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RESEARCH ARTICLE

Dengue virus infection: a retrospective study and comparative analysis of hematological profiles and organ function biomarkers in seropositive cases

Adiatuj Jahan Rimu[1], Md Shafiul Azam[2], Pronoy Kumer Sarker[3], Ashraf Ullah[4] ,Mst.Umme Habiba[5], Md. Farhad Hossain Jony[6], Md. Shapan Ali Sheikh[7], Md. Al-Amin Hossen[8*]

[1] *Adiatuj Jahan Rimu, Department of Public Health & Life Sciences, University of South Asia, Dhaka, Bangladesh*

[2] *Md Shafiul Azam, Department of Medical Biotechnology, University of Technology Sydney-(UTS), Sydney, Australia*

[3] *Pronoy Kumer Sarker, Department of Laboratory Medicine, Popular Diagnostic Centre Limited, Dhaka, Bangladesh*

[4] *Ashraf Ullah, Department of Biochemistry and Biotechnology, University of Science and Technology Chittagong, Bangladesh*

[5] *Mst.Umme Habiba, Department of Life Sciences, Independent University, Dhaka, Bangladesh*

[6] *Md. Farhad Hossain Jony, Department of Biochemistry & Molecular Biology, Primeasia University, Dhaka, Bangladesh*

[7] *Md. Shapan Ali Sheikh, Department of Biochemistry & Molecular Biology, Primeasia University, Dhaka, Bangladesh*

[8] *Md. Al-Amin Hossen, Department of Biochemistry & Endocrinology, United Hospital Limited, Dhaka, Bangladesh*

*** Corresponding author:** Md. Al-Amin Hossen, alaminhossainrocky@gmail.com

ABSTRACT

Background: Dengue virus (DENV) infection is a rapidly spreading mosquito-borne disease with significant global health implications, particularly in tropical and subtropical regions. Despite extensive research, regional variations in clinical and laboratory profiles necessitate further investigation to improve diagnosis and management. **Aim of the Study**: This retrospective study aimed to analyze the hematological, biochemical, and serological profiles of seropositive dengue patients admitted to a tertiary care hospital in Bangladesh, with a focus on identifying gender-specific patterns and disease severity markers. **Methods**: A total of 134 serologically confirmed dengue patients (93 males, 41 females) admitted to a tertiary care hospital between June and September 2024 were included. Data were extracted from medical records, including demographics, clinical symptoms, hematological parameters (complete blood count, platelet indices), liver and renal function tests, inflammatory markers (CRP, ESR), and serological status (NS1, IgM, IgG). Laboratory analyses were performed using standardized automated techniques. Statistical analyses included descriptive statistics, comparative tests (t-tests, Mann-Whitney U), and correlation analyses (Spearman's rho) to assess relationships between key parameters. **Results:** The study population had a male predominance (69.4%), with a mean age of 32.5 ± 18.2 years. The most affected age group was 15–30 years (32.8%). Fever (98.5%), headache (92.5%), and vomiting (85.1%) were the most common symptoms, with rash being more prevalent in females (43.9% vs. 30.1%, *p*=0.12). Hematological findings revealed

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thrombocytopenia (mean platelets: 148 ± 98 $\times 10^3/\mu L$) and leukopenia (4.5% with WBC <2.0 $\times 10^3/\mu L$). Females had significantly lower hemoglobin (12.5 ± 1.9 g/dL vs. 13.5 ± 1.7 g/dL, *p*=0.003) and higher ALT levels (63.1 ± 550 U/L vs. 45.8 ± 180 U/L, *p*=0.04). Severe abnormalities included thrombocytopenia (<50,000/μL) in 9% of cases and elevated ALT >200 U/L in 3.7%. A strong correlation was observed between ALT and AST (r=0.85, *p*<0.001), indicating concurrent hepatic injury. Serologically, NS1 positivity (89%) dominated, confirming acute infection, with no significant gender differences in IgM (7.5%) or IgG (5.2%) rates. **Conclusion:** The study highlights gender-specific variations in dengue manifestations, with females showing greater hepatic involvement and anemia. Hematological and biochemical markers remain crucial for early risk stratification and clinical management.

Keywords: Dengue virus; Hematological profile; liver enzymes; Gender; serological markers

1. Introduction

Dengue virus (DENV) infection is a rapidly spreading, mosquito-borne viral disease that poses a significant threat to global public health, particularly in tropical and subtropical regions of the world. The virus belongs to the *Flaviviridae* family and comprises four antigenically distinct serotypes (DENV-1, DENV-2, DENV-3, and DENV-4), each capable of causing a full spectrum of disease[1]. According to estimates by the World Health Organization (WHO), nearly 390 million people are infected annually, with about 96 million presenting clinically apparent infections. The disease is endemic in more than 100 countries across Southeast Asia, the Western Pacific, the Americas, and parts of Africa, where it continues to cause cyclical outbreaks and serious health and economic burdens[2].

Dengue virus is primarily transmitted by female *Aedes aegypti* mosquitoes, which thrive in urban and semi-urban environments. The clinical manifestations of dengue infection range from mild febrile illness known as dengue fever (DF), characterized by high-grade fever, rash, headache, retro-orbital pain, and myalgia, to more severe and life-threatening forms such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). These severe presentations are often associated with increased vascular permeability, hemorrhagic tendencies, thrombocytopenia, and multi-organ dysfunction[3,4].

