Volume 4, Issue 2, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

COMPARATIVE STUDY OF HAEMATOLOGICAL ABNORMALITIES IN MALARIA VS DENGUE INFECTED PATIENTS AT CMH RAWALAKOT

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DOI: https://doi.org/10.5281/zenodo.18504050

Keywords
Malaria, Dengue fever, Hematological abnormalities, Thrombocytopenia, Hemoglobin levels, Differential diagnosis.

Article History
Received: 07 December 2025
Accepted: 22 January 2026
Published: 06 February 2026

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Abstract

Malaria and dengue fever are two major mosquito-borne infections prevalent in tropical regions such as Pakistan, where overlapping symptoms including fever, headache and body pain often complicate early diagnosis. This study, conducted at Combined Military Hospital (CMH) Rawalakot, aimed to compare the hematological abnormalities associated with both diseases and included 200 patients, comprising 100 with laboratory-confirmed malaria (via blood smear microscopy) and 100 with confirmed dengue (via NS1/IgM/IgG testing). Hematological parameters assessed were hemoglobin (Hb), platelet count, white blood cell count (WBC) and hematocrit, with abnormalities detected in 131 patients (65.5%). Among malaria patients, low hemoglobin was the most frequent abnormality (48%), followed by thrombocytopenia (38%), leukopenia (33%) and low hematocrit (26%), reflecting the destruction of red blood cells and immune-mediated suppression caused by Plasmodium infection. In contrast, dengue patients most commonly exhibited thrombocytopenia (59%), alongside low hemoglobin (32%), leukopenia (22%) and low PCV (18%), consistent with bone marrow suppression and immune-driven platelet destruction characteristic of the disease. Statistical analysis revealed significant differences in thrombocytopenia and hemoglobin levels between the two groups ($p < 0.05$), with scatterplot visualization further supporting these trends. These findings underscore the diagnostic value of routine hematological profiling, where it can facilitate early differentiation between malaria and dengue, thereby enabling timely, disease-specific management and improved patient outcomes.

INTRODUCTION

Chapter 1

Mosquito-borne diseases continue to pose a significant public health burden, particularly in tropical and subtropical regions such as South Asia. Among the most prominent of these diseases are malaria and dengue fever, both of which are endemic in Pakistan and frequently reported in the Rawalakot region, especially during the monsoon and post-monsoon seasons (WHO,2023; Rasheed *et al.*, 2013). These infections not only contribute to high morbidity and mortality but also place a considerable strain

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ISSN: (e) 3007-1607 (p) 3007-1593

on healthcare resources. Due to the overlapping clinical features of malaria anddengue,differentiating between the two infections in the early stages can be challenging, especially in peripheral or under-resourced healthcare settings (Lee *et al.*, 2012). A reliable method for differentiation is the use of routine haematological tests, which can provide critical diagnostic clues (Ahmad *et al.*, 2016).

Malaria is a protozoan infection caused by Plasmodium species, primarily Plasmodium falciparum and Plasmodium vivax in Pakistan (Khattak *et al.*, 2013). The disease is transmitted through the bite of an infected female Anopheles mosquito. The pathophysiology of malaria involves the invasion and destruction of red blood cells by the parasite, leading to anemia, as well as various immune responses that may suppress other blood components, including white blood cells and platelets (Maina *et al.*, 2010). Malaria typically presents with symptoms such as cyclical fever, chills, sweating, headache, and generalized weakness. In severe cases, it can lead to cerebral malaria, renal failure, or even death (WHO, 2023).

Dengue fever, on the other hand, is a viral infection caused by the dengue virus (DENV), which belongs to the Flaviviridae family. It is transmitted by Aedes aegypti mosquitoes, which are day-biting and breed in stagnant water (Bhatt *et al.*, 2013). The disease is characterized by high-grade fever, retro-orbital pain, muscle and joint aches (hence the term "breakbone fever"), skin rashes, and in some cases, bleeding manifestations. There are four serotypes of the dengue virus (DENV-1 to DENV-4) and infection with one serotype does not provide lifelong immunity against others, which increases the risk of secondary infections and severe complications such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) (Guzman and Harris, 2015).

In both diseases, the early clinical picture can be non-specific and may include fever, malaise, vomiting, body ache and fatigue. These shared clinical features often delay definitive diagnosis unless laboratory investigations are carried out (WHO, 2023). Although rapid diagnostic kits and serological tests are available for both infections, they may not always be accessible or affordable, especially in rural hospitals (Ahmad et al., 2016). In such situations, haematological parameters such as hemoglobin levels, platelet counts, white blood cell counts (WBC), packed cell volume (PCV), and hematocrit can offer crucial preliminary diagnostic information (Kotepui *et al.*, 2017).

