 - 37.9)	0.002
Parasite count	NA	2808 (1090 - 8189)	24615 (3943 - 60541)	<0.001

Variable	Healthy controls (HC), n= 42	Uncomplicated malaria (UM), n=78	Severe malaria (SM), n = 46	P value for UM vs. SM
Ang-1	9.6 (3.5 - 15.3)	6.3 (3.3 - 8.0)	3.8 (2.2 - 12.7)	0.129
Ang-2	18.7 (12.4 - 22.1)	15.7 (2.6 - 27.4)	19.1 (9.0 - 25.8)	0.429
Ang-2/Ang-1	1.9 (1.2 - 3.5)	2.0 (0.6 - 3.2)	3.1 (1.4 - 5.3)	0.152

WBC = White blood cell ($\times 10^9/L$); Neut. = Neutrophil (%); Lymph = Lymphocyte (%); Mxd. = Mixed Cell Count (%); ALT = alanine transaminase; AST = aspartate transaminase; GGT = gamma-glutamyl transferase; ALP = alkaline phosphatase; Ang-1 = Angiopoietin 1; Ang-2 = Angiopoietin 2, NA = Not Applicable

The serum creatinine of SM patients (95, IQR: 84.3 - 127.0) was significantly higher than UM (72.4, IQR: 59.8 - 90) and HC group (58, IQR: 43 - 74) ($p < 0.0001$) (Figure 1). Similarly, the serum urea levels of SM patients (7.6, IQR: 5.3 - 9.3) were

significantly higher than UM (5.6, IQR: 4.8 - 7.2) and the HC group (5.4, IQR: 4 - 6.5). However, the urea levels of UM and HC were comparable ($p = 0.001$) (Figure 1).

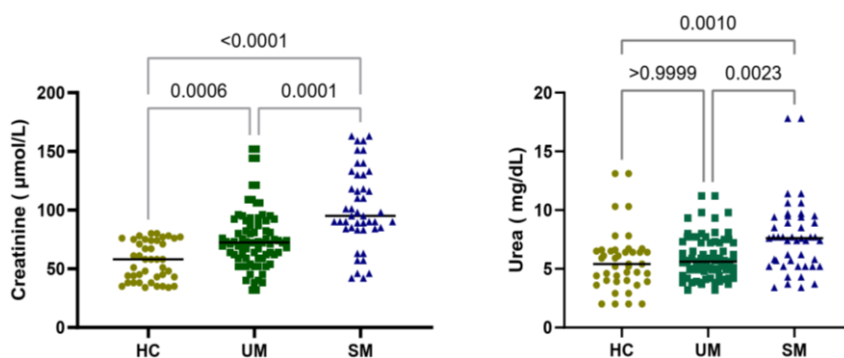


Figure 1. Comparison of serum creatinine and urea levels in malaria patients (UM and SM) and healthy controls (HC).

3.3. Comparison of Estimated Glomerular Filtration Rate Between Healthy Controls Uncomplicated and Severe Malaria

The eGFR of SM patients (99, IQR: 64 - 138) was significantly lower than UM (129, IQR: 95 - 153) and HC group (136, IQR: 115 - 176) ($p < 0.05$). However, eGFR values in the control group and those with uncomplicated malaria were comparable ($p = 0.18$) (Figure 2).

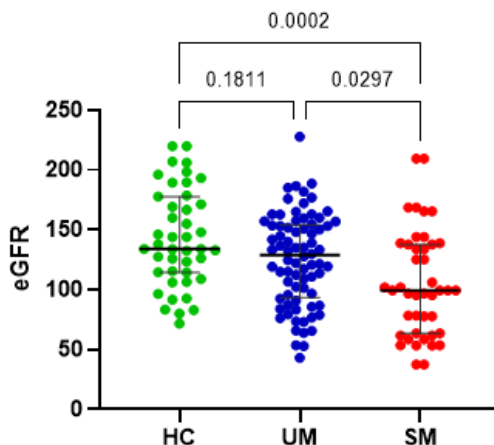


Figure 2. Comparison of eGFR levels in malaria patients (UM and SM) and healthy controls (HC).

