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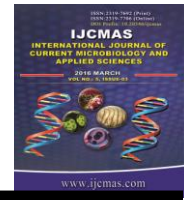

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Climate and Dengue Incidence in and around Bengaluru – Warning Based on Temperature and Rainfall

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Dengue fever is the most prevalent mosquito-borne viral disease worldwide and it causes regular epidemic in India. It is believed that climate is an important factor for dengue transmission and there is much concern as to whether climate change would spread the disease to areas currently unaffected. This study was carried out to report the seroprevalence of dengue virus infection and effect of climate on incidence of dengue in and around Bengaluru city, Karnataka, India. The laboratory records of clinically suspected dengue patients from January to December 2014 and January to November 2015 were analyzed for the anti-dengue immunoglobulin M (IgM) antibodies, tested by dengue monoclonal antibody (IgM) capture enzyme-linked immunosorbent assay (MAC ELISA). A total of 4835 serum samples were tested, of which 1756 were positive. The majority were males (70%) and in the age group of 16–30 years. The incidence of dengue started to increase in June and peaked in August & September and slowly tapered by December. Dengue cases were higher during rainy season and in humid temperature. This observation is useful for planning special preventive strategies during this time. An effective control and preventive programmes depend upon improved surveillance data and action taken.

Introduction

Dengue fever/dengue hemorrhagic fever is a mosquito-borne viral disease. It is a well-known urban disease and the number of cases reported keeps increasing yearly and the peak of the dengue epidemic period is around June to September during the rainy season. In recent years, dengue has become a major global public health concern.

Approximately 2.5 billion people living mainly in urban areas of tropical and subtropical regions are estimated to be at risk of acquiring dengue infection. Dengue infections were first reported in India in 1991 and the first epidemic of DHF occurred in Delhi in 1996. Major dengue outbreaks have occurred irregularly every 3–

4 years. In recent years outbreaks and deaths have been reported from Karnataka, Delhi, Uttar Pradesh, Andhra Pradesh and Tamil Nadu.

The dengue fever is caused by one of the four distinct serotypes of dengue virus DENV1-4 **(**Montoya M etal 2013). The two mosquito species responsible for the transmission of dengue in India are Ae aegypti and Ae albopictus **(**Liu-Helmersson J etal, 2014). The distribution and abundance of mosquito larvae actually reflect the oviposition preferences of adult females and the ability of immature stages to tolerate the conditions that prevail in aquatic habitats **(**Wu P, Lay J etal, 2009). It has been long known that both Aedes vectors breed primarily in artificial water containers and the mosquito's life cycle is closely associated with human activities **(**Chompoosri J, et al, 2012, Khasnis AA et al, 2005). Most of the study indicated that the *A. aegypti* preferred to breed in ant traps, earthen jars, drums, concrete tanks, coconut shells and discarded tires (Simard F etal, 2005, Paupy C etal, 2006 and Lee HL etal, 1987)**.** Aedes mosquitoes proceed through the life cycle from eggs to larvae to pupae to adult. Aedes mosquitoes undergo two stages of life, namely the terrestrial and the aquatic stage. The terrestrial stage includes adult mosquitoes and eggs, whereas the aquatic stage includes immature stages of larvae and pupae. This life cycle takes approximately 1-2 weeks or longer depending on temperature and availability of water and nutrients during aquatic or immature stages. The vector life cycle is directly influenced by ambient temperature and rainfall (Shope R, 1991) Increased temperature could increase dengue risk by increasing the rate of mosquito development and reducing virus incubation time in areas where the vector presently exists, thereby increasing the rate of transmission (Focks DA etal 1995, Kuno G 1995, McMichael AJ, Haines A 1997 and Patz JA etal 1996). However, the mortality rates of adult mosquitoes increase with the extreme hot temperatures above 30^0C and thus decrease dengue risk **(**Hii YL etal 2009).

