Original article

Predicting Dengue Patterns: A Community-Based Prospective Study in Bangladesh

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Abstract

Background:
Dengue continues to pose a major public health threat in Bangladesh, particularly during seasonal outbreaks exacerbated by climatic and environmental conditions.

Objective:
This study aimed to predict dengue transmission patterns using a community-based prospective design that integrates demographic, environmental, entomological, and laboratory variables.

Methods:
A total of 300 participants were enrolled for this study which was conducted in President Abdul Hamid Medical College, Kishoregonj, Bangladesh, from March 2023 to October 2023. Data were collected on sociodemographics, vector breeding sites, preventive practices, climate parameters, and laboratory confirmation of dengue cases. Multiple linear regressions were used to identify significant predictors of dengue incidence.

Results:
Among confirmed cases, 70% were mild, 25% hospitalized, and 5% resulted in death. Most cases (60%) occurred during the monsoon season. Larvae were identified in 70% of breeding sites, with abandoned tires and water tanks as major sources. While 40% of households showed high awareness, preventive practices were inconsistently followed. NS1 and IgM positivity were recorded in 65% and 70% of cases, respectively. Rainfall ($p=0.001$) and breeding sites ($p=0.028$) were statistically significant predictors in the regression model, which achieved 75% prediction accuracy.

Conclusion:
Rainfall and breeding site density are key predictors of dengue outbreaks. Community-based models integrating environmental, behavioral, and diagnostic data are crucial for effective dengue forecasting and control in Bangladesh.

Keywords: Dengue prediction, Bangladesh, rainfall, Breeding sites, Community-based study, NS1, Oreventive practices

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Introduction:

Dengue, caused by DENV and transmitted by Aedes aegypti, has become a major global health emergency. Cases rose from ~505,000 in 2000 to over 5 million in 2019, driven by climate variability, unplanned urbanization, and vector adaptation.[1]Southeast Asia contributes nearly 60% of global dengue morbidity, with incidence rising 1.2% annually over three decades.[2] By April 2024, WHO reported >7.6 million cases, with SEAR and the Americas most affected due to rising temperatures, erratic rainfall, and rapid urbanization. [3,4] Rising temperature and humidity accelerate mosquito development and viral replication, increasing transmission potential. Urban heat islands and poor water infrastructure further aid breeding.[5] Modeling predicts a 90–186% rise in dengue incidence in Asian megacities under a 4°C warming scenario.[6] Bangladesh, in a dengue hyperendemic zone, saw its worst outbreak in 2023 with 321,179 cases and 1,705 deaths.[7] Unlike earlier years, rural and southern districts were heavily affected.[8] Transmission has remained high into 2024–2025, with >78,000 hospitalizations and 2,500 admissions by April 2025. In Bangladesh, monsoon rainfall, high temperatures (28–32°C), and poor water storage drive Aedes proliferation and outbreaks.[9] Surveillance studies show that dengue cases increase significantly with each additional rainy day in a month.[10] Despite known climate–dengue links, Bangladesh lacks prospective community-level studies integrating entomological, behavioral, and lab data. Reliance on hospital surveillance leads to underreporting and missed early warnings.[11]Globally, predictive models using meteorological data have achieved up to 84% accuracy. [12,13] However, most omit behavioral and larval-site data, limiting operational use for vector control. In Bangladesh, the absence of holistic models integrating real-time environmental, behavioral, and virological data remains a critical bottleneck to effective outbreak prediction and early response. Uncontrolled dengue strains health systems, causes absenteeism, and threatens progress toward SDG-3.[14] Hence, an integrated community-based predictive model combining climate, entomological, and behavioral data is urgently needed. These consequences pose a direct threat to Bangladesh's progress toward Sustainable Development Goal 3 (SDG-3), which targets the reduction of communicable diseases and promotion of health and well-being for all.[14] Therefore, developing an integrated community-based predictive model that accounts for climate, entomological dynamics, and local preventive behaviors is urgently needed to strengthen early warning systems and improve public health preparedness in Bangladesh.

