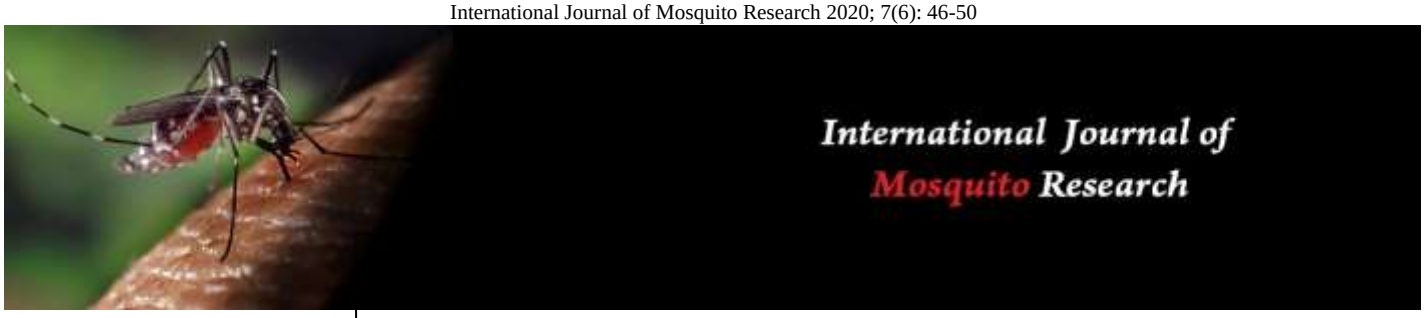

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2020; 7(6): 46-50

Received: 21-09-2020
Accepted: 25-10-2020

Deepthi G Nair
Assistant Professor, Post Graduate, Department of Zoology, MSM College, Kayamkulam, Alappuzha, Kerala, India

Nisha P Aravind
Research and PG, Department of Zoology, CMS College, Kottayam, Kerala, India

Corresponding Author:
Deepthi G Nair
Assistant Professor, Post Graduate Department of Zoology, MSM College, Kayamkulam, Alappuzha, Kerala, India

Association between rainfall and the prevalence of clinical cases of dengue in Thiruvananthapuram district, India

Deepthi G Nair and Nisha P Aravind

DOI: https://doi.org/10.22271/23487941.2020.v7.i6a.488

Abstract
Dengue fever is a fast spreading mosquito borne viral disease transmitted by *Aedes* mosquitoes. The abundance and the transmission potential of *Aedes* mosquitoes are influenced by climatic factors. An investigation was carried out in Thiruvananthapuram district, Kerala to study the correlation between rainfall and prevalence of dengue infection during 2015–2019. Dengue data (2015–2019) were collected from Directorate of Health Services, Thiruvananthapuram and the rainfall data were derived from Indian Meteorological Department, Thiruvananthapuram. The correlation between the rainfall and the prevalence of dengue was assessed by regression analysis. Dengue cases usually follow a seasonal pattern, with most of the cases reported during the monsoon season. Rainfall were positively associated with the number of dengue cases and highly significant correlation was found between dengue cases and rainfall. The regression equation for prevalence of dengue (y) versus rainfall (x) is $y = 1.28 x + 31.03$ ($r = 0.875$, $p < 0.001$). The study indicated that the prevalence of dengue infection in Thiruvananthapuram district may depend on rainfall. Therefore, intensified surveillance and control of mosquito during the period with heavy rainfall is recommended.

