

Original Research Article

Effect of climatic factors like rainfall, humidity and temperature on the dengue cases in the metropolitan city of Maharashtra

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ABSTRACT

Background: Climatic factors may influence the dengue cases in the given geographical area indicating the need of research on it. The research in India, especially Maharashtra is however scarce. Thus a study on climatic factors and dengue cases was planned in metropolitan city of Maharashtra. Objective was to study the effect of climatic factors like rainfall, humidity and temperature on the dengue incidence.

Methods: Retrospective study design was commissioned at tertiary care hospital in the city. The reported DF/DHF cases during January 2009 to December 2018 were mobilised from Integrated Disease Surveillance Project (IDSP) of Epidemiology cell, Mumbai. Climate records were gathered from meteorology department of the city. Data were entered on the Excel sheet. The analysis was done with SPSS version 22.0.

Results: The dengue incidence was high in monsoon and post monsoon season. Both rainfall and humidity were positively and temperature was negatively associated with dengue incidence.

Conclusions: Climatic factors are the best predictors of dengue cases in near future. Weather factors based early warning systems may be incorporated in the routine surveillance system for dengue for preventing the epidemic.

Keywords: Climatic factors, Dengue

INTRODUCTION

Global reports estimates that 3.9 billion people are at risk of infection with dengue viruses and 70% of the actual burden is in Asia. The number of dengue cases reported to WHO increased over 8 fold over the last two decades, from 505,430 cases in 2000, to over 2.4 million in 2010, and 4.2 million in 2019. Reported deaths between the year 2000 and 2015 increased from 960 to 4032.¹

A recent review has reported that India alone contributes to 34% (about 33 million infections) of the total global threat of dengue leading to hyper-endemicity, prevailing mostly in urban areas.² Recurring outbreaks have been reported from many of the states of India including Maharashtra.³

Dengue is driven by complex interactions among host, vector and virus that are exaggerated by climatic factors. Researchers of climate change have suggested that climate change and variability has a significant influence on the epidemiology of infectious diseases, particularly vector-borne diseases.⁴ A systematic review in Malaysia recommended the research on climate and vector-borne diseases to advance the development of climate-based early warning systems.⁵

For tropical zones, including India, very limited research has been conducted to estimate the influence of climatic factors on the burden of dengue.⁶

Few researchers have hypothesized the significant association between dengue cases and climatic factors.⁶

Other valuable research confirmed the positive link between climate and dengue in some states of India like Delhi and Kolkata.⁷⁻¹⁰ But none of the research was based in the state of Maharashtra. During the literature research, we came across with few systematic reviews which included research from various countries of South East Asia and other regions.^{5,11,12} None of the Indian studies were part of these reviews. Having understood that Mumbai-the bread giving city for residents and migrants, there is poor inspect or control on eco-social determinants of dengue. Thus, it is crucial to study the other epidemiological determinants of dengue like climatic factors. Few researchers have suggested the climate based prediction models for dengue.^{7,8,13} Developing climate-based forecasting models would make it possible to deliver an early warning message to public health workers. This will enable them to promptly launch control or prevention activities.¹⁴ A study therefore, on the effect of climatic factors like temperature, humidity and rainfall on dengue cases in the city was planned.

METHODS

Study setting

The study was carried out in one of the tertiary care hospital of the Mumbai city of which is the capital of Maharashtra state and also popularly recognized as economic capital of India. The city is divided into three zones (eastern, western and central) and 24 wards of which the Medical officer in Health (MOH) is the in charge of health for that particular ward population.

The epidemiology cell which is also known as Integrated Disease Surveillance Project (IDSP) is situated at North side of the city. All health care centres in the city including public and private are responsible to report the cases of communicable diseases like Dengue, Malaria, leptospirosis and H1N1 etc. to the epidemiology cell. The data is collected and compiled at IDSP, Mumbai. This is a daily activity under the surveillance project.

Study design

Retrospective study design was planned and official permissions were taken from Epidemiology Cell, Mumbai- Integrated Disease Surveillance Project (IDSP). Duration based sampling technique was applied and ten years data was considered for the study. Records of monthly dengue cases reported to IDSP during 2009 to 2018 was compiled. Each case record was checked for completeness and accuracy.

The incomplete records were excluded from the data. Annual rainfall, temperature and humidity data was mobilized from the Meteorology Department of city. The number of dengue cases was plotted against the climatic factors (monthly average rain in mm, average maximum and minimum temperature in degree Celsius and average morning, evening humidity in percentage) to assess their contribution across the years.

Data analysis

Data entry was done in excel Microsoft office version 2013. Analysis was done by SPSS version 22.0. The correlation between dengue incidence and climatic factors including temperature, rainfall and humidity was evaluated using the bivariate Pearson correlation which was considered as significant at a level of 0.05. In addition to a direct month-by-month correlation, each variable was also lagged up to 2 months with respect to dengue cases. The regression analysis utilizing one dependent and five independent variables was conducted using a basic unlagged dataset. Tables and graphs were prepared wherever appropriate.