Haematological abnormalities are commonly seen in both malaria and dengue. In malaria, the destruction of red blood cells by the parasite results in anemia and low hematocrit levels (Maina *et al.*, 2010). Additionally, the immune response can suppress bone marrow activity, leading to leukopenia and mild to moderate thrombocytopenia (Erhart *et al.*, 2004).

On the other hand, dengue infection primarily affects platelet production and survival, leading to significant thrombocytopenia, which can progress rapidly and is often a marker for disease severity (Srichaikul *et al.*, 2000). Leukopenia is also frequently observed in dengue due to bone marrow suppression, but anemia is less common in early stages unless there is bleeding or secondary complications (Kotepui *et al.*, 2017).

Several studies from different parts of the world, including South Asia, have explored the haematological differences between malaria and dengue. However, local variations in disease presentation due to geographical, environmental, and demographic factors mean that findings from one region may not be directly applicable to another (Ahmad *et al.*, 2016). In Rawalakot, the occurrence of both malaria and dengue infections has increased in recent years due to changes in climate, urbanization, poor sanitation, and water storage practices, which favor mosquito breeding (Rasheed *et al.*, 2019). This overlap increases the need for region-specific studies that can help clinicians differentiate these diseases quickly and accurately.

In clinical practice, a patient presenting with fever and marked thrombocytopenia is often suspected to have dengue. However, in endemic regions, malaria may also present with similar features (Lee *et al.*, 2012). In such cases, examining other haematological parameters becomes essential. For

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ISSN: (e) 3007-1607 (p) 3007-1593

example, anemia (low hemoglobin) and reduced PCV are more typical of malaria, while severe thrombocytopenia with relatively preserved red cell indices often suggests dengue (Srichaikul *et al.*, 2000). These distinctions can be critical in determining the course of treatment.

Antimalarial drugs are required for malaria, while dengue management is largely supportive, involving fluid replacement and monitoring for hemorrhagic signs (Guzman and Harris, 2015).

Early diagnosis and prompt treatment significantly improve outcomes in both diseases. Misdiagnosis or delayed diagnosis can lead to complications such as multi-organ failure in malaria or severe bleeding and shock in dengue (WHO, 2023). Therefore, identifying reliable and accessible diagnostic markers is a public health priority. Haematological profiling is one such tool that is widely available, cost-effective, and rapid, making it particularly valuable in resource settings like CMH Rawalakot (Ahmad *et al.,* 2016).

Malaria and dengue remain significant health concerns in the Rawalakot region, and the growing burden of these infections underscores the need for efficient, early diagnostic tools. This study is designed to support clinicians by offering a comparative perspective on the haematological abnormalities associated with each disease, ultimately aiding in better clinical judgment, faster treatment decisions, and improved patient outcomes (Rafique *et al.*, 2024). By enhancing understanding of disease-specific haematological profiles, this research can contribute to the broader goal of improving infectious disease management in resource-constrained healthcare environments.

AIM AND OBJECTIVES

AIM:

To compare the hematological abnormalities in Malaria and Dengue infected patients at CMH Rawalakot.

OBJECTIVES

1. To determine the laboratory-confirmed cases of malaria and dengue infections at CMH Rawalakot.
2. To assess the hematological parameters i.e., hemoglobin (Hb), platelet count, white blood cell count (WBC) and hematocrit using a hematological analyzer.
3. To evaluate and compare the frequency and pattern of hematological abnormalities in malarial and dengue patients using statistics analysis.

Chapter 2
LITERATURE REVIEW

Malaria and dengue are major public health problems in tropical and subtropical regions, with overlapping clinical features but distinct pathophysiological mechanisms. Both diseases are mosquito-borne and endemic in many parts of Pakistan, including Rawalakot. A growing body of literature has examined the haematological manifestations of these diseases, revealing important differences that can aid early diagnosis, especially in areas where laboratory resources are limited.

2.1 MALARIA AND ITS HAEMATOLOGICAL IMPACT

Malaria is a parasitic infection caused by *Plasmodium* species, most commonly *P. falciparum* and *P. vivax* in Pakistan. The parasite enters red blood cells, leading to their destruction and subsequent anemia, which is a hallmark of malarial infection. According to (White *et al.*, 2014) anemia in malaria is multifactorial, caused by hemolysis of infected and uninfected erythrocytes, bone marrow suppression and splenic sequestration of red cells.