3.4. Receiver Operating Characteristic (ROC) Curves to Determine Differences in Angiotensin Levels of UM and SM

ROC curve analysis of the biomarkers Ang-1, Ang-2, and Ang-2/1 ratio yielded an AUC score of 0.58 (95% CI: 0.47 - 0.70, $p=0.13$), 0.54 (95% CI: 0.43 - 0.64, $p=0.43$), 0.57 (95% CI: 0.47 - 0.68, $p=0.15$), respectively.

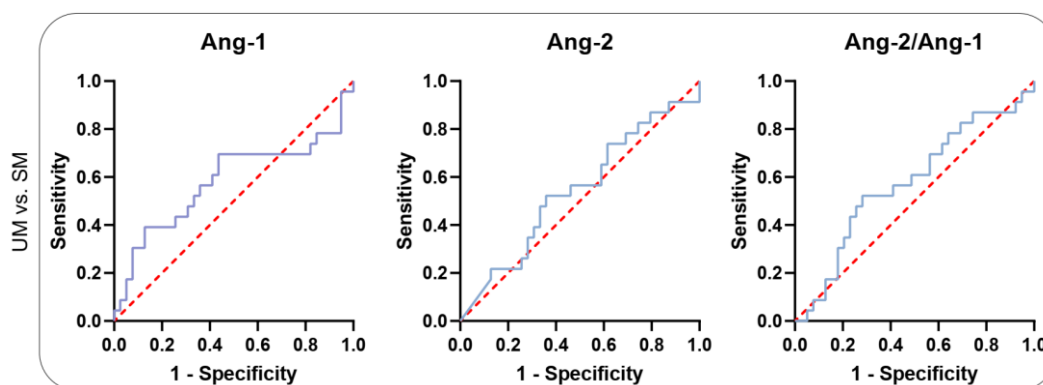


Figure 3. Assessment of angiotensin levels in discriminating between severe malaria (SM) and uncomplicated malaria (UM).

4. Discussion

Malaria is a serious public health issue in Ghana and Sub-Saharan Africa, where it causes more infections and fatalities than in many other regions. This work demonstrated that children less than 5 years old recorded the highest number of parasites in comparison to other age groups. This age group has not fully developed immunity to malaria, hence the reason for the high parasite numbers recorded as compared to the older age groups, who have suffered repeated bites of mosquitoes to build immunity. Again, those with basic education significantly recorded higher parasitaemia than their secondary or higher education counterparts. This result, therefore, supports a study conducted by [11]. This higher level of parasitaemia seen in people with low educational levels may be because people who have a higher education have acquired knowledge of malaria transmission, prevention, and control.

This study's results showed a statistically significant difference in haemoglobin levels between patients with severe malaria and those with uncomplicated malaria. The sequestration of red blood cells that occurs during and even after treatment for malaria may be the cause of the lower haemoglobin levels in the severe malaria group. The lower levels of haemoglobin among the SM group are in agreement with research published earlier [12, 13]. Additionally, a significantly low platelet count was observed and this outcome is in line with past research findings, which found that severe cases of malaria were associated with lower platelet counts [14-16]. Humoral immune response in conjunction with a hyper-reactive spleen may be the cause of the reduced platelet count seen among severe malaria patients who were enrolled in this study.

Serum levels of total and direct bilirubin, AST, ALT, ALP, and GGT were all significantly higher in the group with SM than in the group with UM ($p < 0.05$). The above findings support a study that found that patients with falciparum malaria had significantly higher serum levels of ALP, AST, ALT, total bilirubin, and direct bilirubin ($p < 0.0001$). The elevated levels of serum liver enzymes, transaminases (AST and ALT), and ALP represent the markers of hepatic injury. The indicators of liver injury are elevated serum levels of hepatic enzymes, transaminases (AST and ALT), and alkaline phosphatase. It has been previously reported that the elevation in enzymes of the hepatocytes is due to leakage; likewise, the elevated levels of bilirubin (total and direct) are also because of haemolysed red blood cells by increased density of plasmodium parasites [17].

Renal injuries are usually seen as one of the complications of SM, mostly in the older age group [18]. Some studies have reported some percentages of acute kidney injury (AKI) in severe malaria patients [18, 19]. Markers such as urea and creatinine usually peak during severe malaria episodes. From this study, results indicate that serum creatinine and urea of SM patients were significantly higher than in UM and HC groups. The high creatinine and urea levels observed in this, and several other studies are the main features of acute kidney injuries (AKI) associated with SM. According to [20], SM causes damage to the glomerulus, interstitial areas, and tubules, which leads to AKI. This presentation is very consistent with studies conducted by [21], who found that SM cases had higher serum creatinine and urea levels than groups who had UM and HC.