Keywords: Dengue, rainfall, correlation, Thiruvananthapuram

Introduction
Dengue fever is a fast spreading mosquito borne viral disease transmitted by *Aedes* mosquitoes. Dengue viruses belong to family Flaviviridae and there are four serotypes of dengue viruses DENV-1, DENV-2, DENV-3, and DENV-4. Persons infected with dengue exhibit a wide spectrum of clinical symptoms ranging from asymptomatic to severe clinical manifestations, such as dengue shock syndrome [1]. The number of dengue cases has increased 30-fold globally over the past five decades [2] and about 40% of the world's population are now at risk of dengue [3]. Dengue is a major public health problem in India as dengue has expanded dramatically over the last few decades and at present in most of the states of India, dengue is almost endemic [4]. Some studies have reported that climate change might be responsible for the observed increase in dengue cases across India [5]. Climatic conditions mainly rainfall and temperature affects mosquito abundance and dengue transmission rate [6, 7]. Temperature influences the transmission of dengue fever via the survival and development of mosquito vectors, virus replication, biting rate and incubation period [8]. Rainfall provides breeding sites and stimulates eggs hatching for mosquitoes and therefore vector abundance [9, 10] as it breeds well in the open containers in and around houses.

India receives 75% of its rainfall during the southwest monsoon period from June to September [11] and Indian monsoon rainfall provides ample breeding habitats for dengue vectors *Ae. aegypti* and *Ae. albopictus*, thus leading to high vector densities [12]. Kerala gets rains in four spells: winter (January - February), pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-December). Rainfall is scanty in the pre-monsoon period where as the southwest monsoon, from June to September, accounts for heavy rainfall. The northeast monsoon, starting in October and lasting up to December, is marked with moderate rainfall. Of the total annual rainfall (945 mm) in the state, 48% is received during the southwest monsoon, 32% during the northeast monsoon and the rest during other seasons.

A recent study has compiled all dengue outbreaks in India [13], and it showed that most dengue outbreaks occurred in Punjab, Haryana, Rajasthan, Gujarat and Kerala states during the monsoon or post monsoon period. Kerala experiences the highest number of dengue cases, possibly because of higher percentage of infected mosquitoes, availability of breeding grounds, suitable temperature ranges (23.5–30 °C) and subsequent short incubation periods in all seasons (9–14 days) especially during the rainy seasons [14, 15]. However, the trend of dengue cases in Kerala doesn't show any clear pattern. From 2010 to 2019 there were upswings and downswings in the number of cases [16].

The district of Thiruvananthapuram reports two-third cases of dengue in the state of Kerala [17] and has witnessed a substantial rise in the incidence of dengue cases since 2010 [18]. In the year 2017 outbreaks of dengue with severe clinical manifestations were reported in the district [19]. The climate of Thiruvananthapuram is mostly hot tropical, with the monsoon season extending from June to October. The average annual rainfall in Thiruvananthapuram is 114.7 cm [20] and the district is located at a relatively low altitude. The relationship between incidence of dengue and climate remains poorly understood and often differs across settings because of local climate heterogeneity [21]. Hence the influence of different climatic factors is certainly important to track the dengue fever transmission procedures. In this context an attempt has done to understand the influence of rainfall on dengue incidence of Thiruvanathapuram district, Kerala.

Materials and methods

In this study we have used five (2015-2019) years of monthly data on rainfall and reported cases of dengue in Thiruvananthapuram district, Kerala. The number of monthly reported dengue cases (from January 2015 to December 2019) were collected from Directorate of Health Services (DHS) Government of Kerala, Thiruvananthapuram. Since dengue is a notifiable disease, all the laboratory confirmed cases, including those from the private sector, were reported to the health services. Monthly rainfall data of the district were collected from the Indian Meteorological Department (IMD), Thiruvananthapuram. Since rainfall is different in different parts of the district an averaged data from four substations of the district is used for the study.

The data on monthly rainfall were correlated with the monthly dengue cases using Pearson's correlation. A regression analysis was also attempted to understand the nature of association between the two variables (rainfall and dengue cases). Data on monthly rainfall was taken as independent variable and the reported dengue cases as dependent variable while attempting linear regression.

The model equation that was developed followed a regression relationship is:

$$Y=B\,x + C$$

where Y is the dengue incidence, B is the slope parameter, x is the monthly measurement of rainfall and C is the intercept parameter. The developed linear regression equation suggests that every increase in the rainfall, no matter how small, results in an incremental increase in dengue incidence. All statistical analyses were performed using SPSS software.