Methods:

This community-based prospective study was conducted at President Abdul Hamid Medical College, Kishoregonj, Bangladesh, a high-risk dengue region, from March 2023 to October 2023. The objective was to identify environmental and community-level factors influencing transmission, forecast outbreak patterns, and evaluate preventive measures. A total of 300 participants were enrolled between July 2023 and June 2024. Eligibility included age ≥18 years and permanent residence in the study area. Written informed consent was obtained, and ethical approval was granted by the Institutional Review Board. Demographic data (age, gender, occupation, education) were collected using interviewer-administered questionnaires. Dengue incidence was monitored through clinical evaluation and confirmed by laboratory testing. Cases were classified as mild (outpatient-managed) or severe (hospitalized), with mortality also recorded. Environmental surveillance identified Aedes breeding sites (e.g., tires, water containers, construction areas, potholes, roof tanks), verified by larval presence. Monthly meteorological data (rainfall, temperature, humidity) were collected to assess seasonal effects, particularly during monsoon. Household surveys evaluated community knowledge and practices, including bed net use, water management, and repellent use. Blood samples (n=300) were tested for dengue NS1 antigen and IgM using immunochromatographic assays. Complete blood counts (platelets, hematocrit) were also performed to assess severity. Predictive modeling used multiple linear regression to evaluate the effect of climatic and entomological factors on dengue trends. Data were analyzed in SPSS v26.0. Descriptive statistics summarized demographic, environmental, and clinical variables, while regression models tested associations. A p-value <0.05 was considered statistically significant.

Results:

The largest age group was 26–35 years (30.0%), followed by 18–25 years (25.0%). Males comprised 53.3% of participants. Students (26.7%) were the most common occupation, followed by teachers (16.7%) and farmers (13.3%). Most had secondary (26.7%) or high school (30.0%) education, while 20.0% were graduates (Table-I).

Table-I: Demographic profile of participants (N= 300)

Demographic profile	no. (%)
Age range (years)	
18–25	75(25.0)
26–35	90(30.0)
36–45	60(20.0)
46–60	50(16.7)
60+	25(8.3)
Gender	
Male	160(53.3)
Female	140(46.7)
Occupation	
Student	80(26.7)
Teacher	50(16.7)
Farmer	40(13.3)
Nurse	30(10.0)
Engineer	25(8.3)
Shopkeeper	20(6.7)
Office worker	25(8.3)
Driver	20(6.7)
Education level	
Primary	50(16.7)
Secondary	80(26.7)
High School	90(30.0)
Graduate	60(20.0)
Postgraduate	20(6.7)

Most cases were mild (70.0%), with 25.0% severe and 5.0% fatal. Incidence peaked during the monsoon (60.0%), while summer (16.7%), winter (15.0%), and spring (8.3%) showed lower burdens, confirming strong seasonal influence (Table-II).

Table-II: Dengue case characteristics and seasonal distribution (N= 300)

Variables	no. (%)
Dengue severity	
Mild (new cases)	210(70.0)
Severe (hospitalized)	75(25.0)
Deaths	15(5.0)
Season	
Monsoon	180(60.0)
Summer	50(16.7)
Winter	45(15.0)
Spring	25(8.3)

were the most common breeding sites, followed by potholes and containers. Larvae were detected in 70.0% of surveyed sites, highlighting widespread Aedes activity (Figure-1).

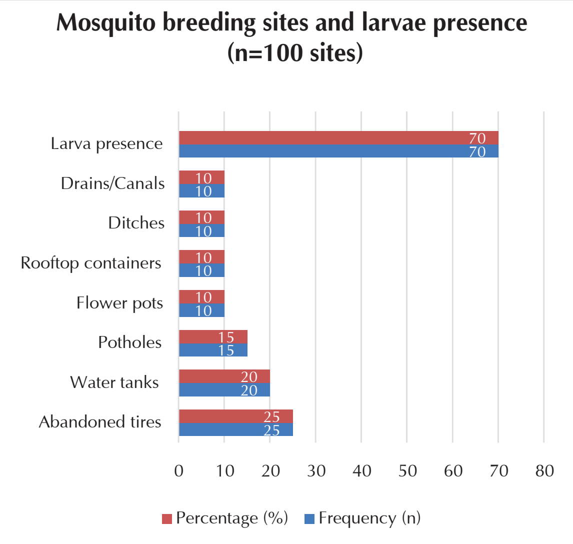

Figure-1: Mosquito breeding sites and larvae presence (n=100 sites)