This study's results for the estimated eGFR indicated that the SM group had significantly lower eGFR as compared with their UM counterparts and HC. These findings therefore support studies conducted by [22, 23] who reported similar lower

eGFR in patients having SM infection. This alteration in the function of the kidney in terms of fluid output, resulting in lower eGFR in SM may be a result of rosette formation or sequestration in blood vessels, which reduces blood supply to the kidneys. This then results in high levels of creatinine accumulation, leading to acute kidney injury [23].

Although the results of this study did not indicate whether Ang-1 and Ang-2 could be used to predict which of the subjects with uncomplicated malaria is slowly progressing to severe malaria, the evidence provided by the results nonetheless showed that decreased Ang-1 and increased Ang-2 levels are indicators of severe malaria disease [24]. As a result, in terms of endothelium activation and the severity of the sickness, the ratio between Ang-2 and Ang-1 may be the most advantageous [25].

Limitations to this current study include a lack of molecular diagnosis of malaria, a small sample size, and a lack of past medical histories could potentially alter the interpretations of the results.

5. Conclusion

In summary, the results of this research demonstrate that haemoglobin, platelet, AST, ALT, ALP, GGT, creatinine and urea have the potential to serve as biomarkers of both UM and SM. Haematological and biochemical investigations are not expensive and simple to perform. These markers serve as desirable candidates for differentiating UM from SM in a Ghanaian population.

Abbreviations

UM	Uncomplicated Malaria
SM	Severe Malaria
WHO	World Health Organization
EDTA	Ethylenediaminetetraacetic Acid
ELISA	Enzyme-linked Immunosorbent Assay
mL	Milliliters
FBC	Full Blood Count
ANG	Angiopoietins
HC	Healthy Controls
IQR	Interquartile Range
ALT	Alanine Transaminase
AST	Aspartate Transaminase
GGT	Gamma-Glutamyl Transferase
ALP	Alkaline Phosphatase
eGFR	Estimated Glomerular Filtration Rate
AKI	Acute Kidney Injury

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Data Availability Statement

Available on demand.

Author Contributions

Enoch Boadi: Conceptualisation, Investigation, Methodology, Writing- original draft

Max Efui Annani-Akollor: Supervision

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Ellis Kobina Paintsil: Data curation, Formal Analysis

Anthony Eric Eshun: Investigation, Methodology

Lydia Omari: Project Administration

Yaw Frimpong: Resources

Egote Alexander Kofi: Writing – original draft, Writing – review & editing

Conflicts of Interest

No conflict of interest from any author.

References

- [1] Cullen, K. A. et al. (2011) 'Division of parasitic diseases and malaria', Centre for Global Health, Centres for Disease Control and Prevention (CDC).
- [2] Anvikar, A. R. et al. (2020) 'Clinical and epidemiological characterisation of severe *Plasmodium vivax* malaria in Gujarat.
- [3] Diema Konlan, K. et al. (2019) 'Utilisation of insecticide-treated bed nets (ITNs) among caregivers of children under five years in the Ho municipality', Interdisciplinary.
- [4] Higgins, S. et al. (2016) 'Dysregulation of angiopoietin 1 plays a mechanistic role in the pathogenesis of cerebral malaria. *Science translational medicine*, 8(358), 358ra 128. pp. 1-25. Available at: <https://doi.org/10.1126/scitranslmed.aaf6812>
- [5] Lovegrove, F. E., et al. (2009) 'Serum angiopoietin-1 and -2 levels discriminate cerebral malaria from uncomplicated malaria and predict clinical outcome in African children', *PLoS ONE*, 4(3), pp. 1-8. Available at: <https://doi.org/10.1371/journal.pone.0004912>
- [6] Snow, R. W. et al., (2005) 'The global distribution of clinical episodes of *Plasmodium falciparum* malaria', *Nature*, 434(7030), pp. 214-217.