Result

Over the last 5 years (2015-2019), 13,515 dengue cases were reported from Thiruvananthapuram District by DHS and the number of reported cases varied from year to year. The highest dengue incidences were reported in 2017 (n= 8955) and lowest in 2018(n = 311). However, the deaths were negligible in contrast with the number of cases reported (Fig.1). The monthly dengue incidence data showed a distinct pattern of incidence (fig.2) with maximum number of cases reported during the monsoon season which starts in the month of June and peaks in months of July and August. The number of cases decline in November and December every year.

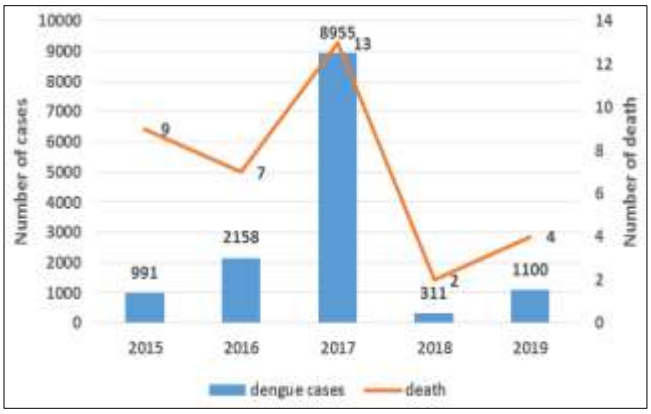

Fig 1: Number of dengue cases and death from 2015-2019

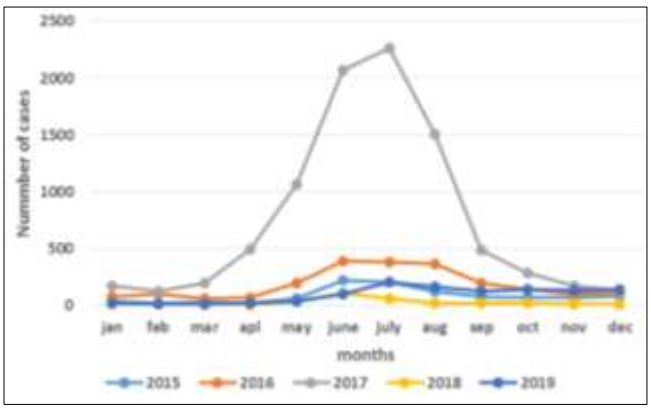

Fig 2: Number of dengue cases in Thiruvananthapuram District on monthly basis from 2015 to 2019

The mean monthly rainfall during the monsoon period in 2015, 2016, 2017, 2018 and 2019 was 227mm, 393mm, 409mm, 542mm, and 384mm respectively. The data showed that there is strong association between monthly dengue cases and monthly rainfall every year (fig.3-7). The peaks of dengue cases and rainfall matched perfectly which suggest that the dengue cases are related to rainfalls.

