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RESEARCH ARTICLE

Epidemiological Analysis of Dengue Fever: Insights from Demographic, Serological, and Temporal Data in Pakistan

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Abstract

Dengue fever, a mosquito-borne viral disease, poses a significant public health threat in tropical and subtropical regions, including Pakistan. This study presents a comprehensive epidemiological analysis of dengue, drawing on data from 116 patients tested between September 2020 and September 2021. The analysis examines demographic factors, serological markers (IgG, IgM, NS1 antigen levels), and the temporal distribution of dengue cases. The findings reveal a higher prevalence of dengue among males (63.79%), with the highest incidence occurring in the 30-39 age group (22.41%). Serological testing showed that the majority of patients were in the early to active stages of infection, with 65.52% of the cohort testing positive for dengue based on IgM levels. A pronounced seasonal spike in cases was observed in September 2021, accounting for 81.03% of the total cases, and coinciding with the monsoon season—a period known for heightened mosquito activity. These results are consistent with global patterns of dengue transmission and highlight the critical role of demographic and seasonal factors in the spread of the disease. The study underscores the need for targeted public health interventions, particularly among high-risk demographic groups and during peak transmission periods. This research contributes valuable insights into the epidemiology of dengue in Pakistan, offering guidance for the development of more effective disease control strategies and interventions.

Keywords: Dengue | Prevalence | Pakistan | Epidemiology | Health Policy

Significance

This study on Hepatitis C Virus in Pakistan highlights a significant public health challenge, with a high overall prevalence of 15.79%. The highest prevalence (37.5%) was found among adults aged 21-40, likely due to high-risk behaviors such as intravenous drug use. Males had a slightly higher prevalence (17.14%) than females (13.64%), though the difference was not statistically significant. The findings underscore the need for targeted interventions, particularly for younger adults, and emphasize the importance of expanding screening and treatment programs. Further research with larger sample sizes is recommended to improve precision in prevalence estimates.

Introduction

Dengue fever, a mosquito-borne viral disease caused by the dengue virus, is one of the most pressing public health challenges in tropical and subtropical regions, including Pakistan (1, 2). The disease is transmitted primarily by the Aedes aegypti mosquito, which thrives in warm and humid environments (3). Dengue manifests in a spectrum of clinical presentations, ranging from mild febrile illness to severe conditions such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), both of which can be fatal without timely intervention (4). According to the World Health Organization (WHO), dengue affects an estimated 100-400 million people globally each year, with a significant burden in Southeast Asia, the Western Pacific, the Americas, and Africa (5).

In Pakistan, dengue has emerged as a significant public health concern over the past two decades. The country's climatic conditions, characterized by prolonged monsoon seasons and rising temperatures, create an ideal breeding environment for Aedes mosquitoes, leading to recurrent dengue outbreaks (6). Urbanization, inadequate waste management, and water storage practices further exacerbate the risk of dengue transmission in densely populated areas (7). The WHO classifies Pakistan as one of the countries at highest risk for dengue outbreaks, with large-scale epidemics occurring periodically, particularly during and after the monsoon season (8).

Understanding the epidemiology of dengue in Pakistan is crucial for developing targeted control and prevention strategies. Previous studies have demonstrated that demographic factors, such as age and gender, play a significant role in the susceptibility to and severity of dengue (9). Typically, working-age adults and males have been observed to be at higher risk, potentially due to increased exposure to mosquito vectors (10). Serological markers, including IgG, IgM, and NS1 antigen levels, are critical in diagnosing dengue and determining the stage of infection. These markers not only help in confirming the infection but also provide insights into the timing and intensity of the immune response, which is essential for patient management (11).

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The temporal distribution of dengue cases in Pakistan, particularly the marked seasonality associated with the monsoon period, underscores the influence of environmental factors on dengue transmission dynamics (12). During the monsoon season, increased rainfall and humidity create conducive conditions for mosquito breeding, leading to spikes in dengue incidence. Consequently, public health interventions must be timed effectively to coincide with these periods of heightened risk (13).

