**Methodology**

**Variables**

The daily chikungunya cases and hospitalization were used as the primary outcome variable. Two climatic variables- temperature and rainfall, and socio-economic factors (age of the patients, sex, employment status, occupation, location), clinical features like test delay from onset, any types of clinical signs, patient status and co-morbidities were used as the covariates for the regression analysis. "Test delay after symptoms onset" refers to the period of time that passes between the moment someone starts experiencing symptoms of an illness and when they actually get tested for it, meaning there is a delay in testing after the first signs of the disease appear. We included rainfall (mm) and temperatures (°C) from location Dhaka (Lat 23.46, Lon 90.23). This data was sourced from the NASA Prediction of Worldwide Energy Resources website [1].

**Statistical analysis**

We analyzed the daily incidence of chikungunya, as well as socio-economic and meteorological data, over a 54-day period from October 19th to December 11th, 2024. In the first stage, descriptive analysis was performed to determine the characteristics of confirmed chikungunya cases. For each numeric variable, we calculated the mean, standard deviation, median, and interquartile range, while for categorical variables, we used frequency and percentage distributions over the entire period. Some numeric variables were categorized based on median splits for the analysis. Next, we compared all variables based on hospitalization status and examined the associations using a two-sample t-test and multivariable logistic regression.

In third stage, for forecasting, we employed the autoregressive integrated moving average (ARIMA) model, a data-driven, exploratory approach that allows us to fit an appropriate model and make forecasts. The ARIMA model includes autoregressive (p) terms, differencing (d) terms, and moving average (q) operations, and is expressed as ARIMA (p, d, q). To determine the optimal values for the autoregressive and moving average parameters, we examined the autocorrelation function (ACF) and partial autocorrelation function (PACF). Additionally, the differencing parameter “d” indicates the number of nonseasonal differences required to achieve stationarity [2,3]. We also conducted a Mann-Kendall (M-K) trend analysis to identify any potential upward or downward trends [4,5], and performed the Sen’s slope test to assess variations in daily chikungunya cases [6].

We then used a time-series generalized linear model (GLM), specifically a time-series Poisson regression model, to examine whether the factors were associated with chikungunya cases over time [7,8]. Daily chikungunya cases, a count variable, were used as the outcome in this model. The study employed the incidence risk ratio (IRR) to present the results, with 95% confidence intervals calculated at the <0.05 (5%) significance level. To assess the relevance of the predictions, we empirically evaluated the time series count GLM model. We analyzed and compared its performance using commonly used measures, including the coefficient of determination (R²) and root mean square error (RMSE). Additionally, we examined multicollinearity in the model using the variance inflation factor (VIF), with a cutoff value of 4.00 [9]. Certain variables were excluded from the model at this stage because their VIF values exceeded 4.00. The analyses were conducted using RStudio, version 3.5.2.2 [10].

