The Association of Temperature and Rainfall with Dengue Incidence in India: Statistical Analysis

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Abstract: Dengue has become a major epidemiological threat in several developed as well as developing countries like India. For the past ten years, the incidence of dengue has increased by 5 fold in India with 226 deaths reported this year. The emergence of disease is highly associated with climate factors such as temperature and rainfall. Analyzing this relation will help forecast the incidence of dengue cases and will allow decision makers take precautionary steps in advance. This study, is aimed to investigate the impact of temperature and rainfall on dengue incidences in India with statistical analysis techniques.

Keywords: ***Dengue, Temperature, Rainfall, Regression***

INTRODUCTION

Dengue is a hazardous disease which poses a critical threat to the population. As the fig. 1 shows for the past ten years, the number of dengue cases has gradually increased in India. As per National Vector Borne Disease Control Programme (NVBDCP) figures, the total number of dengue cases reported is 1,53,635 and 226 deaths in the India this year in 2018.

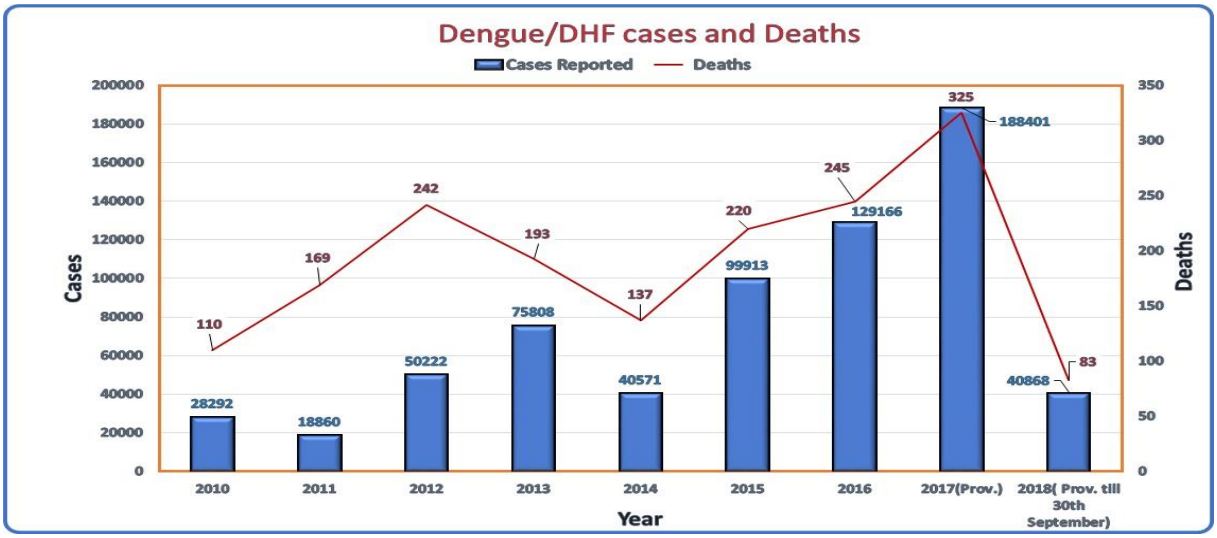

Figure 1 Dengue Cases and Deaths in India (Source: data.gov and National Vector Borne Disease Control Program)

Dengue is a mosquito-borne tropical disease. It is spread by the Aedes aegypti vector mosquito which breeds during the rains. The vector mosquitoes grow in numbers in these conditions. So dengue cases see a sharp spike in the months immediately after the monsoons, i.e. late August and September. After November, when temperatures dip, the virus cannot survive beyond a point and cases slide.