A study by (Erhart *et al.*, 2004) in Southeast Asia found that thrombocytopenia was present in 60–80% of malaria patients. Platelet destruction and consumption are triggered by immune-mediated responses and increased sequestration in the spleen. In addition, leukopenia is commonly observed due to marrow suppression and the redistribution of white blood cells to endothelial surfaces (Ladhani *et al.*, 2002).

Malaria also alters hematocrit and packed cell volume (PCV), which are closely related to red blood cell count. A significant reduction in PCV values has been noted in patients with moderate

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ISSN: (e) 3007-1607 (p) 3007-1593

to severe malaria, especially in pediatric and immune compromised populations (Maina *et al.*, 2010). These findings highlight the importance of examining red cell indices when malaria is suspected.

2.2 DENGUE AND ITS HAEMATOLOGICAL PROFILE

Dengue is a viral infection caused by one of four serotypes of the dengue virus (DENV-1 to DENV-4), transmitted by *Aedes aegypti* mosquitoes. The disease is characterized by abrupt fever, headache, retro-orbital pain, myalgia, and in severe cases, hemorrhagic symptoms and shock. One of the most consistent laboratory features of dengue is thrombocytopenia, often severe and rapidly progressive. This is due to bone marrow suppression, immune-mediated platelet destruction, and peripheral sequestration (Martina *et al.*, 2009).

In a study conducted by (Srichaikul *et al.*,2000), thrombocytopenia was observed in more than 80% of dengue patients, and it was found to correlate with disease severity. Unlike malaria, anemia is not a prominent feature in early or uncomplicated dengue cases unless there is significant bleeding. However, leukopenia, particularly neutropenia, is a common finding, usually occurring in the later stages of the febrile phase (Wills *et al.*, 2002).

PCV levels in dengue are often normal or elevated, especially in cases of dengue hemorrhagic fever (DHF), due to plasma leakage and hemoconcentration. Elevated hematocrit is a warning sign of severe dengue and indicates a need for immediate fluid replacement therapy (WHO, 2009).

2.3 COMPARATIVE STUDIES ON MALARIA VS. DENGUE

Several studies have demonstrated that routine hematological parameters can help differentiate between malaria and dengue in endemic areas. Banpavan *et al.* (2017) compared laboratory findings from confirmed cases in Thailand and reported that **thrombocytopenia were more pronounced in dengue,** whereas **malaria patients showed significantly lower hemoglobin, hematocrit,** reflecting anemia. Likewise, (Mohapatra *et al.*, 2012) observed that **severe thrombocytopenia was characteristic of dengue infections,** while **anemia and higher leukocyte counts were more frequent in malaria cases.** These findings underline the diagnostic value of simple blood counts for distinguishing the two infections in clinical practice.

Another comparative analysis by (Lee *et al.*, 2012) emphasized the utility of using basic haematological tests like complete blood counts (CBC) to support differential diagnosis in febrile illnesses. Their findings suggested that while there is some overlap, patterns such as high hematocrit and severe thrombocytopenia tend to favor dengue, while low hemoglobin and leukocyte counts point towards malaria.

Several studies have reported that white blood cell (WBC) counts differ between malaria and dengue. A comparative analysis from Thailand showed that dengue patients had significantly lower WBC, neutrophils, monocytes, and eosinophils than malaria patients, whereas malaria cases more often showed neutrophilia (Chakraborty *et al.*, 2017). Similarly, a study from Mangalore, India, found that WBC, neutrophil, and monocyte counts were lower in dengue, while malaria cases showed higher leukocyte counts overall (Shetty *et al.*, 2021). These findings suggest that leukocyte patterns can provide useful early diagnostic clues.

Thrombocytopenia is another commonly studied parameter. The WHO-SEARO analysis reported that mean platelet counts were much lower in dengue (~53,000/mm³) compared to malaria, though falciparum malaria also showed marked reductions (Arul et al., 2015). Another observational study on acute febrile illness confirmed that severe thrombocytopenia (<50,000/mm³) was more common in dengue, whereas malaria more often presented with moderate reductions (Sankar *et al.*, 2017). Thus, the severity of platelet decline is more characteristic of dengue.