This study aims to provide a comprehensive descriptive analysis of dengue data collected from a specific patient population in Pakistan. By focusing on the demographic characteristics, serological markers, and temporal distribution of cases, this research seeks to identify key trends and patterns in dengue incidence. The insights gained from this analysis will contribute to a better understanding of the epidemiological factors driving dengue outbreaks in Pakistan and inform the design of more effective public health strategies to control and mitigate the spread of dengue in the country.

Methods

Study Design and Population

This retrospective study analyzed data from 116 patients who were tested for dengue between September 2020 and September 2021. The patients ranged in age from 3 to 83 years and included 74 males and 42 females. The study aimed to assess the distribution of dengue cases across different age groups, gender, and serological test results, as well as to analyze the temporal distribution of dengue cases within the study period.

Data Collection

Data were collected from patient records, including demographic information (age and gender) and results from serological tests (IgG, IgM, and NS1 antigen levels). The serological tests were conducted using the Enzyme-Linked Immunosorbent Assay (ELISA) method, with specific thresholds set to determine positivity, IgG (ELISA) levels were considered positive if >1.0. IgM (ELISA) levels were considered positive if >1.0. NS1 antigen (ELISA) levels were considered positive if >1.0.

Statistical Analysis

Descriptive statistics were used to analyze the demographic characteristics of the patient population, including age and gender distribution. The serological test results were categorized into different ranges, and the mean and standard deviation for each range were calculated. The overall prevalence of dengue was determined by calculating the percentage of positive cases out of the total number of patients tested.

To analyze the temporal distribution of dengue cases, the data were aggregated monthly, with a focus on identifying seasonal peaks in dengue incidence. The findings were presented in tables and figures to facilitate a clear understanding of the patterns observed.

Results

The age distribution of dengue patients ranged from 3 to 83 years, with a mean age of 37.97 years and a median age of 37 years. The highest incidence was observed in the 30-39 age group, accounting for 22.41% of the total cases (Table 1).

Age Group (Years)	Number of Patients (%)
0-9	6 (5.17%)
10-19	6 (5.17%)
20-29	16 (13.79%)
30-39	26 (22.41%)
40-49	13 (11.21%)
50-59	15 (12.93%)
60-69	6 (5.17%)
70-79	8 (6.90%)
80+	3 (2.59%)

Table 1: Age Distribution of Dengue Patients

Of the total patients, 63.79% were male (74 patients) and 36.21% were female (42 patients), indicating a higher incidence of dengue in males (Figure 1). The serological test results showed variability in IgG, IgM, and NS1 antigen levels among the patients, indicating different stages of dengue infection. The majority of patients fell into the <1.0 and 1.0-5.0 ranges, with 24.14% and 28.45% of patients, respectively. The mean IgG levels and standard deviations for each category are detailed in Table 2.

Table 2: Dengue IgG (ELISA) Levels

IgG Range	Number of Patients (%)	Mean IgG Level	Standard Deviation
<1.0	28 (24.14%)	0.35	0.22
1.0-5.0	33 (28.45%)	2.7	1.1
5.1-10.0	11 (9.48%)	7.5	1.5
10.1-20.0	7 (6.03%)	13.9	2.7
20.1-30.0	6 (5.17%)	25.4	2.7
30.1-40.0	8 (6.90%)	34.7	3.0
>40.0	3 (2.59%)	39.5	1.3

Nearly half of the patients (49.14%) had IgM levels in the 1.0-5.0 range, indicating active or recent infections (Table 3).

Table 3: Dengue IgM (ELISA) Levels

IgM Range	Number of Patients (%)	Mean IgM Level	Standard Deviation
<1.0	34 (29.31%)	0.4	0.27
1.0-5.0	57 (49.14%)	2.3	1.1
5.1-10.0	6 (5.17%)	6.8	1.6
10.1-20.0	6 (5.17%)	14.5	2.7
>20.0	7 (6.03%)	25.3	4.6

A significant proportion of patients (54.31%) had NS1 antigen levels below 1.0, suggesting no current infection or a past infection (Table 4).