Figure 1. *Aedes aegypti* mosquito

Accurate and timely diagnosis of dengue, especially in the early phase, is essential for effective patient management and reduction in case fatality rates. While virological and serological tests confirm the diagnosis,

laboratory investigations including hematological and biochemical parameters play a pivotal role in monitoring disease progression and detecting complications. Common hematological abnormalities in dengue infection include leukopenia, thrombocytopenia, elevated hematocrit, and varying degrees of anemia. These changes are often accompanied by alterations in organ function markers, notably elevated liver enzymes (alanine aminotransferase [ALT], aspartate aminotransferase [AST]), impaired renal function (elevated urea and creatinine), and disturbances in serum electrolytes (sodium, potassium), reflecting the systemic nature of the disease[5-7].

Several studies have highlighted the prognostic value of these laboratory markers in assessing disease severity and predicting complications. However, these parameters may vary significantly across different populations due to variations in demographic factors, underlying comorbidities, access to healthcare, and viral serotype predominance[8]. Hence, there is a continuous need for region-specific research to identify consistent patterns that may aid clinicians in risk stratification, early intervention, and resource allocation during outbreaks. This retrospective study aims to analyze the hematological and organ function profiles of seropositive dengue patients admitted to our healthcare facility.

2. Literature review

Dengue virus infection remains one of the most rapidly spreading vector-borne diseases worldwide. The World Health Organization (WHO) estimates that approximately 390 million people are infected with dengue annually, of which about 96 million present with clinical manifestations[9]. The disease is highly prevalent in tropical and subtropical regions, with the burden significantly increasing in areas such as South and Southeast Asia, Latin America, and parts of Africa. The 2019–2020 global epidemic marked one of the most widespread outbreaks, affecting over 2.7 million individuals in Latin America alone, with substantial increases reported in Bangladesh, India, Pakistan, and Vietnam[10,11]. This global upsurge underscores the need for improved surveillance, diagnosis, and region-specific clinical management strategies.

Although dengue is not endemic in mainland Europe, the number of locally acquired (autochthonous) cases has been increasing due to the expansion of Aedes mosquito vectors, climate change, and international travel. Since the first major outbreak in Madeira, Portugal in 2012, several countries including France, Italy, Spain, and Croatia have reported rising cases of autochthonous transmission. France and Italy now report the majority of these cases, with Italy experiencing larger outbreak clusters[12-14]. In 2024 alone, France recorded 83 local cases and Italy reported 213, the highest annual totals to date. The spread of *Aedes albopictus* across at least 13 European countries, and the more recent detection of *Aedes aegypti* in Cyprus and Madeira, has significantly increased the risk of sustained transmission. Additionally, imported dengue cases remain a major concern, with over 4,900 imported infections across Europe in 2023, including 2,600 in France by mid-2024 and 904 in the UK[15,16]. Warmer and wetter climates have extended the vector season, enhancing the potential for outbreaks. The outbreak in Paris in 2023, including the first recorded transmission in northern France, highlights the need for enhanced surveillance and rapid public health response, particularly in the context of large international events like the 2024 Summer Olympics. Prompt case detection, vector control, and epidemiological investigations are essential strategies to limit dengue spread in an increasingly vulnerable European landscape[17].

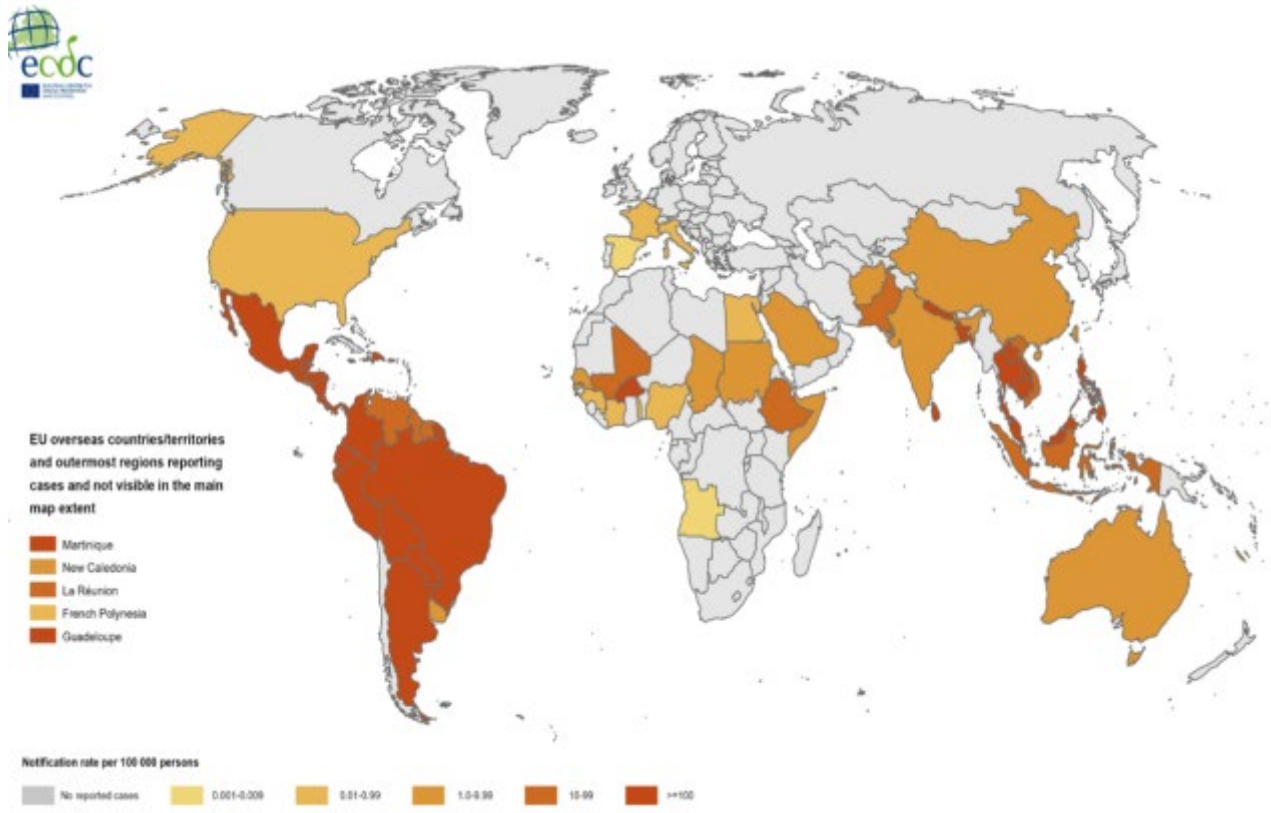

Figure 2. Reported dengue cases in Europe (Feb 2023 – Jan 2024) [17]

