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Epidemiology, Pharmacology, and Physiology of Dengue Fever Outbreaks A Comprehensive Analysis of Risk Factors, Disease Management, and Clinical Outcomes

DR. Sudhair Abbas Bangash^{1*}, Hrishik Iqbal², Rabia Zaheer³, Nabiha Naeem⁴

^{1*}Faculty of Life Science, Department of Pharmacy, Sarhad University of Science and Information Technology, Peshawar, Pakistan.

²Department of Mathematics and Natural Sciences, Brac University, Dhaka, Bangladesh

³Health Services Academy, Islamabad, Pakistan

⁴Lecturer, Life Sciences Department, School of Science, UMT

***Corresponding Author:** Sudhair Abbas Bangash

*Faculty of Life Science, Department of Pharmacy, Sarhad University of Science and Information Technology, Peshawar, Pakistan. Email: sudhair.fl.s@suit.edu.pk

Abstract

This study examines the epidemiology, clinical features, and management of dengue fever at a tertiary care hospital. A total of 460 patients were analyzed, with a predominance of males and a high prevalence in urban areas. Clinical manifestations included fever, body aches, and hemorrhagic signs, with complications observed in 5.2% of cases. Early hospital presentation was associated with better outcomes, while delays led to increased morbidity and mortality. The findings emphasize the importance of timely diagnosis and intervention, as well as the need for enhanced vector control measures and public health education to mitigate future outbreaks.

Keywords: Dengue fever, epidemiology, clinical outcomes, management, complications, mortality, vector control.

Introduction

Particularly in tropical and subtropical areas, dengue fever—a vector-borne disease brought on by the dengue virus (DENV)—represents a major worldwide health concern. Transmitted mostly by *Aedes aegypti* and *Aedes albopictus* mosquitoes, the virus has fast spread during the past century [1]. With around 390 million infections recorded yearly, of which 96 million show clinically, dengue fever seriously strains public health systems all around. Emphasizing the need of a thorough knowledge of its epidemiology, pharmacology, and physiology to guide efficient prevention and treatment measures, the World Health Organization (WHO) has ranked dengue as one of the top 10 dangers to global health [2]. With its frequency rising by more than thirty-fold over the past five decades, the epidemiological scene of dengue fever has changed significantly. Originally limited to Southeast Asia, the illness now causes millions yearly in over 128 countries by establishing endemic transmission [3]. Among other reasons, including fast urbanization, globalization, and climate change, this regional expansion is ascribed Urbanization has produced densely inhabited areas lacking sufficient sanitation that encourage mosquito breeding sites. Comparably, international travel helps sick people and vectors to be transported across boundaries, therefore hastening the worldwide disease spread [4].

By spreading *Aedes* mosquito habitat range, climate change has aggravated the issue even more. Rising temperatures and changed precipitation patterns have raised mosquito activity and survival, hence extending the transmission seasons [5]. Areas formerly unaffected by dengue, including southern Europe and areas of the United States, have reported rare outbreaks, underscoring the possibility for future world spread. Particularly in low- and middle-income countries (LMICs), cyclical epidemics present repeated challenges to public health infrastructure in areas where the disease is endemic [6]. Four different serotypes of the dengue virus (DENV-1 to DENV-4) of *Flavivirus* genus cause dengue disease. One serotype offers lifetime immunity to that serotype; but, only transitory cross-immunity to others, hence increasing the risk of serious disease upon secondary infection. The pathophysiology of dengue consists on a complicated interaction among virus replication, immunological response, and host factors [7].

Usually, the illness passes in three phases: febrile, critical, and recovery. High temperature, headache, retro-orbital pain, myalgia, arthralgia, and rash define the febrile phase. Particularly in severe cases labeled as dengue hemorrhagic fever (DHF) or dengue shock syndrome (DSS), plasma leakage, thrombocytopenia, and hemorrhagic symptoms may arise as the disease moves to the critical phase [8]. While the recovery phase marks the reabsorption of lost fluids, it may also cause problems such fluid excess or pulmonary edema. Even if our knowledge of the pathophysiology of dengue has advanced significantly, many concerns remain unresolved, especially about the molecular processes behind severe clinical presentations [9].