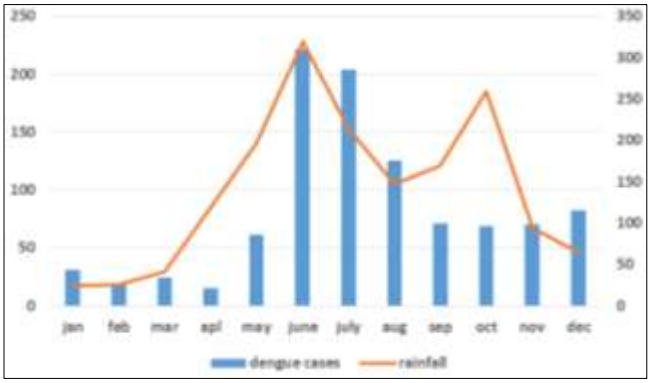

Fig 3: Association of dengue cases and rainfall during the year 2015

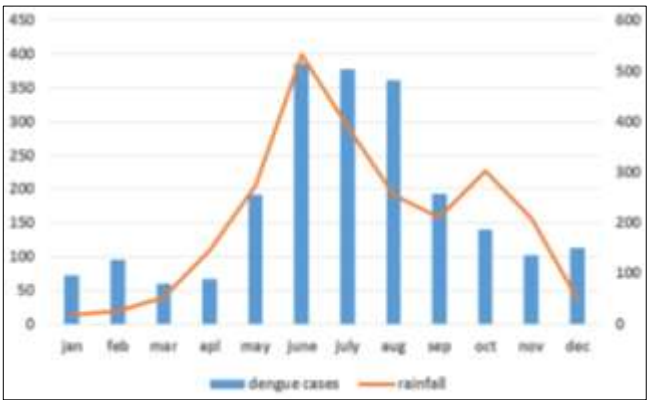

Fig 4: Association of dengue cases and rainfall during the year 2016

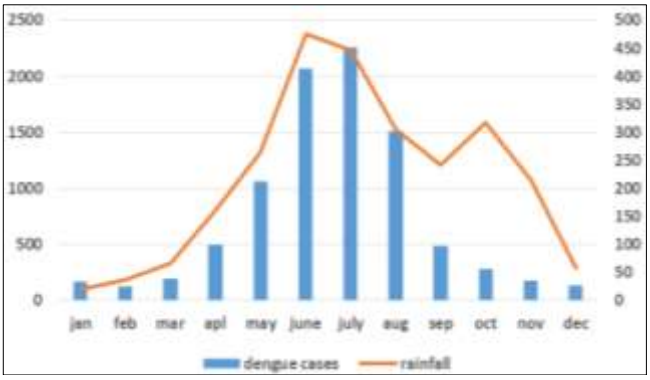

Fig 5: Association of dengue cases and rainfall during 2017

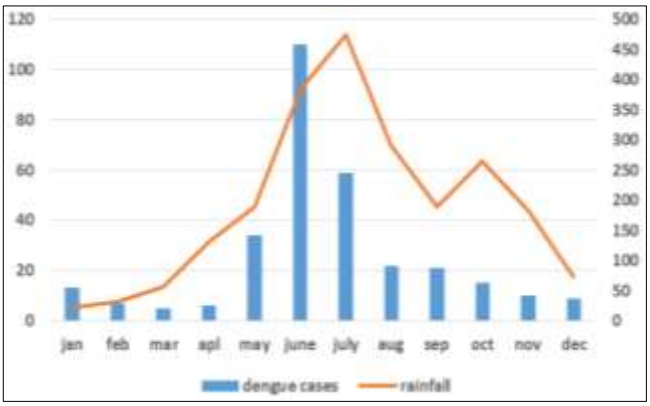

Fig 6: Association of dengue cases and rainfall during the year 2018

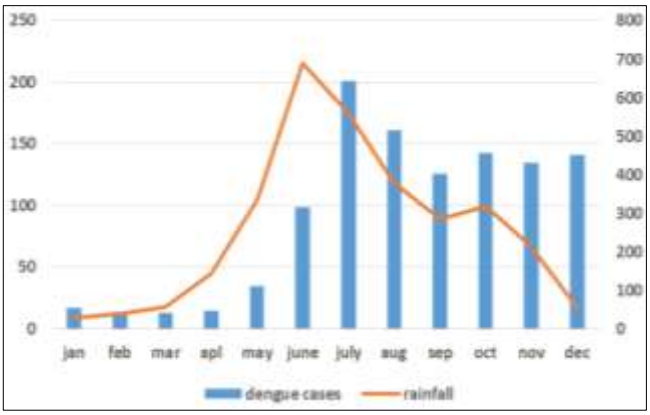

Fig 7: Association of dengue cases and rainfall during the year 2019

Pearson's correlation analysis was performed to find relation between the numbers of monthly reported dengue fever cases with monthly average rainfall. High correlation was observed between average rain fall with average cases (76.5%; r= 0.875) (fig.8). When the data was analysed yearly, in 2017 there was highest correlation (73%; r=0.854) followed by year 2016(68%; r= 0.828) followed in 2018 correlation (56%; r= 0.747) whereas the years 2015 & 2019 shows low percentage of correlation with the rainfall (52%; r= 0.726) & (32%; r= 0.564) respectively. The details of correlation between rainfall and dengue cases are presented in Table 1.

The least square equation plot Dengue prevalence (y) versus rainfall (x) is y = 1.28 x + 31.03 (r = 0.875, $p < 0.001$).

Table 1: Correlation between dengue cases and rainfall from 2015 to 2019

	2015	2016	2017	2018	2019
Pearson's r	0.726**	0.828***	0.854***	0.747**	0.564
pvalue	0.008	< .001	< .001	0.005	0.056
r2	0.527	0.68	0.729	0.558	0.318
Percentage of correlation	52%	68%	73%	56%	32%

Note: * $p < .05$, ** $p < .01$, *** $p < .001$

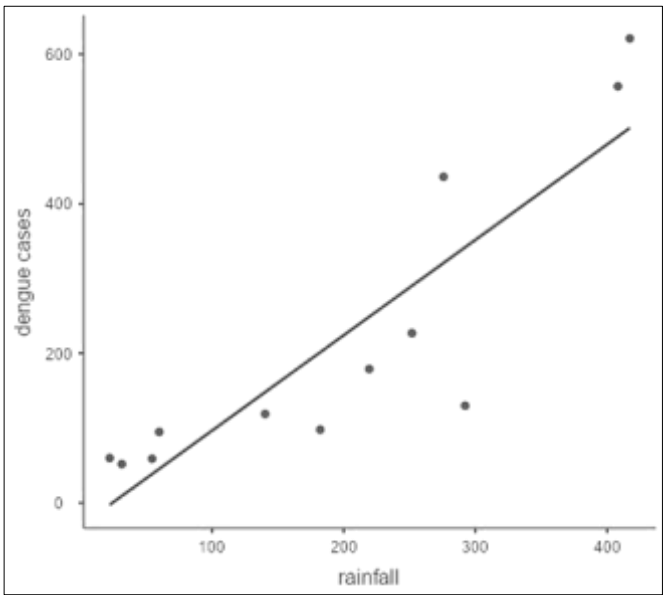

Fig 8: Scatter plot of monthly mean rainfall and dengue cases

Discussion