In Asia, India has contributed a substantial portion of the global dengue burden. Between 2015 and 2020, numerous retrospective and prospective studies from Indian tertiary care centers consistently reported thrombocytopenia, leukopenia, elevated liver enzymes (ALT, AST), and hemoconcentration as common findings in dengue-positive patients. These hematological profiles were significantly associated with more severe forms of dengue, such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), especially in areas dominated by the DENV-2 serotype[18,19].

Sri Lanka experienced a major outbreak in 2017, with over 186,000 cases and 440 deaths. Clinical analysis from this outbreak revealed marked thrombocytopenia, hepatic involvement, and vascular complications, particularly in children and young adults. Nepal, too, faced a notable rise in cases during 2023, with a study involving 692 patients showing that 52% had thrombocytopenia and 29% had leukopenia. Over 50% had elevated SGPT/SGOT levels. Notably, NS1-only positive patients had more severe leukopenia, while IgM-positive patients were more likely to experience thrombocytopenia[20-21].

In Southeast Asia, countries such as Cambodia and Vietnam have documented consistent hematological trends in dengue patients. Clinical studies have shown that during the early febrile phase, leukocytosis is common, followed by leukopenia, rising hematocrit, and progressive thrombocytopenia during the critical phase. These alterations were particularly pronounced between days 4–6 of illness and correlated with complications such as DHF and DSS[22]. In Africa, dengue is an emerging but often under-recognized illness. A 2018 study conducted in northwest Ethiopiahighlighted significant hematological and biochemical changes in dengue-positive patients, including thrombocytopenia, leukopenia, anemia, and elevated liver enzymes. These parameters provided early indications for clinical deterioration and were crucial in resource-limited settings[23].

Interestingly, a 2024 study from Mayo Kebbi Province in Chad (Tchad) presented a different profile. Among 130 seropositive individuals, the majority (92%) exhibited leukocytosis rather than the expected leukopenia. Additionally, anemia was present in 53% and thrombocytopenia in only 12% of patients, suggesting regional variability in immune response or viral serotype characteristics[24]. In Nigeria, a 2024 study focusing on HIV-positive individuals found a dengue seroprevalence rate of 61.7%. Patients showed various hematological abnormalities, including anemia and thrombocytopenia, emphasizing the potential overlap between dengue and other immunocompromising conditions in Africa[25].

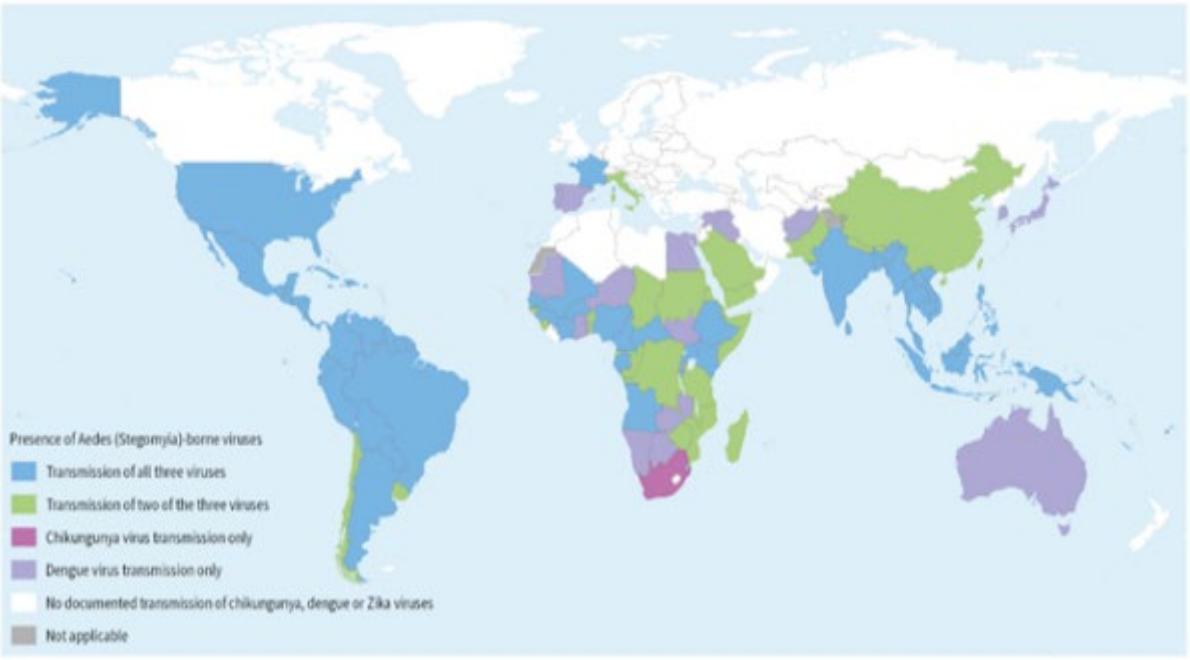

Figure 3. World map of dengue evidence consensus[25]

Bangladesh has experienced some of the most severe dengue outbreaks in South Asia. The 2019 outbreak remains the most devastating, with over 100,000 hospitalizations and 164 recorded deaths. It extended from traditionally endemic urban zones to rural, non-endemic areas. A study in Tangail among pediatric patients revealed that nearly 40% had thrombocytopenia, and DHF and DSS cases were recorded even in previously unaffected regions[26].