Based on dynamic process of the epidemic, some area might have longer epidemic duration while others might have stronger intensity even though the duration is short. This situation might be contributed by the persistent occurrence of dengue cases. Vector breeding and disease transmission have close connection to environment, epidemiology and entomology characteristics. Thus, this study was aims to investigate to improve our knowledge on the potential influence of temperature and rainfall on the incidence of dengue fever.

Materials and Methods

This was an analysis of routine laboratory diagnostic work and so the ethical approval was not necessary. Age, sex and address data of all patients who presented with signs and symptoms of fever, headache and joint pain which were suggestive of dengue virus infection, dengue hemorrhagic fever (DHF) or dengue shock syndrome (DSS) at the KC general Hospital, Jayanagar General hospital, Bengaluru, Karnataka, and at the primary and community health centers in Bengaluru Urban and Rural district between January to December 2014 and January to November 2015 were recorded and serum samples were collected. Serum samples were tested for the presence of antidengue immunoglobulin M (IgM) in Public Health Institute, Health and family welfare department, govt of Karnataka (PHI, Bengaluru), using dengue monoclonal antibody (IgM) capture enzyme-linked immunosorbent assay (MAC ELISA) kit, supplied by the National Institute of Virology, Pune, India.

Data of the rainfall and temperature in Bengaluru: - The data of the rainfall (mm) and temperature in and around Bangalore were obtained from the Meteorological centre, government of India, Palace road, Bangalore. These data were utilized in assessing the incidence of cases from Jan 2014 to November 2015.

Results and Discussion

The total number of samples analyzed from Jan 2014 to November 2015 was 4835. The positive cases from Jan 2014 to December 2014 were 493 and from Jan 2015 to November 2015 were 1263. The split cases in each month of both years and also corresponding mean temperature and rainfall of the each month is mentioned in the tables 1, 2, 3 and 4.The correlation between temperature and rain fall with the incidence of cases and their significance is calculated using P value by Spearman's statistical analysis.

The present study shows that, from Jan 2014 to May 2014 mean temperature is between 30°C - 35°C (table no: - 1) and rainfall (table no: - 2) is almost nil. At this time incidence of dengue cases are 1-2 per month. From June 2014 onwards temperature is around between 28^{0}C to 29^{0}C and rainfall ranges from 5 to 10 mm per day till October 2014. Incidence of cases started to increases from 20 cases in June 2014 to 111 cases in October (table no: - 1). From November 2014 onwards to Jan 2015, temp is around 29^{0}C to 30^{0}C and rainfall from 0 to 3mm, incidence of cases started to decrease from 83 to 20. From February 2015 to may 2015(table no: - 3), temp was more than 30^{0}C and rainfall (table no: - 4) was 0 to 3mm and cases from 10 to 20 per month till May. From June to October 2015, temp is around 28^{0}C - 29^{0}C and rainfall is more than 5 to 8 mm per day. Cases started to increase from 186 in June, 334 in July, 280 in August, 148 in September , 147 in October and 55 in November 2015(table no: - 4).

Table.1 Incidence of Dengue Cases in the Year 2014- Jan to December in Relation to Temperature

Table.1 Incidence of dengue cases in the year 2014- Jan to December in relation to temperature		
Month	Positive cases (X)	Mean temperature in centigrade. (Y)
Jan	3	28.5
Feb	1	31.08
March	1	32.9
April	0	35.42
May	5	33.91
June	20	30.09
July	33	28.4
August	89	28.21
September	99	28.95
October	111	28.85
November	83	28.21
December	48	28.02

Results details after applying Spearman's formul

The value of R is -0.64561 and the two tailed value of **P are 0.02335.** By normal standard, the association between the incidence of dengue cases and temperature would be considered statistically significant.

Table.2 Incidence of Dengue Cases in the Year 2014- Jan to December in Relation to Rainfall

Table no: 2. Incidence of dengue cases in the year 2014- Jan to December in relation to rainfall		
Month	Positive cases(X)	Rainfall (mm) (Y)
Jan	3	0
Feb	1	0.007
March	1	0.015
April	0	0.5
May	5	2.4
June	20	5.73
July	33	3.25
August	89	3.36
September	99	10.63
October	111	3.3
November	83	3.02
December	48	3.2

Results Details After Applying Spearman's Formula

The value of R is 0.77408 and the two tailed value of **P is 0.00313.** By normal standard, the association between the incidence of dengue cases and rainfall would be considered statistically significant.