We have presented a simple analysis of the association of dengue epidemics with rainfall and from the results it was clear that the epidemic has a well-defined seasonality. Rainfall was significantly different among pre-monsoon, monsoon and post-monsoon periods. Average monthly premonsoon rain recorded was 148.9mm, during monsoon it increased to 264.12mm and during post monsoon the amount falls to 178.1mm only. There is increasing number of dengue cases from June onwards i.e. during the monsoon period and the number of cases decline in post monsoon season during all the five years of the study. Rainfall provides breeding habitats and opportunities for the proliferation of vectors in the environment. An increase in the amount of rainfall leads to more potential breeding sites, which, in turn, lead to an increase in the number of mosquitoes hatching [15]. Relatively high prevalence of *Ae eagypti* indices during the monsoon and post monsoon seasons were reported [25–27].

Many studies have reported the influence of rainfall on vector distribution and dengue cases. Dengue is endemic in Thailand

and Latin American countries, where a positive association between the prevalence of dengue and rainfall has been reported [22]. Aguiar *et al*. have shown that in Brazil, the risk of dengue infection is highly seasonal and increases primarily during the rainy season, when vector infestation reaches its peak [23]. Similarly, studies have also reported that compared with drier conditions, in wetter conditions, mosquitoes expand their spatial range thereby leading to increased risk of dengue infection [24]. Season specific pattern of dengue cases has been reported by others also [28, 29]. Hence seasonality could be a useful tool in the design of early warning systems for the prevention and control of dengue epidemics in our communities.