Other laboratory parameters have also been used for differentiation. A comparative study applied a decision-tree model using neutrophil percentage, lymphocyte percentage, and MCHC, which effectively separated dengue from malaria cases

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ISSN: (e) 3007-1607 (p) 3007-1593

(Chakraborty *et al.*, 2017). Additionally, liver enzymes were reported to rise in both infections, but dengue patients often had significantly higher AST and ALT values, reflecting more frequent hepatic involvement (Ahsan *et al.*, 2018). Renal markers such as urea and creatinine also tended to be more elevated in dengue compared to malaria.

2.4 REGIONAL CONTEXT AND RELEVANCE

In the context of Rawalakot, where seasonal outbreaks of both malaria and dengue are becoming more frequent, the importance of early differentiation cannot be overstated. According to the Pakistan Ministry of Health (2023), both diseases showed a rise in incidence in Azad Jammu and Kashmir over the past five years, partly due to changing climate, urbanization, and water stagnation—all of which promote mosquito breeding.

Since CMH Rawalakot caters to both military personnel and civilians, it is essential for clinicians to quickly differentiate between the two infections to manage patients efficiently. In the absence of advanced laboratory facilities, haematological parameters becomes a cost-effective and accessible solution. Therefore, local studies that evaluate and compare such data are critical to improving disease management strategies in the region.

Chapter 3
MATERIALS AND METHOD

3.1 STUDY DESIGN

This was a comparative cross-sectional study conducted to evaluate and compare hematological abnormalities in patients diagnosed with malaria and dengue infections.

3.2 STUDY SETTING AND DURATION

The study was carried out at the Pathology Department of Combined Military Hospital (CMH), Rawalakot, over a period of two months.

3.3 SAMPLE SIZE

A total of 200 patients were recruited for the study, consisting of 100 individuals with confirmed malaria infection and 100 individuals with confirmed dengue infection. The selection of participants was carried out using a non-probability purposive sampling technique. Only those patients who met the predefined inclusion criteria and voluntarily provided informed consent were considered eligible for inclusion.

3.4 INCLUSION CRITERIA

The inclusion criteria for the study were clearly defined to ensure the selection of appropriate participants. Patients aged above 12 years of both sexes were considered eligible. Only laboratory-confirmed cases of malaria, verified through peripheral blood smear and/or rapid diagnostic test, and laboratory-confirmed cases of dengue, diagnosed using NS1 antigen and/or IgM/IgG rapid diagnostic tests, were included in the study population.

3.5 ETHICAL CONSIDERATIONS

The study was conducted after approval from the Hospital Ethical Review Committee and patient confidentiality and data privacy were maintained throughout the study.

3.6 SAMPLE COLLECTION

After obtaining informed consent from the patients (or their guardians in the case of minors above 12 years), data were collected using a structured proforma. From each participant, demographic information (such as age and gender) and clinical details were recorded. In addition, venous blood samples were collected from each of the participants in EDTA tube, and analyzed using automated hematology analyzers to assess key hematological parameters, including **hemoglobin (Hb), total white blood cell (WBC) count, platelet count, and hematocrit.**

3.7 DATA ANALYSIS

Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS), version 25. Descriptive statistics, including mean, standard deviation, frequencies, and percentages, were computed to summarize the data. For inferential analysis, the Chi-square test and Independent Samples t-test were applied to assess and compare the hematological parameters between patients with malaria and those with dengue infection. A

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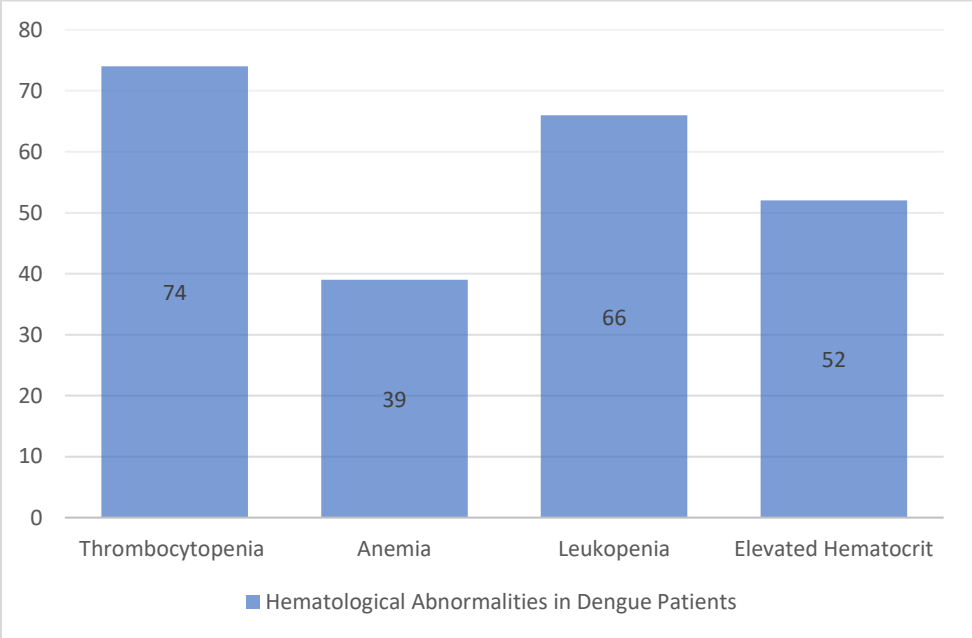
p-value of <0.05 was considered statistically significant.