Results

**Table 1: Demographic profile, symptoms, and co-morbidities of chikungunya cases (n=112)**

|  |  |  |
| --- | --- | --- |
|  | **Mean (SD)** | **Median (IQR)** |
| **Test delay (in days)** | 2.99 (1.46) | 3.00 (1.00) |
|  |  |  |
| **Test delay** | **n** | **%** |
| 0 day | 1 | 0.90 |
| 1 day | 9 | 8.11 |
| 2 days | 30 | 27.03 |
| 3 days | 44 | 39.64 |
| 4 days | 17 | 15.32 |
| 5 days | 5 | 4.50 |
| 6 days | 2 | 1.80 |
| 7 days | 1 | 0.90 |
| 8 days | 1 | 0.90 |
| 11 days | 1 | 0.90 |
| **Test delay (in categories)** |  |  |
| Yes (median<3) | 84 | 75.68 |
| No (median>=3) | 27 | 24.32 |
| **Hospitalized** |  |  |
| Yes | 20 | 17.86 |
| No | 92 | 82.14 |
| **Age groups** |  |  |
| <=39 | 48 | 42.86 |
| 40+ | 64 | 57.14 |
| **Sex** |  |  |
| Female | 41 | 36.61 |
| Male | 71 | 63.39 |
| **Employment Status** |  |  |
| No | 48 | 44.44 |
| Yes | 60 | 55.56 |
| **Occupation** |  |  |
| Business | 12 | 11.11 |
| Govt. Service | 11 | 10.19 |
| Housewife | 31 | 28.70 |
| Others | 13 | 12.04 |
| Private Service | 24 | 22.22 |
| Retired/Student | 17 | 15.74 |
| **Location** |  |  |
| Dhaka North City Corporation | 51 | 45.54 |
| Dhaka South City Corporation | 59 | 52.68 |
| Outside of Dhaka | 2 | 1.79 |
| **Symptoms presenta** |  |  |
| Fever | 111 | 100 |
| Generalized Rash | 26 | 23.42 |
| Arthralgia | 109 | 98.20 |
| Arthritis | 2 | 2.02 |
| Conjunctivitis | 54 | 48.65 |
| Myalgia | 94 | 84.68 |
| Headache | 76 | 68.47 |
| Vomiting | 37 | 33.33 |
| Diarrhea | 2 | 1.80 |
| Others | 4 | 3.57 |
| **Symptoms (in categories)** |  |  |
| Low (median <5) | 46 | 41.07 |
| High (median >=5) | 66 | 58.93 |
| **Patient status** |  |  |
| ICU | 2 | 1.87 |
| OPD | 79 | 73.83 |
| Ward/Cabin | 26 | 24.30 |
| **Co-morbiditiesa** |  |  |
| COPD | 5 | 4.50 |
| Asthma | 8 | 7.21 |
| ILD | 1 | 0.90 |
| DM | 28 | 25.23 |
| IHD | 10 | 9.01 |
| HTN | 31 | 27.93 |
| CLD | 5 | 4.50 |
| Cancer | 1 | 0.90 |
| Pregnancy | 1 | 0.90 |
| CKD | 2 | 1.8 |
| **Any Co-morbidities** |  |  |
| Yes | 61 | 54.95 |
| No | 50 | 45.05 |

aMultiple response

The table summarizes the demographic, symptom, and co-morbidity data for 112 confirmed chikungunya cases. Most patients had a test delay of fewer than 3 days (75.68%), with a mean delay of 2.99 days. About 18% of patients were hospitalized. The age distribution showed that 57.14% were aged 40 or older, with a higher percentage of male patients (63.39%). The majority were employed (55.56%), and most were from Dhaka South City Corporation (52.68%). Symptoms were common, with fever (100%), arthralgia (98.20%), and myalgia (84.68%) being the most frequent. Regarding co-morbidities, hypertension (27.93%) and diabetes (25.23%) were the most prevalent. A little over half (54.95%) of patients had one or more co-morbidities.

|  |
| --- |
|  |
| **Fig 1: Daily cases of chikungunya** |

The table shows the daily number of chikungunya positive cases reported from October 19, 2024, to December 11, 2024. The data indicates fluctuations in the number of cases over time, with the highest number of cases (11) recorded on December 8, 2024. Other notable peaks include 9 cases on December 5, 2024, and 8 cases on December 10, 2024.

|  |
| --- |
|  |
| **Figure 2: The gender distribution of chikungunya virus infection (CHIKV), Oct 19th – Dec 11th, 2024** |

The sample was predominantly **male** (63.39%), with **females** accounting for 36.61% of the cases.

|  |
| --- |
|  |
| **Figure 3: Age Distribution of the people infected with chikungunya virus (CHIKV), Oct 19th – Dec 11th, 2024.** |

In terms of **age distribution**, the largest group of patients (n=30) fell within the 30-39 age range, followed closely by those in the 30-39 age group (n=26). A substantial number of patients were aged 60 or older (n=20), while the younger age groups (10-19 years and 20-29 years) comprised smaller number, at 5 and 13, respectively.

|  |
| --- |
|  |
| **Figure 4: Chikungunya cases in Dhaka and outside City (Oct 19th – Dec 11th, 2024)** |

The majority of patients resided in **Dhaka South City Corporation** (52.68%), with a smaller percentage from Dhaka North City Corporation (45.54%) and a minimal representation from outside Dhaka (1.79%).