To understand the role of rainfall on dengue transmission, Pearson's correlation analysis were carried out which showed a strong positive association between dengue cases and total rainfall (r=0.087) and highly significant correlation observed during the year 2017 (73%). In this study, the greatest number of dengue cases were also reported in 2017 (n= 8955). Regression analysis is able to explore the nature of association between variables by determining the amount of variance (r2) in the dependent variable (dengue incidence) that can be explained by independent variable (rainfall). The r2 value was 0.765 which indicates that rainfall approximately explains around 76.5 percent of variance ($p < 0.001$) in dengue and regression equation $y = 1.28 x + 31.03$ ($r = 0.875$, $p < 0.001$) which explains for every 1.28 ml of rainfall, there is an average increase of one dengue case. In a recent study, high dengue incidence, ranging between 21 and 50 per million, was reported for the states of Punjab, Gujarat, Karnataka, Kerala, Tamil Nadu and Orissa, and Kerala showed significant associations between dengue cases and annual rainfall, as well as rainy days greater than 1 mm and greater than 10 mm and the cases were highly correlated with rainfall [14].

In the present study it was found that maximum rainfall was observed in august 2018 but highest number of dengue cases were reported in 2017 and least number were reported in 2018. Possible explanation for low incidence of dengue in 2018 may be because of herd immunity attained after the significant outbreak of dengue in 2017. The pattern of rainfall may also play a part as extremely heavy rainfall may flush mosquito larvae away from breeding sites or kill them outright [10]. In a study significantly lesser positivity was found for containers during monsoon period when compared to pre-monsoon period in Thiruvavnanthapuram district [17].

Conclusion

The present study showed that rainfall, as a single factor, likely plays a significant role in the incidence of dengue in Thiruvananthapuram district. Therefore, intensification of surveillance and control of mosquitoes especially during the monsoon period is recommended. However, other seasonal factors like ambient temperature and humidity which also determine the transmission of dengue, should be taken into account since these factors will become favorable with rainfall.