The 2023 outbreak in Bangladesh was even more alarming, with over 321,000 hospitalizations and 1,705 deaths between April and December. This outbreak had a fatality rate of approximately 0.53%. A hematological study conducted in Jashore District observed a significant drop in platelet and neutrophil counts from day 1 to day 3 in dengue-positive patients. Interestingly, leukocyte and lymphocyte counts increased during the same period, while hemoglobin and hematocrit levels remained relatively stable[27,28].

A more recent study by Saha et al. (2024), focusing on pediatric dengue cases in Dhaka, further confirmed classical laboratory findings: thrombocytopenia, leukopenia, elevated transaminases, hematocrit changes, and electrolyte imbalances. These findings reinforce the utility of hematological and biochemical markers in monitoring pediatric dengue in Bangladesh[29].

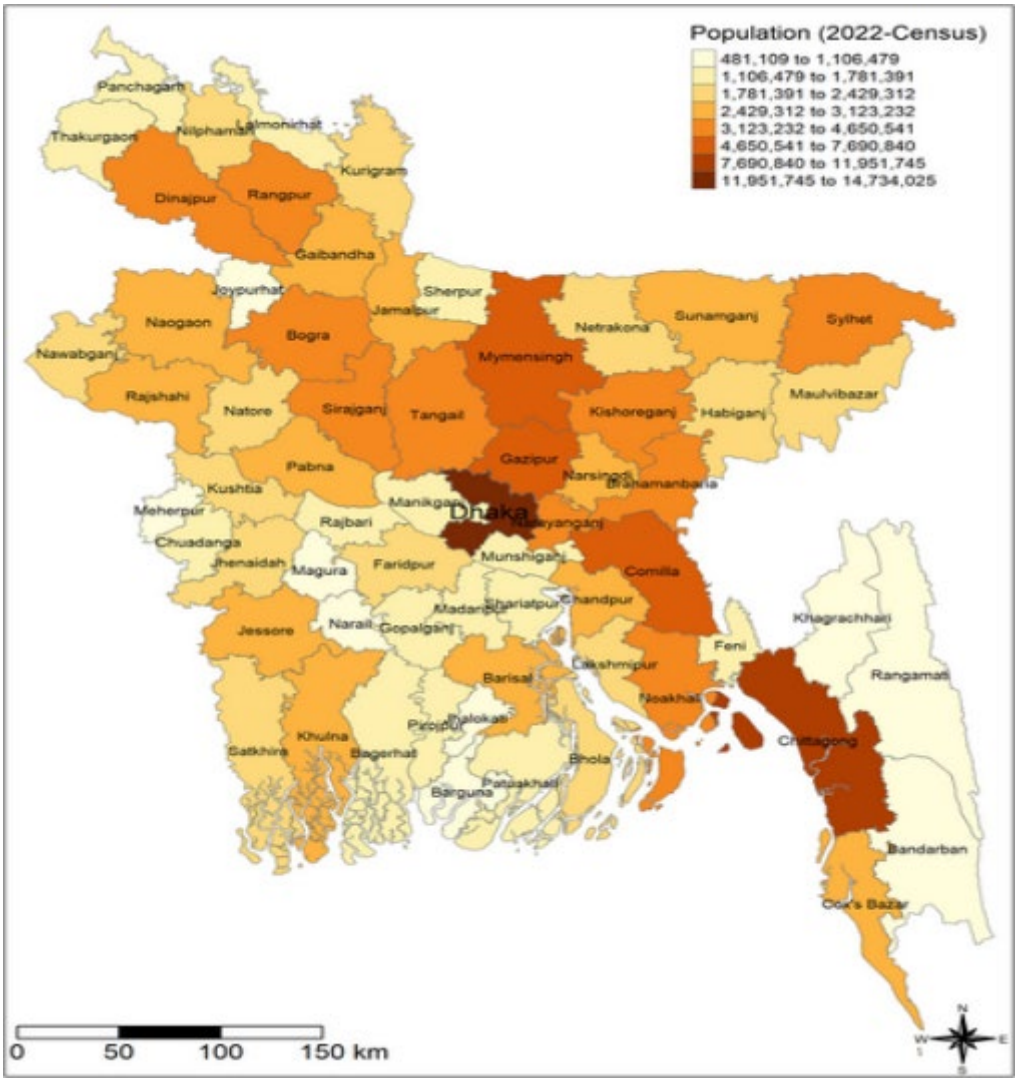

Figure 4. District-wise dengue cases and incidence rate in Bangladesh (2019–2023) [30]

Diverse reports from Southeast Asia and the Middle East post-2010 support similar clinical trends. In Cambodia, meta-analyses have consistently shown early leukocytosis transitioning into leukopenia, lymphocytosis, progressive thrombocytopenia, and elevated liver and renal function biomarkers during critical dengue phases[31]. In Pakistan, the 2019 dengue outbreak resulted in over 52,000 confirmed cases. Clinical studies documented typical dengue-related hematological abnormalities such as thrombocytopenia, leukopenia, and elevated biochemical markers, many of which were associated with DHF and DSS, contributing to approximately 90 fatalities[32].

3. Materials and methods

3.1. Study design and setting

This study was designed as a retrospective observational analysis conducted at Padma General Hospital, Bangladesh. The study was carried out over a four-month period, from June to September 2024. The primary objective was to assess the hematological and biochemical profiles of seropositive dengue patients and evaluate organ function biomarkers to identify common clinical patterns and indicators of disease severity.