Awareness levels were high in 40.0% of households, medium in 35.0%, and low in 25.0%. Preventive practices included mosquito nets (60.0%), water cleanup (50.0%), and repellents (45.0%), showing moderate adoption (Figure-2).

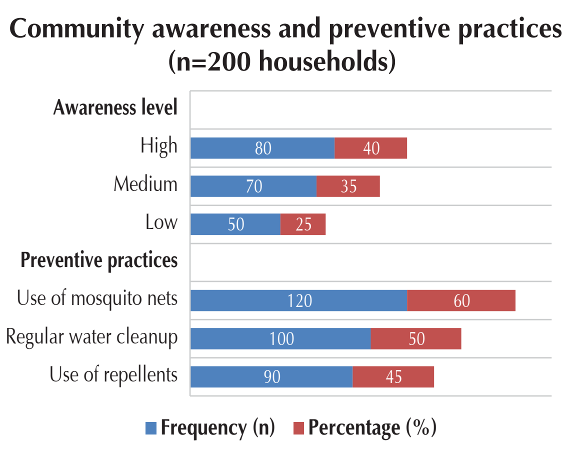

Figure-2: Community awareness and preventive practices (n=200 households)

Most cases occurred with moderate (41.7%) or high rainfall (33.3%), while low rainfall months had fewer cases. Incidence peaked at 25–30°C (45.8%) and >30°C (33.4%). Dengue burden was moderate (20–50 cases) in 41.7% of months and high (>50 cases) in 25.0% (Table-III).

Table-III: Climate patterns and monthly dengue case trends (n=24 months)

Climate patterns	no. (%)
Rainfall category	
Low (<50 mm)	6(25.0)
Moderate (50–150 mm)	10(41.7)
High (>150 mm)	8(33.3)
Temperature range	
<25°C	5(20.8)
25–30°C	11(45.8)
>30°C	8(33.4)
Dengue cases trend	
Low (<20 cases)	8(33.3)
Moderate (20–50)	10(41.7)
High (>50 cases)	6(25.0)

NS1 antigen was positive in 65.0% and IgM in 70.0% of patients. Thrombocytopenia (<100 Ч 10^9/L) occurred in 40.0%, while 30.0% had elevated hematocrit. These findings confirm significant laboratory evidence of dengue infection (Table-IV).

Table-IV: Laboratory test results among dengue suspected patients (N=300)

Laboratory Variables	no. (%)
NS1 antigen test	
Positive	195(65.0)
Negative	105(35.0)
IgM antibody test	
Positive	210(70.0)
Negative	90(30.0)
Platelet count	
<100 x 10^9/L	120(40.0)
100–150 x 10^9/L	90(30.0)
>150 x 10^9/L	90(30.0)
Hematocrit level	
Normal (36–48%)	210(70.0)
Elevated (>48%)	90(30.0)

Predictive modeling inputs and performance achieved 75.0% correct predictions, supporting its use as an early warning tool (Figure-3).

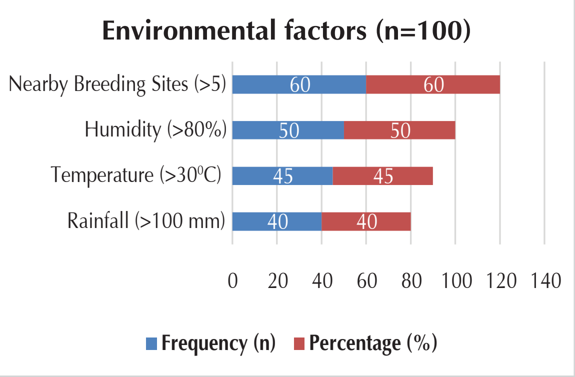

Figure-3: Predictive modeling inputs and performance (n=100)

Rainfall (β=+0.23, p=0.001) and breeding sites (β =+3.17, p=0.028) were significant predictors of dengue incidence, while temperature and humidity showed no significant associations (Table-V).