Table.3 Incidence of Dengue Cases in the Year 2015- Jan to November in Relation to Temperature

Incidence of dengue cases in the year 2015- Jan to November in relation to temperature		
Month	Positive cases(X)	Mean temperature in centigrade. (Y)
Jan	26	28.06
Feb	12	31.03
March	13	32.88
April	18	32.72
May	44	30.60
June	186	29.52
July	334	29.33
August	280	29.00
September	148	29.46
October	147	29.50
November	55	27.02

Results Details After Applying Spearman's Formula

The value of R is -0.666674 and the two tailed value of **P are 0.04987.** By normal standard, the association between the incidence of dengue cases and temperature would be considered statistically significant.

Table.4 Incidence of Dengue Cases in the Year 2015- Jan to November in Relation to Rain Fall

Incidence of dengue cases in the year 2015- Jan to November in relation to rain fall		
Month	Positive cases(X)	Rainfall (mm) (Y)
Jan	26	0.29
Feb	12	00
March	13	1.21
April	18	7.55
May	44	5.75
June	186	2.84
July	334	3.03
August	280	3.5
September	148	5.99
October	147	2.80
November	55	3.89

Results Details after Applying Spearman's Formula

The value of R is 0.35 and the two tailed value of **P is 0.35582.** By normal standard, the association between the incidence of dengue cases and rainfall would be considered statistically significant.

Cases started to decrease from November 2015 onwards. The results of this study clearly indicate that climatic variability that is rainfall and temperature is absolutely associated with the incidence of dengue and also seems to have played an important role in transmission of dengue fever.

These results are consistent with findings of other studies and may assist to forecast dengue outbreaks in different regions **(**Hii YL etal 2009, Descloux E etal 2012, Hsieh YH etal 2009 and Johansson MA etal 2009). A similar study from Southern Thailand asserts that there was a unique association between local climate and dengue incidence (Promprou S etal 2005). A similar study in Tamilnadu indicates that there is a definitive association between climate variation and dengue incidence (Chandy S etal 2013). Considering the data from Latin American countries, Goncalves, Neto and Rebelo (Gonçalves et al 2004) found a positive correlation between disease and amount of rainfall. The impacts of temperature and rainfall on dengue transmission are partly translated through the effects of temperature and rain on the rates of biological development, feeding, reproduction, population density and survival of Aedes mosquitoes. Maximum Temperature of range 26–30°C influences the life cycle of Aedes mosquitoes including growth rate, mosquito survival rate of 88–93%, larval survival and the length of reproductive cycle (Hopp MJ et al 2001, Patz JA etal 2005 and Tun-Lin W et al 2000). Temperature and humidity plays a significant role in the dengue transmission and influences the dynamic modeling of vector–host interaction and potential predictors of dengue outbreaks **(**Chen SC etal 2012 and Wu PC etal 2007). Rainfall provides breeding sites for the mosquitoes to hatch and develop into the adult stage. Our present study confirm the impact of climate on dengue transmission is significant and suggest that the greatest potential of dengue transmission in Karnataka occur in June to September in which average temperature is around 28–29°C in the mid of rainy season. The results obtained from this study have an important implication for further research, surveillance and control of DF outbreak in Karnataka.

In conclusion, the number of mosquito population varies according to seasonal variations. During favorable periods that are from June to September, when the size of the mosquito population increases, the potential for dengue infection in the humans also increases. Many methods are available for the control of the dengue vectors e.g. environmental control, chemical control, biological control, genetic control, human behavioral control and others. Of these method, human behavioral control, environmental control and effective vector surveillance was considered to be the most important in a long-term basis for the control of dengue fever.

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