3.2. Study population

The study population comprised 134 patients of varying age groups and both genders who were admitted to BIHS General Hospital with a serologically confirmed diagnosis of dengue virus infection. Inclusion criteria required confirmation of dengue through a positive result for at least one of the following tests: NS1 antigen, IgM antibody, or IgG antibody. Only patients with complete clinical and laboratory records available during hospitalization were included. Patients with co-infections (such as malaria, typhoid, or COVID-19), pre-existing chronic liver or kidney disease, hematological malignancies, or incomplete laboratory data were excluded to ensure data consistency and reliability.

3.3. Data collection procedure

Data for this study were collected retrospectively from the medical records department and the laboratory information system of BIHS General Hospital. The dataset included a wide range of clinical, demographic, and laboratory variables. Demographic data such as age and gender were recorded for all patients. Clinical characteristics documented at the time of admission included blood pressure, pulse rate, respiratory rate, and patient-reported dengue-related symptoms such as fever, headache, myalgia, rash, and bleeding tendencies. Serological confirmation of dengue infection was based on positivity for NS1 antigen, IgM antibody, and/or IgG antibody. Hematological parameters evaluated from patient records included red blood cell (RBC) count, hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), platelet count, mean platelet volume (MPV), and white blood cell (WBC) count along with a detailed differential leukocyte count (neutrophils, lymphocytes, monocytes, eosinophils, basophils, and immature granulocytes).

In addition to hematological data, two key inflammatory markers were assessed: C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). Evaluation of renal function included levels of serum creatinine, urea, and uric acid. Liver function tests comprised total bilirubin, alanine transaminase (ALT), aspartate transaminase (AST), and alkaline phosphatase (ALP). Finally, electrolyte balance was examined through measurements of serum sodium, potassium, and chloride concentrations.

3.4. Laboratory analysis

All laboratory investigations were carried out in the central diagnostic laboratory of BIHS General Hospital using standardized procedures and equipment, in compliance with national diagnostic guidelines. For serological testing, NS1 antigen, IgM, and IgG antibodies specific to dengue virus were detected using enzyme-linked immunosorbent assay (ELISA) kits or rapid immunochromatographic test. Hematological parameters including red cell and white cell indices, platelet counts, and differential counts were obtained from a complete blood count (CBC) analysis performed on an automated hematology analyzer, such as the Sysmex XN-Series.

For biochemical testing, including markers of liver and renal function (ALT, AST, ALP, bilirubin, creatinine, urea, and uric acid), blood samples were analyzed using automated clinical chemistry analyzers (e.g., Roche Cobas or Beckman Coulter AU series). These tests were conducted using enzymatic and colorimetric methods, following standard calibration protocols. Serum electrolyte levels, specifically sodium, potassium, and chloride, were measured using the ion-selective electrode (ISE) method, ensuring accurate assessment of electrolyte balance. The inflammatory marker CRP was quantified through immunoturbidimetric assays, while ESR was manually measured using the Westergren method, a widely accepted approach for evaluating erythrocyte sedimentation.

3.5. Statistical analysis

Collected data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize the data: mean ± standard deviation (SD) for continuous variables and frequencies (%) for categorical variables. Comparative analyses between different seropositive groups (e.g., NS1-only vs. IgM/IgG positive) were conducted using independent sample t-tests for normally distributed data and the Mann-Whitney U test for non-normally distributed data. Chi-square tests were employed to examine associations between categorical variables. A p-value < 0.05 was considered statistically significant. Correlation between clinical severity indicators (such as platelet count and ALT/AST levels) and other laboratory markers was assessed using Pearson's or Spearman's correlation coefficients, depending on data distribution.

3.6. Ethical considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision). All patient information was anonymized to ensure confidentiality. As the study involved retrospective analysis of existing clinical data, the requirement for individual informed consent was waived by the ethics committee.

4. Results

The study included 134 serologically confirmed dengue patients, comprising 93 males (69.4%) and 41 females (30.6%), establishing a male-to-female ratio of approximately 2.3:1. This gender disparity is in line with trends observed in many dengue-endemic regions and may be attributed to greater outdoor exposure among males, particularly in working-age populations, increasing the likelihood of mosquito contact. The overall mean age of participants was 32.5 ± 18.2 years, with males having a slightly higher mean age (33.1 ± 17.8 years) than females (31.2 ± 19.1 years), though the difference was not statistically significant ($p = 0.56$), indicating comparable age distributions between sexes. Age-wise, the 15–30 years group had the highest disease burden, accounting for 32.8% of the cohort, followed by 31–40 years (20.9%), <15 years (18.7%), 41–50 years (12.7%), 51–60 years (7.5%), 61–70 years (4.5%), and >70 years (3.0%). Notably, pediatric cases (<15 years) included a higher proportion of females (22.0%) than males (17.2%), though not statistically significant ($p = 0.51$). The distribution in middle and older age brackets was relatively balanced, with no significant gender-based differences across age groups. These findings highlight dengue as a disease primarily affecting younger individuals, particularly adolescents and young adults.

The clinical symptom profile across the study population was consistent with classical dengue manifestations. Fever was the most universally reported symptom, present in 98.5% of patients, with a slightly higher occurrence in males (98.9%) than females (97.6%), though this was not statistically significant ($p = 0.48$). Headache was the second most common symptom, reported in 92.5% of cases, again with a slightly higher prevalence among females (95.1%) compared to males (91.4%) ($p = 0.42$). Vomiting was documented in 85.1% of the cohort, showing minimal gender variation (86.0% in males vs. 82.9% in females, $p = 0.64$). Abdominal pain was more frequently reported in males (21.5%) than in females (14.6%), although this difference did not reach statistical significance ($p = 0.32$). Rash occurred in 34.3% of patients and was more commonly observed in females (43.9%) than males (30.1%), suggesting a gender-related trend that approached significance ($p = 0.12$), possibly linked to immune or hormonal factors. Other symptoms, such as lethargy (12.7%) and restlessness (8.2%), were less frequent and showed no significant gender differences, although both were marginally more common in males (**Table 1**).