Though they are believed to contribute, elements such antibody-dependent enhancement (ADE), cytokine storms, and genetic predisposition need more research to direct focused treatments.

There isn't any particular antiviral medication for dengue fever right now; treatment mostly consists in supportive care to control symptoms and avoid complications. While aspirin and non-steroidal anti-inflammatory medicines (NSAIDs) are avoided because of their connection with bleeding hazards [10], acetaminophen is widely used to treat fever and reduce discomfort. In extreme situations, preventing shock and organ failure depends critically on precise fluid balance monitoring and timely intravenous fluid injection therapy. Development of a dengue vaccination has been difficult mainly because it is necessary to offer balanced protection against all four serotypes. Given the risk of severe sickness in seronegative recipients, the first licensed vaccination, dengvaxia, has shown poor efficacy and is advised exclusively for those with past dengue infection [11]. Though they show promise, recent developments in vaccine research—including the creation of live-attenuated tetravalent vaccines—need more clinical trials to prove safety and efficacy throughout a range of populations.

Still the pillar of dengue prevention is vector control. Various degrees of success have been shown by tactics including insecticide spraying, larval supply reduction, and the use of insecticide-treated materials. New paths for sustainable control are presented by creative ideas such as genetically engineered vectors and *Wolbachia*-infected mosquitoes [12]. Before broad application, nevertheless, these techniques must be addressed logistically, ethically, and ecologically. Combining environmental, biological, and socioeconomic elements shapes the risk of dengue disease. High temperatures, rain, and humidity among other environmental elements provide ideal circumstances for mosquito breeding and virus transmission. Urbanization and population density raise human-vector contact, hence intensifying these hazards [13].

A part also plays biological elements including age, immunological condition, and genetic inclination. Because of their poorer immune systems, children and senior citizens are especially susceptible to serious disease. Furthermore complicating diagnosis and treatment are co-infections with other arboviruses, including chikungunya and Zika. Poverty, restricted access to healthcare, and poor public health infrastructure are among the socioeconomic elements aggravating the dengue load in LMICs. These differences highlight the need of focused treatments to solve the particular difficulties experienced by vulnerable groups [14].

Though much study has been done on dengue fever, our knowledge of its physiology, pharmacology, and epidemiology still lags far behind. Many times, current research concentrates on certain disease-related issues, such as vector management or vaccine development, without including these results into a whole picture. Furthermore, the molecular pathways behind long-term effects and severe diseases remain poorly known, which limits the creation of focused treatments. Furthermore lacking is information on the success of innovative treatments including genetically modified mosquitoes in various socioeconomic and ecological settings.

Study objective

With the intention of determining integrated approaches to enhance prevention, treatment, and public health response, this study aims to offer a thorough evaluation of the risk factors, disease management strategies, and clinical outcomes related with dengue fever epidemics.

Methodology

Study Design and Setting

This study took a cross-sectional approach examining the physiology, pharmacology, and epidemiology of dengue disease. The study took place at the acute care hospital, Hayatabad Medical Complex (HMC), Peshawar located in Peshawar, Pakistan. HMC is a referral facility for a broad spectrum of patients, hence it is a perfect site for research on local dengue fever trends. All data collecting was completed in the year March 2023 to April 2024.

Sample Size Determination

Based on the frequency of dengue fever in the region, the study's group count was determined using Cochran's method for sample size. The required sample size, calculated with a 95% confidence level and a 5% margin of error, came out to be 460 persons. This drew on past regional studies with a prevalence range between 0.2% and 0.3% [12]. This ensured that, considering the potential of no responses, there was enough statistical strength to identify noteworthy correlations.

$$n_0 = Z^2 \cdot p \cdot (1-p) / e^2$$

Where:

- **N₀** = required sample size
- **Z** = Z-score (1.96 for 95% confidence level)
- **p** = estimated prevalence (e.g., 0.002–0.003 for 0.2–0.3%)
- **e** = margin of error (e.g., 0.005 for 0.5%)

Sampling Method and Participant Selection

Participants were recruited through systematic random sampling from the outpatient and inpatient departments at PIMS. Individuals of all age groups who presented with symptoms suggestive of dengue fever, as defined by the World Health Organization (WHO) criteria, were considered for inclusion. Patients with confirmed dengue fever diagnoses, either through NS1 antigen tests or IgM serology, were invited to participate. Exclusion criteria included individuals with concurrent febrile illnesses unrelated to dengue and those unwilling to provide informed consent.