RESULTS

The total dengue cases from 2009 to 2018 in a metropolitan city were 10907. Number of cases varied substantially between years, with less than 900 (861) cases reported in 2014 and more than 1700 (1756) reported in 2011.

Table 1: Month wise dengue cases during 2009-2018 in Mumbai.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	13	66	20	11	94	33	32	21	32	11
February	3	37	5	9	41	21	22	23	16	6
March	6	18	6	5	24	26	21	22	8	2
April	10	15	8	6	29	23	28	21	12	7
May	8	8	2	4	37	32	30	27	31	12
June	30	20	22	10	32	27	38	48	31	21
July	80	81	115	60	66	52	57	63	70	59
August	159	245	207	157	87	65	78	106	93	153
September	244	253	353	242	168	167	248	382	412	399
October	323	173	517	237	189	213	211	228	212	249
November	121	51	344	166	96	146	108	189	185	48
December	119	37	157	101	64	56	46	50	32	36
Total	1115	1004	1756	1008	927	861	919	1180	1134	1003

The data on month-wise dengue cases in a city for the past 10 years is presented in Table 1 that marks the increasing trend of dengue cases from month of June till November and drop in December. The table demonstrated the highest number of dengue cases in September and lowest in the March.

Climate in Mumbai

Extreme high temperatures rising to 34.38°C in May and dipping low up to 16.5°C in December. In this metropolitan city, mean rainfall during monsoon was 6419.00 mm and annual mean rainfall was 2235.70 mm. The average morning humidity was 77.00 and evening humidity was 62.27 percentage. The year 2010 recorded the heaviest rainfall and extreme levels of humidity in the past 10 years. Extreme temperature was observed in the year 2009.

Correlation analysis

Correlation analyses between the number of dengue cases and climate variables at a lag of zero to two months were accomplished. The time lag with the highest correlation coefficient was developed from cross-correlation analyses with monthly lags of zero, one and two months.

Table 2: Correlation between climatic factors and dengue cases.

Climatic factors	Pearson correlation coefficient with dengue		
	Zero-month lag	One-month lag	Two-month lag
Maximum temperature	0.135	-0.570	-0.694 *
Minimum temperature	0.218	-0.489	-0.638 *
Morning humidity	0.441	0.808 *	0.861*
Evening humidity	0.391	0.761 *	0.927 *
Rainfall	0.124	0.542	0.912 *

*Indicates significant at p value <0.05

The most significant results were discovered for lags of 2 months, which are exhibited in this paper (Table 2). In Pearson correlation analysis (without applying lag-preceding month), the results showed positive but non-significant correlation between dengue cases and humidity, rainfall. Applying two months as lag, showed significant positive correlation for rainfall and humidity and moderate negative correlation with temperature.

Figure 1 exhibits narrowing of the gap between the average maximum and minimum temperature for a period of time, which corresponds with the monsoon period and highest number of dengue infection of a year. An analysis

shows moderately negative correlation between temperature and dengue with 2 months lag (-0.694 maximum temperature and -0.638 minimum temperature). One degree rise of minimum temperature is associated with almost 57 more dengue cases as per regression analysis.

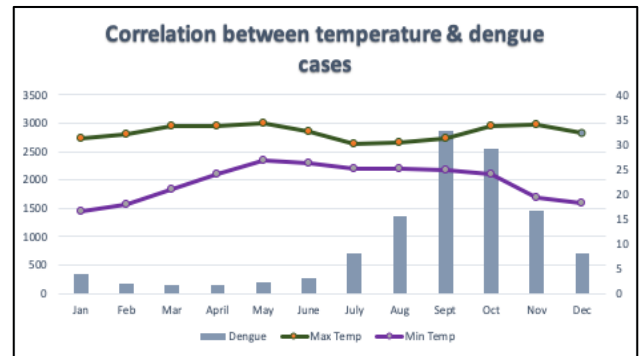


Figure 1: Correlation between temperature and dengue cases.

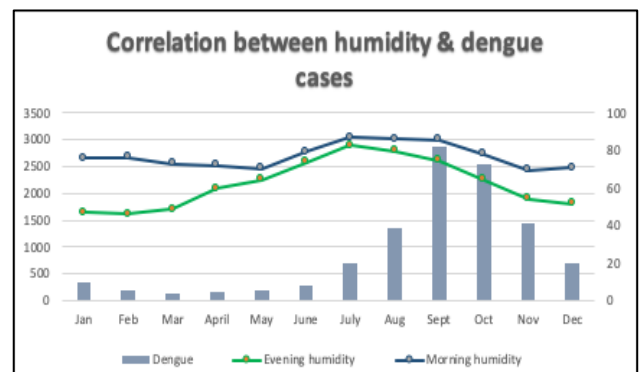


Figure 2: Correlation between humidity and dengue cases.