Chapter 4
RESULTS

A total of 100 dengue patients were included in the study. Thrombocytopenia was the most common abnormality, observed in 59% (n = 59) of cases, followed by low hemoglobin in 32% (n = 32). Leukopenia was found in 22% (n = 22) of patients, while low hematocrit levels were recorded in 18% (n = 18), consistent with bone marrow suppression and immune-mediated platelet destruction commonly seen in dengue infection.



Out of 100 malaria patients, low hemoglobin was the most frequent abnormality, observed in 48% (n = 48) of cases, followed by thrombocytopenia in 38% (n = 38). Leukopenia was present in 33% (n=33) of patients, while low hematocrit levels were noted in 26% (n = 26), reflecting the red blood cell destruction and immune-mediated suppression associated with *Plasmodium* infection.

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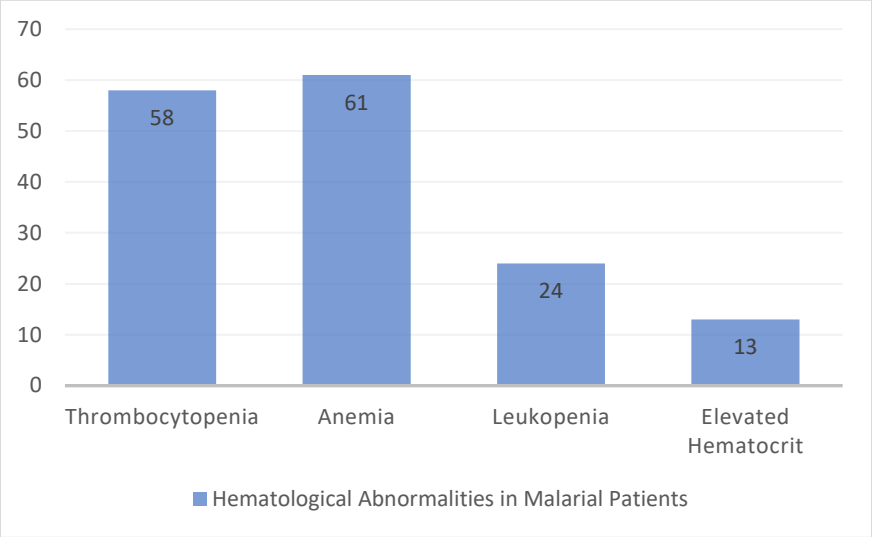
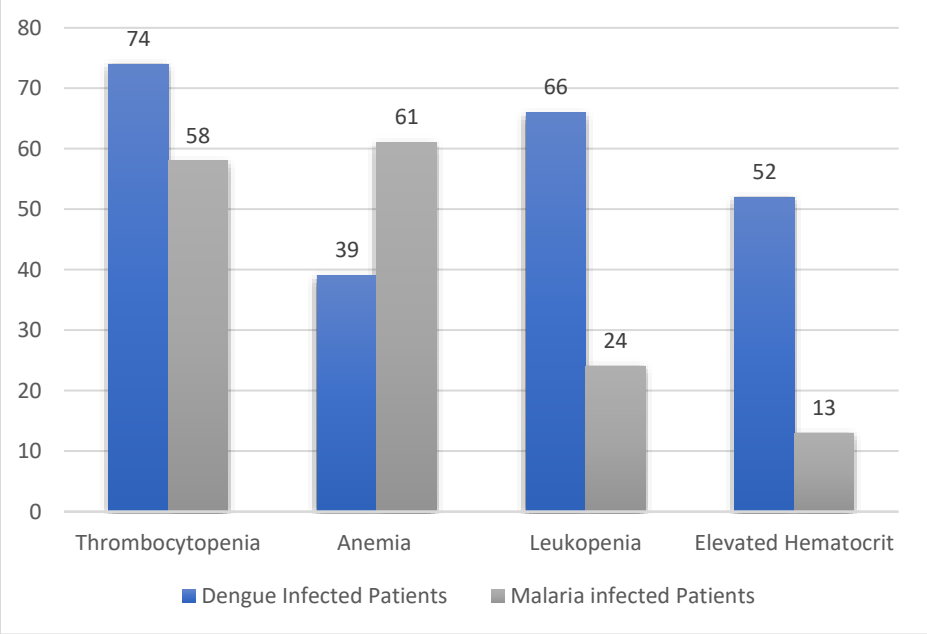