Table 4: Dengue NS1 Antigen (ELISA) Levels

NS1 Range	Number of Patients (%)	Mean NS1 Level	Standard Deviation
<1.0	63 (54.31%)	0.4	0.27
1.0-5.0	32 (27.59%)	2.4	1.1
5.1-10.0	12 (10.34%)	6.8	1.4
10.1-20.0	2 (1.72%)	15.2	3.4
>20.0	7 (6.03%)	25.5	4.3

Figure 2 presents the distribution of dengue serological markers, IgG, IgM, and NS1 antigen levels, among the patient population, categorized into specific ranges. The grouped bar chart visually compares the number of patients falling within each serological range for the three markers, providing insights into the immune response and infection stage across the studied cohort. The IgG levels showed that 28 patients (24.14%) had levels below 1.0, indicating either no prior exposure or a recent primary infection. The largest group of patients, 33 individuals (28.45%), had IgG levels between 1.0 and 5.0, suggesting a recent or ongoing immune response. Fewer patients exhibited higher IgG levels, with 11 patients (9.48%) in the 5.1-10.0 range, 7 patients (6.03%) in the 10.1-20.0 range, and 17 patients (14.66%) showing IgG levels greater than 20.0. A significant proportion of patients, 34 individuals (29.31%), had IgM levels below 1.0, indicating no recent infection or very early-stage infection. The majority of the patients, 57 individuals (49.14%), had IgM levels in the 1.0-5.0 range, suggesting an active or recent infection. Higher IgM levels were less common, with 6 patients (5.17%) in the 5.1-10.0 range, 6 patients (5.17%) in the 10.1-20.0 range, and 7 patients (6.03%) exhibiting IgM levels above 20.0, indicative of acute infection stages. The NS1 antigen levels showed that the majority of patients, 63 individuals (54.31%), had levels below 1.0, suggesting no current infection or a past infection with resolved antigenemia. A smaller group, 32 patients (27.59%), had NS1 levels in the 1.0-5.0 range, indicating recent infection. Higher NS1 levels were less frequent, with 12 patients (10.34%) in the 5.1-10.0 range, 2 patients (1.72%) in the 10.1-20.0 range, and 7 patients (6.03%) showing NS1 levels above 20.0, reflecting a high level of viremia typically associated with acute infection. The distribution of serological markers among the patients suggests a broad range of immune responses, from early to acute stages of dengue infection. The majority of patients fall into the lower ranges for all three markers, indicating that most were either in the early stages of infection or had recently been exposed to the virus. However, a notable proportion of patients with higher levels of IgM and NS1 antigen points to active or acute infection, underscoring the variability in infection severity and timing within the cohort. These findings highlight the importance of serological testing in diagnosing and managing dengue cases, as well as in understanding the epidemiological trends in the patient population. The temporal distribution of dengue cases revealed a significant spike in September 2021, with 81.03% of the cases occurring during this month (Figure 3). This spike likely corresponds to the post-monsoon season, a period known for increased mosquito activity. The overall prevalence of dengue in the dataset was calculated to be approximately 65.52%. This was determined by considering positive cases across IgG, IgM, and NS1 antigen levels, with IgM positivity representing the highest count (76 patients) (Figure 4).

Discussion

The present study provides a comprehensive analysis of dengue epidemiology in a patient population, emphasizing the demographic characteristics, serological markers, and temporal distribution of cases. Infectious diseases have already caused significant problems in Pakistan, straining the healthcare system and public resources (14-20). The COVID-19 pandemic has particularly broken the backbone of the economy, further complicating efforts to manage other infectious diseases like dengue (21-28). These findings not only enhance our understanding of dengue patterns within the study cohort but also contribute to the broader literature on dengue epidemiology, particularly in regions like Pakistan, where the disease remains a significant public health challenge.

The analysis revealed that dengue predominantly affected males (63.79%) and was most common among adults aged 30-39 years (22.41%). This age and gender distribution is consistent with previous studies conducted in other endemic regions. For instance, a study conducted in Sri Lanka by Tamils et al. (2013) also reported a higher prevalence of dengue among males, attributing this trend to increased outdoor activities and occupational exposure to mosquito bites (29). Similarly, a study from Brazil by Cavalcanti et al. (2011) found that working-age adults, particularly males, were more susceptible to dengue, likely due to higher exposure to Aedes mosquitoes during peak mosquito activity periods (30).