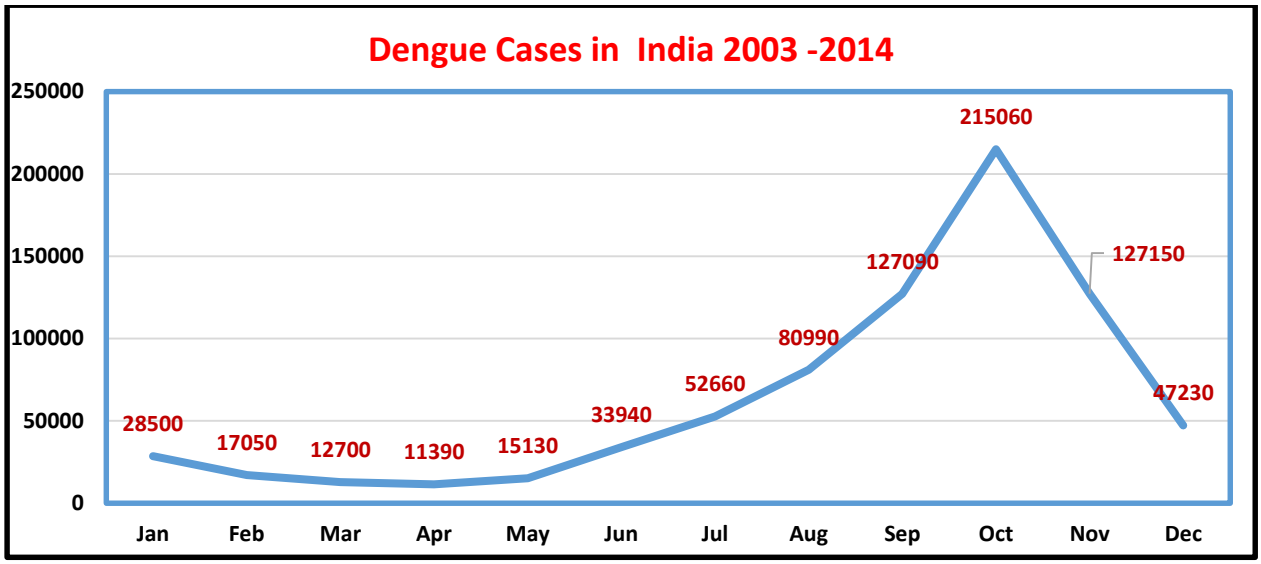

Figure 2 Dengue Cases and Deaths in India (Source: data.gov and National Vector Borne Disease Control Program)

This disease is often known as a disease related to climate changes. Research in mainly developed countries has shown that some changes in weather are associated with increased mortality. The disease is driven by complex interactions among host, vector and virus that are influenced by climatic factors. These cases are steadily reported during and post-monsoon season indicating its correlation with weather parameters.

Previous studies in other parts of the world have shown a significant correlation between number dengue incidences and climatic factors like rainfall, temperature and. Rainfall creates abundant breeding sources for Aedes aegypti, mosquitoes. As temperature increases, the Aedes aegypti mosquito needs shorter periods of development in all stages of their life cycle, which leads to increased population growth.

There is a growing research interest to study the impact of climate factors such as temperature, rainfall, humidity on the emergence of vector-borne diseases such as dengue. As of now no effective vaccine and specific treatment exist, vector control currently represents the only resource to mitigate dengue outbreaks. Establishing this relation will help understand the spread of dengue and will allow decision makers take precautionary steps beforehand. Our study explains the multi-regression to model the relation between dengue cases and weather parameters, i.e. maximum temperature, rainfall. These associated dengue risk factors are helpful in the implementation of public healthcare policies.

Datasets used: We carried the study of association of dengue incidences and climate factors: temperature and rainfall for the period 2003 to 2014. The data was collected from source Data.gov and National Vector Borne Disease Control Program (NVBDCP). Table 1 depicts sample of monthly rainfall data. We consider average of monthly rainfall.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003	7.6	45.6	33.3	35.4	39.1	184.5	316.7	255.3	191.4	100.6	15.5	18.6
2004	25.7	8.8	11.4	59	88.9	158.7	242.1	248.7	124.6	92.2	15.8	4.6
2005	28.1	41.8	42.5	37.7	46.1	143.2	334.1	190.1	206.9	99.3	27.2	11.2
2006	17.7	11.9	35.6	32.7	75	141.8	287.6	281.3	178.6	51.8	34.6	13.1
….	….	….	….	….	….	….	….	….	….	….	….	….
2014	19.2	27.4	36.1	22.2	72.9	95.4	261.2	237.5	188	60.2	14.4	10.7

Table 1 Year wise monthly rainfall.