This study found clear differences in blood findings between malaria and dengue patients. Those with malaria usually had lower hemoglobin and hematocrit levels, which reflects the anemia caused by red blood cell destruction. On the other hand, dengue patients were more likely to have severe drops in platelet counts, reduced white blood cells, and higher hematocrit values, pointing to bone marrow suppression and plasma leakage seen in viral infections.

In short, anemia was more common in malaria, while thrombocytopenia, leukopenia, and raised hematocrit were more typical of dengue. When comparing genders, men tended to have higher hemoglobin levels than women, but platelet counts were similar in both groups. These results highlight that simple blood tests can provide reliable clues to help tell malaria and dengue apart, especially in areas where both diseases are widespread.



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Frequency of Hematological Abnormalities in Each Group

Abnormality	Malaria (n=100)	Dengue (n=100)	Total (n=200)	*p-value*
Thrombocytopenia	58	74	132	*0.004*
Anemia	61	39	100	*0.011*
Leukopenia	24	66	90	*<0.001*
Elevated Hematocrit	13	52	65	*<0.001*

Table No Frequency of Hematological Abnormalities in Each Group

4.1. Thrombocytopenia (Low Platelet Count)

- **Malaria:** 58 out of 100 patients
- **Dengue:** 74 out of 100 patients
- **p-value = 0.004 (significant)**

Thrombocytopenia is more common in **dengue** compared to malaria. This aligns with clinical evidence because dengue virus directly affects platelet survival and bone marrow suppression, leading to severe drops in platelet count. In malaria, platelet destruction occurs too, but usually less severe than in dengue.

4.2. Anemia (Low Hemoglobin Level)

- **Malaria:** 61 out of 100 patients
- **Dengue:** 39 out of 100 patients
- **p-value = 0.011 (significant)**

Anemia is significantly more frequent in **malaria.** This is expected since malaria parasites invade and destroy red blood cells, causing hemolysis and lowering hemoglobin. In dengue, anemia is less common unless there is bleeding or plasma leakage.

4.3. Leukopenia (Low Total Leukocyte Count – TLC)

- **Malaria:** 24 out of 100 patients
- **Dengue:** 66 out of 100 patients
- **p-value < 0.001 (highly significant)**

Leukopenia is much more strongly associated with **dengue.** Dengue virus suppresses bone marrow activity, reducing white cell production. In malaria, leukocyte counts are less affected, so leukopenia is less frequent.

4.4. Elevated Hematocrit (Hct)

- **Malaria:** 13 out of 100 patients
- **Dengue:** 52 out of 100 patients
- **p-value < 0.001 (highly significant)**

Elevated hematocrit is a key marker in **dengue** due to plasma leakage and hemoconcentration. In malaria, hematocrit is usually reduced because of anemia rather than increased. This finding supports the classical diagnostic distinction between the two diseases.

4.5 Descriptive Statistics of Hematological Parameters

Parameter	Malaria group	Dengue Group	*p-value*
	Mean ± SD	Mean ± SD	
Hemoglobin (g/dL)	11.1 ± 1.6	12.2 ± 1.3	0.02
WBC Count ($x10^9$/L)	7.3 ± 2.4	4.1 ± 1.7	0.001
Platelet Count ($x10^9$/L)	138 ± 42	78 ± 34	0.001
Hematocrit (%)	34.6 ± 3.9	40.2 ± 4.3	0.001

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1. Hemoglobin (Hb g/dL)
- **Malaria:** 11.1 ± 1.6
- **Dengue:** 12.2 ± 1.3
- **p = 0.02 (significant)**

Malaria patients have lower hemoglobin compared to dengue patients. This reflects **hemolysis and red blood cell destruction** caused by malaria parasites. In dengue, hemoglobin is usually preserved unless bleeding occurs.