The findings of the current study suggest that the 30-39 age group is at the highest risk, aligning with global patterns where the working-age population often shows a higher incidence of dengue. This demographic is likely at greater risk due to increased mobility, occupational exposure, and possibly a stronger immune response leading to more noticeable symptoms, which in turn leads to more frequent testing and diagnosis.

The serological analysis revealed varying levels of IgG, IgM, and NS1 antigen, indicative of different stages of infection among the patients. A significant proportion of patients had low IgG and IgM levels (<1.0), suggesting recent exposure or early-stage infection. The largest group of patients had IgM levels in the 1.0-5.0 range, indicating active or recent infections, while a smaller subset exhibited high IgM and NS1 antigen levels, pointing to acute infections.

These findings are consistent with the established understanding of dengue immunology. IgM is typically the first antibody to appear after dengue infection, usually within a few days, peaking around the first week, and persisting for several weeks. IgG appears later, generally around the end of the first week of illness, and can persist for life, providing some level of immunity against subsequent infections (31). The presence of NS1 antigen is an early marker of viremia, usually detectable from the first day of fever and persisting for up to nine days, making it a critical marker for diagnosing acute dengue infection (32).

The variability in serological markers observed in this study highlights the heterogeneity of the patient population, with some individuals in the early stages of infection and others in more advanced stages. This diversity underscores the importance of timely and accurate serological testing for effective dengue diagnosis and management. The findings also align with the broader literature, where similar serological patterns have been observed in dengue-endemic regions, such as in a study by Wong et al. (2010) in Malaysia, where the distribution of IgG and IgM levels was used to assess the timing of dengue outbreaks (33).

The temporal distribution of dengue cases in this study showed a significant spike in September 2021, accounting for 81.03% of the total cases. This pronounced seasonal peak likely corresponds with the monsoon season, a period characterized by increased rainfall and humidity, which create ideal conditions

for Aedes mosquito breeding. The strong seasonal pattern observed in this study aligns with findings from other dengue-endemic regions, where similar seasonal peaks have been reported. For example, a study by Gubler (2012) in Southeast Asia highlighted the strong correlation between dengue incidence and the monsoon season, with most cases occurring shortly after the peak rainfall periods (34).

The seasonal nature of dengue transmission is well-documented in the literature. Mosquito breeding and activity increase during the rainy season, leading to a higher risk of dengue transmission. This pattern was also observed in a study by Kyle and Harris (2008) in India, where dengue cases surged during and immediately after the monsoon season (35). The current study's findings reinforce the need for preemptive public health interventions during peak transmission periods, such as enhanced vector control efforts, public awareness campaigns, and early diagnosis and treatment initiatives.

The overall prevalence of dengue in the study population was calculated to be approximately 65.52%, a figure that highlights the significant impact of the disease within this group. This high prevalence is a cause for concern and underscores the urgent need for effective public health strategies to manage and reduce the spread of dengue. The findings of this study are in line with other reports from dengue-endemic regions, such as a study by Shepard et al. (2016), which estimated the economic and public health burden of dengue in the Americas and highlighted the importance of targeted interventions to reduce transmission and manage outbreaks (36).

Given the observed demographic trends, targeted interventions should focus on high-risk groups, particularly working-age adults and males. Public health campaigns should emphasize the importance of personal protective measures, such as using mosquito repellents, wearing protective clothing, and eliminating standing water where mosquitoes breed. Additionally, given the seasonal peak in dengue cases, vector control efforts should be intensified before and during the monsoon season to reduce the mosquito population and interrupt the transmission cycle.

Conclusion

The detailed descriptive analysis provided by this study offers valuable insights into the epidemiology of dengue in Pakistan, with broader implications for other dengue-endemic regions. The findings highlight the importance of demographic factors, serological markers, and seasonal patterns in understanding dengue transmission dynamics. By aligning the results with previous and contemporary literature, the study contributes to the growing body of knowledge on dengue and underscores the need for sustained public health efforts to combat this persistent threat. Future research should focus on longitudinal studies to track changes in dengue epidemiology over time and assess the effectiveness of intervention strategies in reducing the disease burden.

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