- [7] Li, G. et al.,(2020) 'Distribution of malaria patients seeking care in different types of health facilities during the implementation of National Malaria Elimination Programme', *Malaria journal*, 19(1), pp. 1-10.
- [8] Dhangadamajhi, G. et al. (2019) 'Effect of Plasmodium falciparum infection on blood parameters and their association with clinical severity in adults of Odisha, India', *Acta tropica*, 190, pp. 1-8. *Perspectives on infectious diseases*, 2019.
- [9] Muwonge, H. et al.(2013) 'How reliable are haematological parameters in predicting uncomplicated Plasmodium falciparum malaria in an endemic region?', *International Scholarly Research Notices*, 2013(1), p. 673798.
- [10] Zuberi, U. et al. (2024) 'Altered haematological parameters in children with malaria infection, a systematic review and meta-analysis', *Diagnostic Microbiology and Infectious Disease*, 108(4), p. 116190.
- [11] Awosolu, O. B. et al. (2021) 'Prevalence, Parasite Density and Determinants of Falciparum Malaria Among Febrile Children in Some Peri-Urban Communities in Southwestern Nigeria: A Cross-Sectional Study', *Infection and drug resistance*, pp. 3219-3232.
- [12] Ayyadevara, R. (2022) 'Effect of malaria on biochemical and haematological parameters: a hospital-based case-control study', *MRIMS Journal of Health Sciences*, 10(3), pp. 41-46.
- [13] Squire, D. S. et al. (2016) 'Effect of Plasmodium falciparum malaria parasites on haematological parameters in Ghanaian children', *Journal of parasitic diseases*, 40, pp. 303-311.
- [14] Bhattacharya, D. (2016) 'Indian Monsoon Climate and Malaria: Medical Meteorology', *Journal of Malaria Control & Elimination*, 5(2), pp. 2-6.
- [15] Devineni, S. B. et al. (2015) 'Study of platelet count in malaria patients and the correlation between the presence and severity of platelet count with type of malaria', *Journal of Evolution of Medical and Dental Sciences, Malaria surveillance-United States*, pp. 1-17.
- [16] Kumar, N. (2016) 'Correlation of type of species and parasite density in malaria with platelet count, mean platelet volume and platelet distribution width', *Journal of Evolution of Medical and Dental Sciences-Jemds*, 5(89), pp. 6622-6625.
- [17] Asare, I. D. (2019) 'Evaluation of Renal and Hepatic Dysfunction among Children Less than Five Years with Malaria in Jasikan District, Oti Region-Ghana'. *University of Ghana*. 4(67), pp. 11734-11747.
- [18] Koopmans, L. C. et al., (2015) 'Acute kidney injury in imported Plasmodium falciparum malaria', *Malaria journal*, 14(1), pp. 1-7.
- [19] Storm, J., & Craig, A. G. (2014). Pathogenesis of cerebral malaria—inflammation and cytoadherence. *Frontiers in cellular and infection microbiology*, 4, 100.
- [20] Fang, Y., Li, C., Shao, R., Yu, H., & Zhang, Q. (2018). The role of biomarkers of endothelial activation in predicting morbidity and mortality in patients with severe sepsis and septic shock in intensive care: a prospective observational study. *Thrombosis research*, 171, 149-154.
- [21] Vinhaes, C. L., et al. (2021). Dissecting disease tolerance in Plasmodium vivax malaria using the systemic degree of inflammatory perturbation. *PLoS Neglected Tropical Diseases*, 15(11), e0009886.
- [22] Rivera-Correa, et al. (2019). Autoantibody levels are associated with acute kidney injury, anaemia and post-discharge morbidity and mortality in Ugandan children with severe malaria. *Scientific Reports*, 9(1), 14940.
- [23] Bhardwaj, N., et al. (2020). Clinicopathological study of potential biomarkers of Plasmodium falciparum malaria severity and complications. *Infection, Genetics and Evolution*, 77, 104046.
- [24] Storm, J., & Craig, A. G. (2014). Pathogenesis of cerebral malaria—inflammation and cytoadherence. *Frontiers in cellular and infection microbiology*, 4, 100.
- [25] Fang, Y., et al. (2018). The role of biomarkers of endothelial activation in predicting morbidity and mortality in patients with severe sepsis and septic shock in intensive care: a prospective observational study. *Thrombosis research*, 171, 149-154.