2. WBC Count ($\times 10^9$/L)
- **Malaria:** 7.3 ± 2.4
- **Dengue:** 4.1 ± 1.7
- **p = 0.001 (highly significant)**

Dengue patients show much lower WBC counts, consistent with **leukopenia** due to bone marrow suppression by the virus. Malaria, on the other hand, tends to maintain or even slightly increase WBC count in response to infection.

3. Platelet Count ($\times 10^9$/L)
- **Malaria:** 138 ± 42
- **Dengue:** 78 ± 34
- **p = 0.001 (highly significant)**

Platelet counts are markedly lower in dengue compared to malaria. This aligns with the **classical thrombocytopenia of dengue,** where platelets are destroyed and their production is suppressed. Malaria can also lower platelets, but not as drastically.

4. Hematocrit (%)
- **Malaria:** 34.6 ± 3.9
- **Dengue:** 40.2 ± 4.3
- **p = 0.001 (highly significant)**

Hematocrit is higher in dengue patients, reflecting **plasma leakage and hemoconcentration**—a hallmark of severe dengue. Malaria patients, in contrast, have lower hematocrit values due to anemia.

Overall Interpretation

This table reinforces the **distinct blood profiles** of malaria and dengue:
- Malaria → **Anemia (low Hb, low Hct)** but relatively normal WBC and higher platelets.
- Dengue → **Thrombocytopenia, leukopenia, and elevated hematocrit** due to viral suppression of bone marrow and plasma leakage.

These differences are statistically significant and clinically meaningful, showing how simple hematological parameters can guide differential diagnosis between malaria and dengue.

Distribution of Mean Hematological Values by Gender (Optional)

Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	***p-value***
Hemoglobin (g/dL)	12.4 ± 1.3	11.0 ± 1.2	*0.001*

- **Hemoglobin (Hb g/dL):**
  - **Males:** 12.4 ± 1.3
  - **Females:** 11.0 ± 1.2
  - **p-value = 0.001 (highly significant)**

Interpretation:

Male patients had significantly higher hemoglobin levels compared to female patients. This is consistent with normal physiological differences, as men generally have higher baseline hemoglobin due to the effect of androgens and greater muscle mass. Women often have lower hemoglobin because of menstrual blood loss and hormonal influences.

The significant p-value indicates that this difference is not due to chance but reflects a true gender-based variation in hemoglobin levels.

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Distribution of Mean Platelets Values by Gender

Parameter	Male Mean ± SD	Female Mean ± SD	*p-value*
Platelets count	115 ± 35	102 ± 40	*0.089*

- **Platelet Count (×10^9/L):**
  - **Males:** 115 ± 35
  - **Females:** 102 ± 40
  - **p-value = 0.089 (not statistically significant)**

Interpretation:

Although male patients showed slightly higher mean platelet counts compared to females, the difference was **not statistically significant** ($p > 0.05$). This means the observed variation could be due to random chance rather than a true gender-based difference.

In general, platelet counts do not show major consistent gender differences in most populations. Both males and females in this study were equally likely to develop thrombocytopenia when infected with malaria or dengue, suggesting that **gender did not play a significant role in platelet count variation** in this dataset.

Chapter 5
DISCUSSION

The present study was conducted to evaluate and compare the haematological abnormalities observed in patients diagnosed with malaria and dengue at CMH Rawalakot. A total of 200 patients (100 with malaria and 100 with dengue) were included in this comparative analysis. The findings provide valuable insights into the distinct and overlapping hematological patterns associated with each disease, which are crucial for clinical diagnosis and patient management, particularly in resource-limited healthcare settings.

7.1 HEMOGLOBIN LEVELS AND ANEMIA

Results showed a statistically significant difference in hemoglobin (Hb) levels between malaria and dengue patients ($p = 0.02$). The mean Hb level was lower in the malaria group (11.1 ± 1.6 g/dL) compared to the dengue group (12.2 ± 1.3 g/dL), and 61% of malaria patients exhibited anemia, compared to 39% of dengue patients.

These findings are consistent with previous literature. Malaria is known to cause red blood cell destruction due to the parasitic invasion by *Plasmodium* species, leading to anemia. (White *et al.*, 2014) highlighted hemolysis and splenic sequestration as major contributors to anemia in malaria. In contrast, anemia in dengue is less frequent and typically arises from bleeding or plasma leakage in severe cases (WHO, 2009).