References

1. World Health Organization (WHO). Dengue and severe dengue. https://www.who.int/en/news-room/fact-sheets/detail/dengue-and-severe-dengue. Accessed October 24, 2020.
2. World Health Organization. Dengue: guidelines for diagnosis, treatment, prevention and control. New Ed World Heaith Organ Geneva. Accessed October 25, 2020.
3. Dengue Immunization, Vaccines and Biologicals. World Health Organization. https://www.who.int/immunization/diseases/dengue/en/. Published 2019. Accessed November 2, 2020.
4. Arya SC, Agarwal N. Dengue and dengue hemorrhagic fever. Aust Fam Physician 2007;36(5):295.
5. Ramesh Dhiman C, Pahwa S, Dhillon GPS, Dash AP. Article in Parasitology Research. Parasitol Res 2010;106(4):763-773.
6. Bisht B, Kumari R, Nagpal BN, Singh H, Kumar S. Influence of environmental factors on dengue fever in Delhi. Int J Mosq Res 2019;6(2):11-18.
7. Xu L, Stige LC, Chan KS *et al*. Climate variation drives dengue dynamics. Proc Natl Acad Sci USA 2017;114(1):113-118.
8. Morin CW, Comrie AC, Ernst K. Climate and dengue transmission: Evidence and implications. Environ Health Perspect 2013;121(11-12):1264-1272.
9. Méndez-Lázaro P, Muller-Karger FE, Otis D, McCarthy MJ, Peña-Orellana M. Assessing climate variability effects on dengue incidence in San Juan, Puerto Rico. Int J Environ Res Public Health 2014;11(9):9409-9428.
10. Promprou S, Jaroensutasinee M, Jaroensutasinee K. Climatic factors affecting dengue haemorrhagic fever incidence in Southern Thailand. Dengue Bull 2005;29:41-48.
11. Guhathakurta P, Rajeevan M, Sikka DR, Tyagi A. Observed changes in southwest monsoon rainfall over India during 1901-2011. Int J Climatol 2015;35(8):1881-1898.
12. Angel B, Joshi V. Distribution and seasonality of vertically transmitted dengue viruses in *Aedes* mosquitoes in arid and semi-arid areas of Rajasthan, India. J Vector Borne Dis 2008;45:56-59.
13. Chakravarti A, Arora R, Luxemburger C. Fifty years of dengue in India. Trans R Soc Trop Med Hyg 2012;106(5):273-282.
14. Mutheneni SR, Morse AP, Caminade C, Upadhyayula SM. Dengue burden in India: Recent trends and importance of climatic parameters. Emerg Microbes Infect 2017;6(8):1-11.
15. Kakarla SG, Caminade C, Mutheneni SR *et al*. Lag effect of climatic variables on dengue burden in India Epidemiol Infect 2020, 1-10.
16. Vanaja Cheesh Kumar TK, Nujum ZT, Umarul F, Kuriakose A. A study on container breeding mosquitoes with special reference to *Aedes (Stegomyia) aegypti* and *Aedes albopictus* in Thiruvananthapuram district, India J Vector Borne Dis 2014;51(1):27-32.
17. Kumar NP, Jayakumar PR, George K, *et al*. Genetic characterization of dengue viruses prevalent in Kerala State, India J Med Microbiol 2017;62:545-552.
18. IDSP - dhs. https://dhs.kerala.gov.in/idsp-2/. Accessed October 26, 2020.
19. Rainfall data for major cities of India. http://www.rainwaterharvesting.org/rainfall_index.htm#. Accessed October 26, 2020.
20. Johansson MA, Cummings DAT, Glass GE. Multiyear climate variability and dengue - El Niño southern oscillation, weather, and dengue incidence in Puerto

Rico, Mexico, and Thailand: A longitudinal data analysis. PLoS Med 2009;6(11):1-9.
21. Indaratna K, Hutubessy R, Chupraphawan S *et al*. Application of geographical information systems to co-analysis of disease and economic resources: Dengue and malaria in Thailand. Southeast Asian J Trop Med Public Health 1998;29(4):669-676.
22. Aguiar M, Rocha F, Pessanha JEM, Mateus L, Stollenwerk N. Carnival or football, is there a real risk for acquiring dengue fever in Brazil during holidays seasons? Sci Rep 2014;5(1):1-12.
23. Kolivras K. Changes in dengue risk potential in Hawaii, USA, due to climate variability and change. Clim Res 2010;42(1):1-11.
24. Kumar RR, Kamal S, Patnaik SK, Sharma RC. Breeding habitats and larval indices of *Aedes aegypti* (L) in residential areas of Rajahmundry town, Andhra Pradesh - PubMed. Indian J Med Res 2002;115:31-36.
25. Katyal R, Gill K, Kumar K. Seasonal variations in *Aedes aegypti* population in Delhi, India. Dengue Bull 1996;20:78-81.
26. Sharma R, Panigrahi N, Kaul S, Barua K, Bhardwaj M. Status Report on DF/DHF During in the National Capital Territory of Delhi, India. Dengue Bull 1998-1999;23:109-112.
27. Schwartz E, Weld LH, Wilder-Smith A *et al*. Seasonality, annual trends, and characteristics of dengue among Ill returned travelers, 1997-2006. Emerg Infect Dis. 2008;14(7):1081-1088.
28. Karim MN, Munshi SU, Anwar N, Alam MS. Climatic factors influencing dengue cases in Dhaka city: A model for dengue prediction. Indian J Med Res 2012;136(1):32-39.