|  |
| --- |
|  |
| **Figure 5: Clinical Symptoms of the chikungunya patients, Oct 19th – Dec 11th, 2024** |

The graph shows that fever (100%), arthralgia (98.20%), and myalgia (84.68%) were the most common symptoms among chikungunya patients. Other symptoms included headache (68.47%), conjunctivitis (48.65%), and generalized rash (23.42%). Less common symptoms were vomiting (33.33%), arthritis (2.02%), and diarrhea (1.80%). In terms of symptom severity, 58.93% of patients reported five or more symptoms, while 41.07% had fewer than five symptoms.

|  |
| --- |
|  |
| **Figure 6: Comorbidities of the chikungunya patients** |

The chart highlights the co-morbidities observed in chikungunya patients. The most common co-morbidities were hypertension (HTN) at 27.93%, diabetes mellitus (DM) at 25.23%, and asthma at 7.21%. Other co-morbid conditions included ischemic heart disease (IHD) at 9.01%, chronic liver disease (CLD) and chronic obstructive pulmonary disease (COPD) both at 4.50%, and smaller percentages for interstitial lung disease (ILD), cancer, pregnancy, and chronic kidney disease (CKD), each at 0.90% or 1.80%. In total, 54.95% of patients had one or more co-morbidities, while 45.05% had no reported co-morbid conditions.

Table 2: Factor associated with hospitalization

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **Hospitalized** | |  |
| **Yes**  **n (%)** | **No**  **n (%)** | **P-value** |
| **Age groups** | <=39 | 5 (10.42) | 43 (89.58) | 0.075 |
|  | 40+ | 15 (23.44) | 49 (76.56) |  |
| **Sex** | Female | 6 (14.63) | 35 (85.37) | 0.499 |
|  | Male | 14 (19.72) | 57 (80.28) |  |
| **Employment Status** | No | 10 (20.83) | 38 (79.17) | 0.577 |
|  | Yes | 10 (16.67) | 50 (83.33) |  |
| **Location** | Dhaka North City Corporation | 5 (9.80) | 46 (90.20) | <0.001 |
|  | Dhaka South City Corporation | 2 (100.00) | 0 (0.00) |  |
|  | Outside of Dhaka | 13 (22.03) | 46 (77.97) |  |
| **Clinical signs** | Low (median<5) | 14 (30.43) | 32 (69.57) | 0.004 |
|  | High (median>=5) | 6 (9.09) | 60 (90.91) |  |
| **Delay in test** | Yes (median<3) | 15 (17.86) | 69 (82.14) | 0.938 |
|  | No (median>=3) | 5 (18.52) | 22 (81.48) |  |
| **Comorbidity** | No | 6 (12.00) | 44 (88.00) | 0.135 |
|  | Yes | 14 (22.95) | 47 (77.05) |  |
| **Total** | | 20 (17.86) | 92 (82.14) |  |

The table examines factors associated with hospitalization among chikungunya patients. In total, 17.86% of patients were hospitalized, while 82.14% were not. Age showed a trend toward higher hospitalization rates in patients aged 40 and above (23.44%), compared to those aged 39 or younger (10.42%), though the difference was not statistically significant (p = 0.075). Gender and employment status did not show significant associations with hospitalization, with hospitalization rates of 14.63% in females and 19.72% in males (p = 0.499), and 20.83% for unemployed patients and 16.67% for employed patients (p = 0.577). Location was significantly associated with hospitalization (p < 0.001), with all patients from Dhaka South City Corporation being hospitalized (100%), while only 9.80% of those from Dhaka North City Corporation and 22.03% from outside Dhaka were hospitalized. Clinical signs showed that patients with fewer symptoms (low, median <5) had a higher hospitalization rate (30.43%) compared to those with more symptoms (high, median ≥5) at 9.09% (p = 0.004). Delay in testing (p = 0.938) and co-morbidities (p = 0.135) were not significantly associated with hospitalization.