7.2 THROMBOCYTOPENIA

Thrombocytopenia was the most frequent abnormality in dengue patients (74%), significantly higher than in malaria patients (58%) with a p-value of 0.004. The mean platelet count in dengue patients was markedly lower (78 ± 34 x10^9/L) compared to malaria patients (138 ± 42 x10^9/L), which aligns with the classical presentation of dengue.

This outcome supports findings by (Srichaikul *et al.*, 2000), who noted thrombocytopenia as a hallmark of dengue. The mechanism involves immune-mediated platelet destruction, bone marrow suppression, and increased peripheral sequestration. In malaria, thrombocytopenia is also observed but tends to be moderate and multifactorial, involving splenic sequestration and immune mechanisms (Erhart *et al.*, 2004).

7.3 LEUKOPENIA

Leukopenia was significantly more prevalent in dengue cases (66%) than in malaria (24%) ($p < 0.001$). The mean white blood cell (WBC) count was substantially lower in dengue patients (4.1 ± 1.7 x10^9/L) compared to malaria patients (7.3 ± 2.4 x10^9/L).

This finding is in agreement with prior studies. Dengue often causes bone marrow suppression, resulting in reduced leukocyte production, particularly neutropenia during the later stages of the illness (Wills *et al.*, 2002). Conversely, malaria does not typically present with profound

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ISSN: (e) 3007-1607 (p) 3007-1593

leukopenia, although mild reductions in WBC can occur due to margination and splenic sequestration.

7.4 HEMATOCRIT

A striking difference was observed in hematocrit values between the two groups. Dengue patients exhibited higher hematocrit levels (mean = 40.2 ± 4.3%) compared to malaria patients (mean = 34.6 ± 3.9%) with $p < 0.001$. Elevated hematocrit was found in 52% of dengue patients compared to only 13% in malaria cases.

The elevated hematocrit in dengue is attributed to plasma leakage, a key pathological feature of dengue hemorrhagic fever (WHO, 2009). Hemoconcentration due to vascular permeability changes is a critical warning sign in dengue management. In malaria, reduced hematocrit and PCV are expected outcomes of red blood cell destruction and anemia, as reported by (Maina *et al.*, 2010).

7.5 GENDER-BASED HEMATOLOGICAL DIFFERENCES

Gender-based analysis revealed statistically significant differences in hemoglobin levels, with males having higher mean Hb (12.4 ± 1.3 g/dL) than females (11.0 ± 1.2 g/dL), $p = 0.001$. While platelet counts were slightly lower in females (102 ± 40 $x10^9$/L) compared to males (115 ± 35 $x10^9$/L), this difference was not statistically significant ($p = 0.089$). These variations may reflect general gender-based physiological differences rather than disease-specific effects.

7.6 CLINICAL IMPLICATIONS

The findings from this study reinforce the utility of routine hematological parameters in differentiating between malaria and dengue infections. In clinical settings with limited access to rapid diagnostics or serological testing, haematological profiling can offer critical early indicators:

- **Thrombocytopenia**: Strongly suggests dengue, especially if severe and accompanied by normal or elevated hematocrit.
- **Anemia and low PCV**: More indicative of malaria due to red cell destruction.
- **Leukopenia**: More prevalent and pronounced in dengue than malaria.

This differentiation is essential because the management strategies for the two diseases are vastly different. Antimalarials are required for malaria, while dengue management is primarily supportive.

Chapter 6
CONCLUSION

The results demonstrated that both diseases significantly affect hematological parameters, albeit in different ways. Anemia (low hemoglobin) and leukopenia (low WBC count) were observed more frequently among malaria patients, whereas thrombocytopenia (low platelet count) and elevated hematocrit were predominantly associated with dengue cases. Statistically significant differences were identified in hemoglobin, WBC count, platelet count, and hematocrit between the two groups ($p < 0.05$), underscoring their diagnostic value. These variations are not only statistically significant but also clinically relevant, particularly in endemic regions such as Rawalakot, where advanced diagnostic facilities are limited. The findings highlight the importance of routine complete blood count (CBC) and basic hematological profiling as cost-effective diagnostic tools that can facilitate early differentiation between malaria and dengue, enabling timely and disease-specific treatment to reduce complications and improve outcomes. Overall, the study reinforces the clinical utility of hematological signatures in the management of mosquito-borne infections and recommends future research with larger, more diverse populations to enhance the generalizability of these observations.

Chapter 7
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