Table-V: Multiple linear regression analysis of environmental factors associated with dengue occurrence

Variable	Coefficient (β)	p-value
Rainfall (mm)	+0.23	0.001
Temperature (°C)	–0.29	0.876
Humidity (%)	+0.89	0.165
Breeding sites	+3.17	0.028
Constant (Intercept)	–30.12	0.721

Discussion:

This prospective community-based study aimed to forecast dengue transmission in a high-risk Bangladeshi region using demographic, environmental, entomological, behavioral, and lab-confirmed data. It fills a key gap in Bangladesh's community-level dengue early warning systems. Most dengue cases occurred in young adults aged 26–35, with males slightly predominant (53.3%), similar to a Bangladeshi multicenter study linking male exposure to outdoor occupations.[15] An Indonesian study also linked age and occupation to vulnerability.[16] The high proportion of students (26.7%) aligns with Philippine data showing students as a high-risk group.[17]In our study, 25.0% of dengue cases required hospitalization and 5.0% resulted in death. Similar trends were seen in Dhaka, where 65.3% of cases occurred in monsoon, with 3.6% needing ICU care and 1.7% mortality, especially among children.[18] Likewise, 60.0% of our cases occurred in monsoon, confirming previous links between peak transmission and seasonal rains.[9] Our entomological survey found larvae in 70.0% of breeding sites, mainly in abandoned tires and water tanks. This matches findings from Dhaka and Gazipur, where these sites were major Aedes aegypti habitats.[10,19] Although 40.0% of households showed high awareness, preventive practices were limited-only 60.0% used nets, and fewer used repellents or cleaned water containers. This reflects national KAP surveys showing poor translation of awareness into action.[20] Rainfall was a major climatic factor, with 75.0% of cases during moderate or heavy rain periods. A 22-year national review also linked dengue incidence with rainfall and temperature, while a Dhaka study found each rainy day raised hospitalizations by 6% the following month.[10,21] NS1 and IgM tests confirmed recent infection in 65.0% and 70.0% of patients, respectively. Thrombocytopenia (40.0%) and high hematocrit (30.0%) support previous reports linking NS1-positive cases with severe hematologic changes.[22] The predictive model showed 75.0% accuracy, with rainfall and breeding site density as significant predictors, while temperature and humidity were not. This aligns with recent studies highlighting rainfall and larval indices as more reliable than climatic data alone.[23] A multicity study also found better prediction when entomological indicators were included.[24] Rainfall (β=+0.23, p=0.001) and breeding sites (β=+3.17, p=0.028) were significant predictors, supporting prior studies linking rainfall >150 mm to mosquito growth.[25] Temperature and humidity were not significant, consistent with Dhaka-based models showing inconsistent temperature effects.[26] The non-significant intercept reinforces the need to include environmental variables in prediction. These results highlight the importance of combining entomological and climatic data in predictive models for timely dengue interventions in vulnerable areas like Bangladesh.

Limitations:

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

Conclusion:

This community-based study highlights key factors influencing dengue transmission in a high-risk region of Bangladesh. Rainfall and breeding site density emerged as significant predictors of dengue incidence, whereas temperature and humidity were less impactful. Despite moderate awareness, preventive practices were insufficient, pointing to a need for targeted interventions. Laboratory findings confirmed recent infections and hematological abnormalities, reflecting the clinical burden. With 75% accuracy, the predictive model shows promise for early outbreak warnings. Integrating environmental, behavioral, and lab data offers a practical approach to improving dengue control in endemic settings.

Conflict of interest: None declared

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