Table 1. Baseline characteristics of study participants (N=134)

Variable	Total (n=134)	Male (n=93)	Female (n=41)	p-value
		• Demographics		
Age (years), mean ± SD	32.5 ± 18.2	33.1 ± 17.8	31.2 ± 19.1	0.56
		• Age group distribution		
<15 years	18.7% (25)	17.2% (16)	22.0% (9)	0.51
15-30 years	32.8% (44)	33.3% (31)	31.7% (13)	0.85
31-40 years	20.9% (28)	22.6% (21)	17.1% (7)	0.46
41-50 years	12.7% (17)	12.9% (12)	12.2% (5)	0.91
51-60 years	7.5% (10)	7.5% (7)	7.3% (3)	0.97
61-70 years	4.5% (6)	4.3% (4)	4.9% (2)	0.89
>70 years	3.0% (4)	3.2% (3)	2.4% (1)	0.79
		• Symptoms (%)		
Fever	98.5	98.9	97.6	0.48
Headache	92.5	91.4	95.1	0.42
Vomiting	85.1	86.0	82.9	0.64
Abdominal pain	19.4	21.5	14.6	0.32
Rash	34.3	30.1	43.9	0.12
Lethargy	12.7	13.2	11.6	0.79
Restlessness	8.2	9.1	6.3	0.54

In the laboratory findings, a comprehensive comparison of hematological and biochemical parameters was performed between male and female dengue patients. The total white blood cell (WBC) count averaged $5.8 \pm 3.1 \times 10^3/\mu L$, with no significant difference between males (5.6 ± 2.9) and females (6.2 ± 3.5), ($p = 0.28$), and values remained within the normal reference range of $4.0–11.0 \times 10^3/\mu L$. Hemoglobin levels showed a statistically significant gender difference; females had notably lower hemoglobin (12.5 ± 1.9 g/dL) compared to males (13.5 ± 1.7 g/dL), with a p-value of 0.003, indicating mild anemia was more common in females, even though both groups' mean values fell within the normal range of 12.0–16.0 g/dL. Platelet counts averaged $148 \pm 98 \times 10^3/\mu L$ for the whole cohort, with males showing a slightly higher mean (152 ± 102) than females (139 ± 89), but this difference was not statistically significant ($p = 0.45$). These platelet counts reflect the typical thrombocytopenia associated with dengue, considering the normal reference range of $150–450 \times 10^3/\mu L$.

Liver enzyme analysis revealed that alanine aminotransferase (ALT) levels were significantly elevated in females (63.1 ± 550 U/L) compared to males (45.8 ± 180 U/L), with a p-value of 0.04. This suggests greater hepatic involvement in female patients, although the large standard deviations indicate considerable variability and some extreme values, such as a case with ALT reaching 3770 U/L. Aspartate aminotransferase (AST) levels were also higher in females (80.5 ± 1800 U/L) than males (62.4 ± 980 U/L), but the difference did not reach statistical significance ($p = 0.08$). Both ALT and AST reference ranges lie between 7–55 U/L and 8–48 U/L respectively, so these values indicate considerable liver stress in some patients.

C-reactive protein (CRP), a marker of inflammation, was elevated in both genders but showed no significant difference; females had a mean CRP of 9.8 ± 21.4 mg/dL, while males had 7.9 ± 16.5 mg/dL ($p = 0.12$). Both means exceed the normal range (<1.0 mg/dL), consistent with the acute inflammatory state seen in dengue infection. Renal function measured by serum creatinine was within normal limits for both groups (0.94 ± 0.42 mg/dL overall), with no significant gender differences ($p = 0.18$). Electrolyte levels, specifically

sodium, were similar across genders, averaging 135 mmol/L in males and 136 mmol/L in females (p = 0.23), all within the normal range of 135–145 mmol/L (Table 2).

Table 2. Complete laboratory parameters by gender

Parameter	Total (n=134)	Male (n=93)	Female (n=41)	p-value
WBC (×10³/μL)	5.8 ± 3.1	5.6 ± 2.9	6.2 ± 3.5	0.28
Hemoglobin (g/dL)	13.2 ± 1.8	13.5 ± 1.7	12.5 ± 1.9	0.003*
Platelets (×10³/μL)	148 ± 98	152 ± 102	139 ± 89	0.45
ALT (U/L)	51.2 ± 320	45.8 ± 180	63.1 ± 550	0.04*
AST (U/L)	68.3 ± 1250	62.4 ± 980	80.5 ± 1800	0.08
CRP (mg/dL)	8.5 ± 18.2	7.9 ± 16.5	9.8 ± 21.4	0.12
Creatinine (mg/dL)	0.94 ± 0.42	0.97 ± 0.45	0.87 ± 0.35	0.18
Sodium (mmol/L)	135 ± 4	135 ± 4	136 ± 4	0.23

Gender analysis revealed clinically important differences beyond statistical significance. While males maintained higher hemoglobin levels (p=0.003), females demonstrated more pronounced hepatic involvement with higher ALT (p=0.04) and showed trends toward more severe inflammatory responses (higher CRP p=0.12).