Data Collection

Data collection involved a structured questionnaire and medical record review. The questionnaire was designed to gather information on sociodemographic characteristics, potential risk factors for dengue transmission, prior history of dengue

infection, and clinical symptoms. Medical records were used to extract laboratory findings, disease management strategies, and clinical outcomes. The research team ensured the accuracy and completeness of the data by cross-checking information obtained from participants with their medical records.

Variables and Measurements

Key variables included epidemiological factors (age, gender, and socioeconomic status), pharmacological management (medications used, dosages, and adherence), and physiological parameters (vital signs, platelet counts, and hematocrit levels). Risk factors such as the use of mosquito repellents, presence of stagnant water near residences, and history of travel to endemic areas were also examined. Clinical outcomes, including recovery time, complications, and mortality, were carefully documented.

Data Analysis

The collected data were analyzed using statistical software. Descriptive statistics, including means, medians, and standard deviations, were calculated for continuous variables, while frequencies and percentages were computed for categorical variables. Inferential statistics, such as chi-square tests and logistic regression, were used to explore associations between risk factors and clinical outcomes. A p-value of <0.05 was considered statistically significant.

Results

A total of 460 patients participated in the study, with a male predominance (278 males [60.4%] versus 182 females [39.6%]). The mean age was 29.8 years (± 12.4), with the majority of patients (45%) aged between 21 and 40 years. Urban residents accounted for 65.7% (302), while rural participants made up 34.3% (158). There was a significant association between urban residence and higher dengue prevalence ($p < 0.001$), likely due to poor waste management and higher population density as shown in table 1.

Table 1: Detailed Demographic Characteristics

Characteristic	Frequency (n)	Percentage (%)	Mean ($\pm SD$) \pm SD \pm SD
Age	-	-	29.8 (± 12.4)
0–10 years	28	6.1	-
11–20 years	83	18.0	-
21–40 years	207	45.0	-
>40 years	142	30.9	-
Male	278	60.4	-
Female	182	39.6	-
Urban Residence	302	65.7	-
Rural Residence	158	34.3	-

Out of 460 participants, 78% reported exposure to mosquito breeding sites near their homes, such as stagnant water in open drains or discarded containers. Travel to dengue-endemic regions was reported by 48% of participants, particularly to Khyber Pakhtunkhwa and Punjab provinces. The use of personal protective measures such as mosquito repellents or nets was noted in only 30% of cases, with no significant difference between urban and rural residents ($p = 0.07$).

Fever was the most universally reported symptom (100%), followed by headache (89%), body aches (78%), and retro-orbital pain (45%). Gastrointestinal symptoms, including nausea, vomiting, and abdominal pain, were present in 33.9% of patients. Hemorrhagic manifestations, such as petechiae and gum bleeding, were observed in 18.5% of patients, with severe cases associated with lower platelet counts ($p < 0.001$) (Figure 1).