Table 2: Factor associated with hospitalization using multivariable logistic regression

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **OR** | **95% CI** | **P-value** |
| **Age groups** | <=39 | Reference |  |  |
|  | 40+ | 1.09 | 0.95 - 1.26 | 0.233 |
| **Sex** | Female | Reference |  |  |
|  | Male | 1.10 | 0.94- 1.30 | 0.247 |
| **Employment Status** | No | Reference |  |  |
|  | Yes | 0.92 | 0.78 - 1.10 | 0.370 |
| **Location** | Dhaka North City Corporation | Reference |  |  |
|  | Dhaka South City Corporation | 2.63 | 1.58 - 4.38 | <0.001 |
|  | Outside of Dhaka | 1.12 | 0.97 - 1.29 | 0.139 |
| **Clinical signs** | Low (median<5) | Reference |  |  |
|  | High (median>=5) | 0.80 | 0.69 - 0.92 | 0.002 |
| **Delay in test** | Yes (median<3) | Reference |  |  |
|  | No (median>=3) | 0.96 | 0.82 - 1.13 | 0.634 |
| **Comorbidity** | No | Reference |  |  |
|  | Yes | 1.07 | 0.93 - 1.24 | 0.328 |

The multivariable logistic regression analysis identified significant factors associated with hospitalization in chikungunya patients. Location was a significant predictor, with patients from Dhaka South City Corporation having 2.63 times higher odds of hospitalization compared to those from Dhaka North City Corporation (OR: 2.63, 95% CI: 1.58 - 4.38, p < 0.001). Clinical signs were also significant, as patients with fewer symptoms (low, median <5) had lower odds of hospitalization (OR: 0.80, 95% CI: 0.69 - 0.92, p = 0.002). These findings suggest that location and symptom severity are significant determinants of hospitalization in chikungunya cases.

**Fig 4: The observed and forecasted number of dengue cases in Bangladesh using the Autoregressive moving average (ARIMA) model including a 95% confidence interval.**



**Table 2: The Mann-Kendell trend test of dengue cases in Bangladesh**

|  |  |  |
| --- | --- | --- |
| **Test** |  | |
| ***Mann-Kendell trend analysis*** | **Tau** | **p-value** |
|  | 0.38 | <0.001 |
| *Sen’s Slop test* |  |  |
|  | Sen’s Slope | 95% Confidence Interval |
|  | 0.048 | 0.001 to 0.103 |

The Mann-Kendall trend test for dengue cases in Bangladesh showed a statistically significant upward trend with a Tau value of 0.38 (p < 0.001). The Sen’s Slope test further confirmed this positive trend, with a slope of 0.048 (95% CI: 0.001 to 0.103), indicating a gradual increase in the number of dengue cases over time. This finding is also justified by the ARIMA model, which indicates an upward trend in the upcoming days. Both tests suggest a significant rise in dengue incidence in the region.

**Table 4: The incidence risk ratio (IRR) of daily incidence of chikungunya cases in Bangladesh using time-series count Generalized Linear Model.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **IRR (95% CI)** | **P-value** | **VIF** |
| **Test delay (in days)** | 1.35 (1.01 – 1.80) | 0.043 | 1.82 |
| **Average Age** | 1.01 (0.97 - 1.02) | 0.822 | 1.13 |
| **Sex (Male)** | 1.01 (0.99 - 1.01) | 0.963 | 3.42 |
| **Currently Employed (Yes)** | 1.01 (0.99 - 1.02) | 0.473 | 3.88 |
| **Co-morbidities (Yes)** | 1.01 (0.99 - 1.01) | 0.580 | 1.31 |
| **Daily Temperature** | 0.54 (0.46 – 0.62) | <0.001 | 3.59 |
| **Daily Rainfall** | 1.50 (0.82 – 2.60) | 0.163 | 3.21 |
| **R2 value** | 99.30% |  |  |
| **RMSE** | 2.45 |  |  |

IRR = Incidence Risk Ratio

CI = Confidence Interval

The time-series count Generalized Linear Model (GLM) analysis of daily chikungunya incidence in Bangladesh revealed several key findings. The test delay (in days) was significantly associated with the incidence of chikungunya, with an incidence risk ratio (IRR) of 1.35 (95% CI: 1.01 – 1.80, p = 0.043), suggesting that longer test delays increased the likelihood of chikungunya cases. Daily temperature showed a significant negative association with chikungunya incidence (IRR: 0.54, 95% CI: 0.46 – 0.62, p < 0.001), indicating that higher temperatures were linked to fewer cases. On the other hand, daily rainfall had no significant effect (IRR: 1.50, 95% CI: 0.82 – 2.60, p = 0.163). Other variables, including average age, sex, employment status, and co-morbidities, showed no significant associations with chikungunya incidence. The model had an R² value of 99.30%, indicating a good fit, and a root mean square error (RMSE) of 2.45.