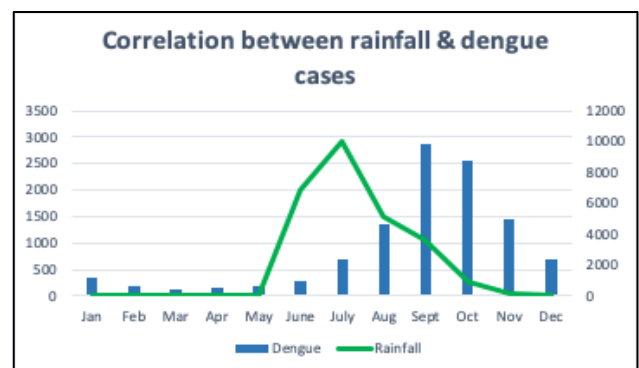


Figure 3: Correlation between rainfall and dengue cases.

Figure 2 reveals significant positive correlation between average relative humidity and dengue cases (0.861 morning humidity and 0.927 evening humidity). The concavity started at least two months before the starting

of the increase in the number of dengue cases and lasted two months ahead of outbreak period. Linear regression analysis shows increase of 66 dengue cases with every one degree rise of humidity.

After incorporating the data of two month as a lag phase, dengue cases showed strong positive correlation (0.912) with rainfall, as seen in Figure 3. There will be addition of 35 dengue cases with every 1000 mm increase in rainfall.

DISCUSSION

The availability of digital data and latest analytical software tools play a vital role in data analysis and studying the relationship of various climatic factors with infectious diseases like dengue. The analysis further facilitates in predicting the dengue cases.

Dengue cases were consistently high in the second half (from June through November) of each year which has been similarly specified by other Indian studies.^{15,16} The peak occurred in September-October months which is the period of season change from monsoon to winter throughout India indicating active transmission period during monsoon and post-monsoon period as well. The findings corresponds to other Indian studies.⁹ However, it's utterly different (Jan-March) in other parts of the world and little extended (May to December) in country like Vietnam.^{17,18} Year wise data on dengue reflects outbreak in the year 2011 which however do not coincide with the national or state data. As per national data reports on dengue, country experienced the outbreak in the year 2017 and the Maharashtra state reported highest number of dengue cases in the year 2018.^{19,20} The difference may be due to vast geographical change among various districts of the state.

Present paper marks first report on the effect of climate on dengue cases in Mumbai.

Dengue infection has multiple determinants. Its occurrence is influenced by many factors like climatic, environmental conditions and socio-cultural behaviours. The study finds positive correlation of climatic factors and dengue cases which corresponds to the results of research done in many Indian and other parts of world. Williams et al in Australia on the other hand denies such simple association of climatic factors with dengue.²¹

Various researchers, while studying the association of weather factors to dengue cases, applied variety of time lags in terms of days, weeks and months as well. Researchers who studied the association of meteorological factors and dengue found it significant while others found it non-significant. In present study, both maximum and minimum temperature was found moderately negatively associated with dengue cases. This is in contrast with the findings by other researchers. Maximum temperature was positively associated as

proved by studies done at Cambodia and Indonesia.^{17,22} On the other hand, minimum temperature one-two months back was found as significant predictor for dengue incidence by many other studies.^{7,8,22,23}

The levels of rainfall and humidity two months back had the effect on the number of dengue cases for the present month as is evident from the present study. This is consistent with the other studies. The two months' time lag for the effect is somewhat matching with Indian studies, although some researchers in the other countries found it significant at different time lag like 3-5 months.^{7,8,10,22,24} The research in the other region conversely proved no effect of rainfall on the dengue cases.^{23,25,26} Effect of rainfall may be well explained by creating ample of breeding sites for the mosquito in the city. This is the city where people keep lots of junk items in their balcony or terrace and rainwater stays there to serve as breeding site.

This study demonstrated substantial correlation between humidity and dengue cases. Parallel findings were reported by studies at Delhi and Nepal.^{8,23} Sirisena et al nonetheless mentioned the 9 months' time lag for humidity to act on the number of dengue cases.²⁴ The study thus indicates that climate is an important trigger of mosquito-borne disease, while the exact relationship differs according to local vector ecology across the geographical range of both vector and disease distributions. Such a temporal association of climate with dengue can be explained by its effect on vector population, its breeding during rainfall. The expected time lag between mosquito birth and the appearance of clinical symptoms in humans includes larval and pupa development (10-21 days), a gonotrophic cycle (3-7 days per cycle), extrinsic incubation in mosquitoes (7-15 days), and in-human incubation (1-12 days) for a total lag of 21-55 days (or 3-8 weeks). Thus, two months gap can be justified for the effect of climate on dengue cases.

This study has some limitations. Record-based studies like this often lack the true prevalence of the community as only the hospital reported cases are included.

CONCLUSION

Rainfall and humidity certainly influence the dengue incidence and are suitable predictors of the dengue number in the near future. The observations could be valuable in estimating the dengue cases after one or two months and accordingly plan the interventions to prevent outbreak of dengue in this region.

Recommendations

Incorporating meteorological data model in the routine surveillance system at Integrated Disease Surveillance System of Mumbai city would possibly resists explosive outbreaks.

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