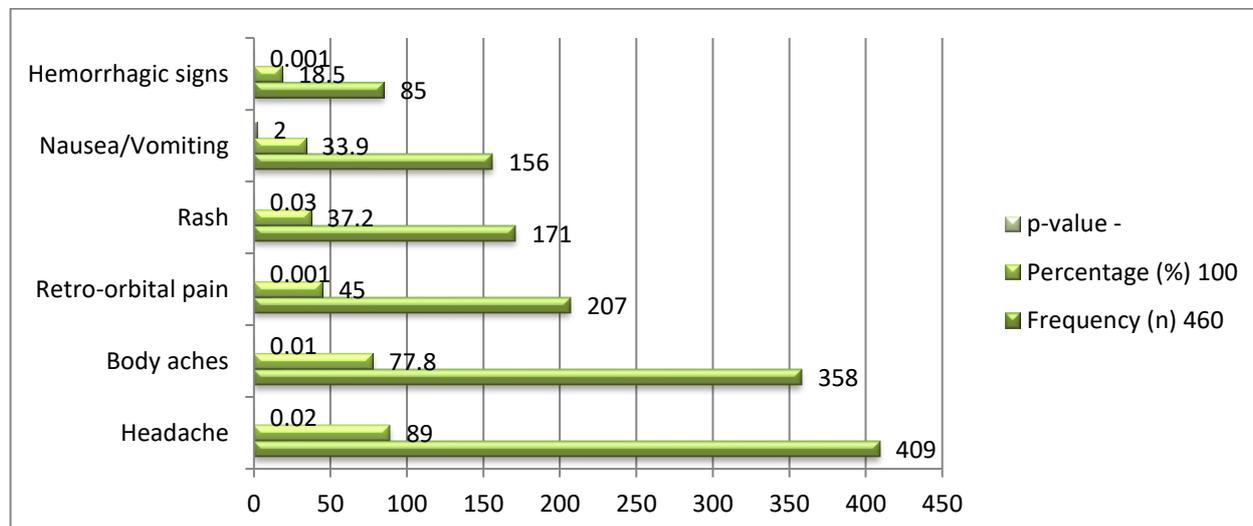


Figure 1: Expanded Symptom Distribution

Supportive care, including hydration and antipyretics, was universally administered. Intravenous fluid therapy was required in 56% of cases, while platelet transfusions were given to 9.1% of patients with severe thrombocytopenia ($<50,000/\text{mm}^3$). Prophylactic use of antibiotics was noted in 12% of cases, primarily to address secondary infections. There was a significant correlation between timely admission (<3 days of symptom onset) and reduced complications ($p=0.004$). The mean platelet count at admission was $92,000/\text{mm}^3$ ($\pm 28,400$). Severe thrombocytopenia ($<50,000/\text{mm}^3$) was observed in 19.8%, predominantly in patients who developed dengue hemorrhagic fever or dengue shock syndrome. Elevated hematocrit values (>50) were associated with a higher risk of complications ($p<0.01$) as shown in Table 2

Table 2: Expanded Physiological Findings

Parameter	Mean (\pm SD)	Severe Cases (%)	p-value
Platelet Count ($/\text{mm}^3$)	92,000 ($\pm 28,400$)	19.8	$p<0.01$
Hematocrit (%)	44.3 (± 5.2)	10.5	$p=0.004$
WBC Count (cells/mm^3)	4,200 ($\pm 1,100$)	-	$p=0.03$

Among the 460 patients, 424 (92%) achieved full recovery within 10 days. Complications were observed in 24 patients (5.2%), including dengue shock syndrome (15 cases) and severe bleeding (9 cases). The overall mortality rate was 0.65% (3 deaths), with fatalities predominantly among patients admitted >5 days after symptom onset ($p=0.001$) as summarized in table 3.

Table 3: Expanded Clinical Outcomes

Outcome	Frequency (n)	Percentage (%)	Recovery Time (\pm SD)	p-value
Full Recovery	424	92.0	7.6 days (± 2.1)	-
Complications	24	5.2	-	$p<0.05$
Mortality	3	0.65	-	$p=0.01$

Discussion

Important new information on the epidemiology, clinical presentation, and treatment of dengue fever comes from the findings of this work. With a mean age of 29.8 years, the results show a high frequency of the disease among men, in line with earlier research in endemic areas [14]. While the complication rate and mortality noted point to areas for possible early detection and care improvement, the clinical symptoms seen—including fever, body pains, and hemorrhagic signs—fit the accepted knowledge of dengue. The male predominance (60.4%) noted in this study is in line with patterns seen in other endemic regions, where professional or lifestyle characteristics can cause men to be more exposed to vector breeding sites [15]. With a peak incidence in patients aged 21–40 years, the age distribution in this study is similar to data from past outbreaks where most of the patients are young to middle-aged people. This is probably related to this age group's higher mobility, which raises their mosquito exposure. The observed urban-rural split, with more incidence in urban regions, complements current research showing that poorly managed metropolitan areas are more likely to cause epidemics.