Temperature data are shown in Table 2. We have considered monthly average temperature.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

2003	24.27	26.36	29.13	32.91	34.12	33.77	31.3	30.93	30.86	30.26	27.86	24.97
2004	23.89	27.05	32.33	32.97	33.23	32.23	31.38	30.85	31.2	29.18	28.23	25.54
2005	24.18	25.74	29.5	32.37	33.57	33.88	30.96	31.45	31.05	29.78	27.6	25.11
2006	25.66	29.33	29.56	32.59	34.09	32.65	31.59	30.76	30.57	30.46	27.61	25.27
….	….	….	….	….	….	….	….	….	….	….	….	….
2014	23.83	25.97	28.95	32.74	33.77	34.15	31.85	31.32	30.68	30.29	28.05	25.08

Table 2 Year wise monthly Temperature.

Average dengue incidences per month from 2003 – 2014.

Month	Dengue Cases
Jan	28500
Feb	17050
Mar	12700
Apr	11390
….	….
….	….
Nov	127150
Dec	47230

Table 3 Dengue Incidences

METHODOLOGY ADOPTED FOR STATISTICAL ANALYSIS:

Multiple Linear Regression:

In statistics, regression analysis is used for analyzing relationship between several variables. The goal is to create a mathematical model that can be used to predict values of dependent variable based upon the values of independent variable. Multiple Linear Regression is the extension of simple regression. It models the relationship between one dependent variable and two or more independent variables. Multiple linear regression analysis helps us to forecast impact of i.e. extent to which the dependent variable will change when we change the independent variables. The dependent variable are referred as the outcome variable or regressand. The independent variables
are referred to as the predictor variables or regressors. In simple regression estimates of dependent variable fall along a line. If there are two independent variables they fall in a plane. For three or more independent variables estimates cannot be visualized as graph but are mathematically described as falling on a hyper plane.
Multiple Linear Regression Equation depicts the simultaneous effect of a number of independent variables. The equations is:

$$Y = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots.$$

Where Y : Dependent variable , X1, X2, X3 ….: Independent variables, a: Constant,
b1, b2, b3 , … : Regression coefficients which denote effect of independent variables Xj on Y
They represent the change in the value of Y for a unit change in the value of variable X.

In the current study we have considered temperature and rainfall as independent variables i.e. X1 and X2. Number of Dengue incidences as Y. To check for association of climate factors with dengue cases we carried statistical analysis by formulating null hypothesis and testing with t-test and p value.
Null Hypothesis H0: There is no association between dengue incidences and climate factors i.e. temperature and rainfall.

t - test is performed to check the significance of individual regression coefficients in the multiple linear regression model. t-test quantifies the strength of evidence against null hypothesis.

The p-value associated with t-test measure the statistical significance of independent variable. As in the majority of analyses, we used an alpha of 0.05 as the cutoff for significance. If the p-value

is less than 0.05, we reject the null hypothesis.

	Coefficients	Standard Error	t Stat	P-value	Lower 95%
Intercept	-12.91414335	8.326434328	-1.55098	0.181603	-34.31792419
Rainfall	0.054734792	0.008628439	6.343533	0.001437	0.032554682
Temperature	0.506736248	0.281957141	1.79721	0.132232	-0.218057655

Table 4 MLR Result

The results of t-test and p values for our data set are shown in the table 4. The Coefficient column represents the estimate of regression coefficients. 'p' value for Rainfall < 0.05 which indicates rainfall is significant association with dengue incidences whereas for temperature 'p' value is > 0.05 indicating it is not significant factor.

Conclusion: In the present study carried out, a significant association between dengue cases and monthly rainfall was observed. This is helpful in developing climate-based disease forecasting models which in turn will aid in planning for control and prevention of the disease.

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