Table 3. Significant gender differences in clinical parameters

Category	Male Findings	Female Findings
Hematological	Higher Hb (13.5 g/dL)	Lower Hb (12.5 g/dL)*
Hepatic	Lower ALT (45.8 U/L)	Higher ALT (63.1 U/L)*
Serological	Higher IgM+ (8.6%)	Lower IgM+ (4.9%)
Vital Signs	Lower pulse (89.4 bpm)	Higher pulse (92.3 bpm)

**Statistically significant (p<0.05)*

The correlation matrix reveals several important relationships among key laboratory and clinical parameters in dengue patients. A very strong positive correlation was observed between alanine transaminase (ALT) and aspartate transaminase (AST) levels, with a Spearman's rho (r) value of 0.85 and a highly significant p-value (<0.001). This indicates that these two hepatic enzymes rise and fall together, reflecting liver involvement in dengue infection. When stratified by gender, the correlation remained strong in both males (r = 0.83) and females (r = 0.89), with no significant difference between genders (p = 0.12) (Table 4).

A moderate positive correlation was found between C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), two inflammatory markers, with an overall r of 0.32 and p = 0.001. This supports their joint role in signaling systemic inflammation during dengue. Gender-specific correlations were similar (males r = 0.30, females r = 0.35), and the difference between genders was not statistically significant (p = 0.45). Platelet count showed a significant inverse correlation with mean platelet volume (MPV) (r = -0.28, p = 0.01), suggesting that as platelet numbers decrease, MPV tends to increase, likely reflecting platelet consumption or destruction common in dengue. This inverse relationship was consistent across males (r = -0.25) and females (r = -0.31) without a significant gender difference (p = 0.18) (Table 4).

White blood cell (WBC) count positively correlated with neutrophil count (r = 0.41, p = 0.002), representing an expected immune response where neutrophils comprise a large proportion of total WBC. Both

genders showed similar correlations (males r = 0.39, females r = 0.44), and no significant difference was found (p = 0.32). Finally, systolic blood pressure (SBP) demonstrated a weak but statistically significant positive correlation with serum sodium levels (r = 0.22, p = 0.02). This association suggests a link between hypotension and hyponatremia in dengue patients, potentially related to fluid shifts or dehydration. Correlations were comparable between males (r = 0.20) and females (r = 0.25), with no significant gender-based difference (p = 0.28) (Table 4).

Table 4. Comprehensive correlation matrix (spearman's rho)

Parameter Pair	r-value	p-value	Male r	Female r	p (gender diff)
ALT vs AST	0.85	<0.001*	0.83	0.89	0.12
CRP vs ESR	0.32	0.001*	0.30	0.35	0.45
Platelets vs MPV	-0.28	0.01*	-0.25	-0.31	0.18
WBC vs Neutrophils	0.41	0.002*	0.39	0.44	0.32
SBP vs Sodium	0.22	0.02*	0.20	0.25	0.28

The data on severe abnormalities and critical cases reveal important clinical challenges among the dengue patients studied. Thrombocytopenia with platelet counts below 50,000/μL was noted in 12 cases, accounting for 9.0% of the cohort. This degree of thrombocytopenia poses a significant risk for bleeding complications, necessitating close monitoring and potentially urgent interventions. Severe hepatic injury, defined by ALT levels greater than 200 U/L, was seen in 5 patients (3.7%), while extremely elevated AST levels above 500 U/L were observed in 4 cases (3.0%). These liver enzyme elevations indicate substantial hepatocellular damage, with case #109 standing out as an extreme outlier. This patient's ALT and AST values reached 3770 U/L and 21940 U/L, respectively, suggesting massive hepatic necrosis and a very poor prognosis. Leukopenia, with white blood cell counts under 2.0 $\times 10^3/\mu L$, was found in 6 patients (4.5%). Such low WBC counts raise concerns about immunosuppression and increased susceptibility to secondary infections. Additionally, hypotension—defined as systolic blood pressure below 90 mmHg—was present in 28 patients, representing 20.9% of the cohort. This clinical sign often reflects circulatory compromise due to plasma leakage, a hallmark of severe dengue, and may require fluid resuscitation and intensive care (Table 5).

Table 5. Prevalence of critical laboratory abnormalities

Abnormality	Cases (n)	Percentage	Most Severe Case (#109)
Thrombocytopenia (<50)	12	9.0%	7 (Platelets)
ALT >200 U/L	5	3.7%	3770 U/L
AST >500 U/L	4	3.0%	21940 U/L
Leukopenia (<2.0)	6	4.5%	1.5 (WBC)
Hypotension (SBP<90)	28	20.9%	70/50 mmHg

The serological profile of the study population shows a clear predominance of NS1 antigen positivity, with 89% (119 out of 134) of patients testing positive. This high NS1 positivity rate strongly indicates that the majority of cases were experiencing a current acute dengue infection. When broken down by gender, 90% of males and 85% of females were NS1 positive, a difference that was not statistically significant (p = 0.38), suggesting similar rates of acute infection between sexes. IgM antibodies, which typically indicate early or recent infection, were detected in 7.5% of patients overall. The prevalence of IgM positivity was slightly higher in males (8.6%) compared to females (4.9%), but this difference did not reach statistical significance (p = 0.42). This suggests a small subset of patients were in the early convalescent phase of dengue. IgG antibodies,

markers of past dengue infection or immunity, were found in only 5.2% of patients, indicating limited prior exposure within this cohort. The rates were almost equal between males (5.4%) and females (4.9%), with no significant gender difference (p = 0.89) (Table 6).

Table 6. NSI, IgG, and IgM Status by Gender

Marker	Total+ (%)	Male+ (%)	Female+ (%)	p-value
NSI	119 (89%)	84 (90%)	35 (85%)	0.38
IgM	10 (7.5%)	8 (8.6%)	2 (4.9%)	0.42
IgG	7 (5.2%)	5 (5.4%)	2 (4.9%)	0.89

5. Discussion

This study of 134 serologically confirmed dengue patients provides comprehensive insights into the demographic, clinical, laboratory, and serological profiles within a dengue-endemic context. The male predominance (69.4%) observed is consistent with numerous prior studies from endemic regions such as Southeast Asia, Latin America, and parts of Africa. For example, studies from Thailand, India, and Brazil similarly report male-to-female ratios ranging from 1.5:1 to 2:1. These findings support the prevailing hypothesis that gender differences in dengue incidence are largely driven by behavioral factors, particularly occupational and environmental exposure. Males, often engaged in outdoor activities and labor, have increased contact with Aedes mosquito vectors, elevating their risk of infection[33-35].