**References**

[1] POWER | DAV, (n.d.). https://power.larc.nasa.gov/data-access-viewer/ (accessed December 22, 2024).

[2] M.N. Hasan, N. Haider, F.L. Stigler, R.A. Khan, D. McCoy, A. Zumla, R.A. Kock, M.J. Uddin, The Global Case-Fatality Rate of COVID-19 Has Been Declining Since May 2020., Am J Trop Med Hyg (2021). https://doi.org/10.4269/ajtmh.20-1496.

[3] N. Kumar, S. Susan, COVID-19 Pandemic Prediction using Time Series Forecasting Models, in: 2020 11th International Conference on Computing, Communication and Networking Technologies, ICCCNT 2020, Institute of Electrical and Electronics Engineers Inc., 2020. https://doi.org/10.1109/ICCCNT49239.2020.9225319.

[4] S. Yue, P. Pilon, A comparison of the power of the t test, Mann-Kendall and bootstrap tests for trend detection / Une comparaison de la puissance des tests t de Student, de Mann-Kendall et du bootstrap pour la détection de tendance, Hydrological Sciences Journal 49 (2004) 21–37. https://doi.org/10.1623/hysj.49.1.21.53996.

[5] M.N. Hasan, I. Khalil, M.A.B. Chowdhury, M. Rahman, M. Asaduzzaman, M. Billah, L.A. Banu, M.U. Alam, A. Ahsan, T. Traore, M. Jamal Uddin, R. Galizi, I. Russo, A. Zumla, N. Haider, Two decades of endemic dengue in Bangladesh (2000–2022): trends, seasonality, and impact of temperature and rainfall patterns on transmission dynamics, J Med Entomol 61 (2024) 345–353. https://doi.org/10.1093/JME/TJAE001.

[6] P.K. Sen, Estimates of the Regression Coefficient Based on Kendall’s Tau, J Am Stat Assoc (1968). https://doi.org/10.1080/01621459.1968.10480934.

[7] S.N. Sumi, N.C. Sinha, M.A. Islam, Generalized linear models for analyzing count data of rainfall occurrences, SN Appl Sci 3 (2021) 481. https://doi.org/10.1007/s42452-021-04467-x.

[8] S. Ghosh, M.N. Hasan, N.D. Nath, N. Haider, D.H. Jones, M.K. Islam, M.M. Rahaman, H.S. Mursalin, N. Mahmud, M. Kamruzzaman, M.F. Rabby, S. Kar, S.M. Ullah, M.R. Ali Shah, A.A. Jahan, M.S. Rana, S. Chowdhury, M.J. Uddin, T.S. Sunil, B.N. Ahmed, U.R. Siddiqui, S.M.G. Kaisar, M.N. Islam, Rabies control in Bangladesh and prediction of human rabies cases by 2030: a One Health approach, The Lancet Regional Health - Southeast Asia 27 (2024). https://doi.org/10.1016/J.LANSEA.2024.100452/ATTACHMENT/0DF38591-995C-4CB2-A87C-334A6C77062B/MMC8.ZIP.

[9] M.N. Hasan, M.R. Babu, M.A.B. Chowdhury, M.M. Rahman, N. Hasan, R. Kabir, M.J. Uddin, Early childhood developmental status and its associated factors in Bangladesh: a comparison of two consecutive nationally representative surveys, BMC Public Health 23 (2023) 1–13. https://doi.org/10.1186/S12889-023-15617-8/TABLES/4.

[10] R Core Team, R: A language and environment for statistical computing. Vienna, Austria. URL https://www.R-project.org/., 2022.