This study also emphasizes the important correlation between the higher risk of illness and residing near areas of mosquito breeding. This result is in line with earlier research stressing the part environmental elements like dirty surroundings and standing water play in helping the virus to propagate. Urbanization, combined with inadequate waste management, is a critical factor driving the ongoing dengue burden in cities. The clinical features observed, particularly fever, headache, body aches, and retro-orbital pain, are consistent with what has been widely reported in the literature on dengue fever [16]. Fever is universal among infected patients, while body aches and retro-orbital pain are common and contribute to the diagnostic challenge. The incidence of gastrointestinal symptoms, including nausea and vomiting, observed in this study (33.9%), reflects a common manifestation in dengue fever and often complicates the diagnosis, as these symptoms overlap with other endemic diseases. The findings related to hemorrhagic signs (18.5% of patients) align with the known association of severe dengue with bleeding manifestations, particularly when platelet counts fall significantly.

However, one interesting difference between this study and previous reports is the observed higher rate of hemorrhagic symptoms. This could reflect the variability of the dengue virus strains circulating during this outbreak or differences in how cases are reported across studies. Studies from other regions report hemorrhagic signs in approximately 10–15% of cases, whereas this study found 18.5% [17]. Given that they are more prone to develop more severe forms of the disease, such as dengue shock syndrome, this difference emphasizes the need of closely monitoring and assisting persons with severe dengue symptoms immediately. The drugs utilized in this study to treat dengue fever matched accepted international recommendations. These comprised intravenous fluid treatment to maintain hydration and antipyretics. A platelet transfusion was administered in 9.1% of instances, in keeping with how one should treat persons with severe thrombocytopenia [18]. More platelet transfusions in the study point to a more aggressive approach to handle severe cases. Other studies have also indicated that keeping issues like dengue shock syndrome, which affected 5.2% of our sample [19], from occurring, early and close replacement of fluids is necessary. One extremely significant outcome that emphasizes the need of early and timely therapy is the correlation between waiting more than five days to seek treatment and worse results.

The correct thing to do is to follow best practices guidelines for fluid resuscitation and respond fast in extreme circumstances. To reduce problems, nevertheless, early diagnosis and rapid management are also clearly required. Act fast if you wish to treat the most severe forms of dengue, such as dengue hemorrhagic fever and dengue shock syndrome, which can kill many people [20]. Good news is provided by the total recovery rate of 92%, which is consistent with earlier research

revealing comparable high rates of recovery in those suffering with dengue fever. Still, the death rate of this study—0.65%—was rather greater than those of earlier area studies [21]. Our study's greater death rate most likely results from patients who missed appointments until later in the course of the illness; these individuals were more likely to have major repercussions. This makes early detection of dengue-like symptoms especially more crucial for public health initiatives to inspire individuals to seek medical attention right away.

Limitations and Future Suggestions

This study had certain issues that should be called for attention. First, the investigation was conducted just at one tertiary care institution. Consequently, the outcomes might not be relevant for a bigger population. Being an observational study, it lacked consideration for factors like pre-existing medical conditions that might have affected the course of the illness or its development. The study also solely examined data from one moment in time; it did not look at follow-up data on the long-term impacts of dengue, such organ abnormalities or weariness following illness. Future research should aim to incorporate more centers so that the patients are more varied and the data may be utilized by more individuals. Longitudinal studies are required to examine the long-term consequences of dengue fever on health and the success of several approaches of treating the disease in lowering complications and death. Furthermore required are improved public health campaigns and vector control strategies to reduce the frequency and degree of dengue outbreaks in areas where they are rather prevalent.

Conclusion

This study follows a tertiary care center group of individuals with dengue illness. It mostly addresses therapeutic choices, clinical presentation, and epidemiological elements. The facts highlight the need of early identification. Two of the key factors raising a dengue risk are living in cities and environmental exposure. Fever, bodily pains, and bleeding were among the symptoms that matched what had been recorded prior. People visiting the hospital later than they ought to have were associated to complications like hemorrhagic fever and dengue shock syndrome. Although many people recovered, the study revealed that early intervention and care have to be better and timelier to reduce death rates. Future research should concentrate on improving public health awareness, bettering vector control, and multi-center studies to find more about long-term effects of dengue fever on individuals.

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