The predominance of younger adults (15–30 years) in the cohort aligns with global epidemiological patterns where dengue disproportionately affects the economically productive segment of the population. This age distribution has important public health implications, as it contributes to significant economic burden due to loss of workdays and healthcare costs. The slightly higher proportion of pediatric females in the under-15 age group, although not statistically significant, is in concordance with pediatric dengue cohorts from South Asia and warrants further investigation to explore possible genetic or hormonal influences on susceptibility in younger females[36,37].

Clinically, fever (98.5%), headache (92.5%), and vomiting (85.1%) were the most frequently reported symptoms, confirming the classical dengue clinical spectrum as described by the WHO (2009) [38]. The observed trend of higher rash prevalence in females (43.9% vs. 30.1%) resonates with some studies suggesting that immune system differences, potentially modulated by sex hormones such as estrogen, may influence cutaneous manifestations of dengue[38]. While not statistically significant in our cohort, this finding invites further research into gender-specific immune responses and their clinical correlates in dengue infection.

Laboratory parameters highlighted important gender disparities. Females exhibited significantly lower hemoglobin levels, consistent with physiological sex differences and possibly influenced by nutritional factors such as iron deficiency, which is prevalent in many endemic regions (WHO, 2011). Elevated ALT levels in females suggest more pronounced hepatic involvement or vulnerability to liver injury during dengue infection. This aligns with prior research indicating that females may experience more severe liver enzyme abnormalities[39], potentially due to hormonal effects on hepatic metabolism or differential immune-mediated damage. Given the wide variability in ALT and AST values, including extreme cases such as patient #109 with massive hepatic necrosis, this finding underscores the necessity of close liver function monitoring, especially in female dengue patients.

The strong positive correlation between ALT and AST levels (r=0.85) is consistent with established knowledge that both enzymes rise concurrently in dengue-associated hepatocellular injury[40]. Moderate

correlations between CRP and ESR support the use of these markers as indicators of systemic inflammation, though dengue is characterized by a complex immune response involving cytokine storms rather than isolated acute-phase reactants (Green & Rothman, 2006). The inverse relationship between platelet counts and mean platelet volume (MPV) reflects ongoing platelet destruction and consumption, phenomena well-documented in dengue pathophysiology[41].

Severe thrombocytopenia (<50,000/μL) in 9% of cases and elevated ALT >200 U/L in 3.7% indicate that a significant minority of patients develop critical complications. Such thrombocytopenia increases the risk of hemorrhagic manifestations and often necessitates supportive interventions such as platelet transfusions or hospitalization (WHO, 2009). Similarly, the documented severe hepatic involvement parallels findings from studies in Vietnam and India, where severe liver injury in dengue correlated with higher morbidity and mortality[42]. The 20.9% prevalence of hypotension reflects substantial plasma leakage and shock, hallmark features of severe dengue, emphasizing the critical need for early fluid management and vigilant clinical monitoring.

Serologically, the predominance of NS1 antigen positivity (89%) confirms that most patients were diagnosed during the acute viremic phase, highlighting the diagnostic utility of NS1 as an early marker in dengue[42]. The relatively low IgG positivity (5.2%) suggests limited prior exposure or secondary infections within this cohort, contrasting with hyperendemic regions such as parts of Southeast Asia where secondary infections often exceed 50% (Kumar et al., 2018). This finding may indicate the study area's evolving dengue epidemiology or reflect the seasonality and sampling timeframe. IgM antibody detection in 7.5% of patients signals recent infections in a subset, consistent with the expected seroconversion timeline[43].

No significant gender differences were observed in serological markers, supporting the notion that humoral immune responses in dengue are generally similar between sexes[44,45]. However, subtle immunological variations influencing clinical manifestations and disease severity may still exist and warrant more detailed immunophenotyping studies.

6. Conclusion

This study provides a detailed characterization of the demographic, clinical, laboratory, and serological features of dengue infection in a dengue-endemic setting. The findings reinforce the predominance of young adult males as the most affected group, likely due to increased exposure to mosquito vectors. Classic clinical symptoms such as fever, headache, and vomiting remain the hallmark of dengue presentation, while laboratory data highlight significant gender differences, particularly with females showing higher hepatic enzyme elevations and mild anemia. The high prevalence of NS1 antigen positivity confirms its diagnostic value in acute dengue, and the documented cases of severe thrombocytopenia and liver dysfunction underscore the importance of early detection and careful clinical management to prevent complications. These insights contribute to improved understanding and management of dengue patients, emphasizing the need for targeted surveillance and gender-sensitive clinical monitoring.

7. Limitations

Several limitations should be considered when interpreting these findings. First, the study was conducted at a single center, which may limit the generalizability of the results to other regions with different epidemiological patterns. Second, the sample size, while adequate, may not have been sufficient to detect all subtle differences, especially in subgroup analyses such as pediatric or severe dengue cases. Third, detailed immunological profiling and viral serotyping were not performed, which could have provided deeper insights into the pathophysiological mechanisms and the impact of secondary infections. Finally, data on potential

confounding factors such as nutritional status, comorbidities, and socio-economic background were limited, which might influence clinical and laboratory outcomes. Future multicenter studies with larger cohorts and more comprehensive immunological and virological analyses are warranted to address these gaps.

Conflict of interest

The authors declare no conflict of interest.

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