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Geographical information system based study on Dengue and Chikungunya at Western Ghats districts, Tamil Nadu, India

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Abstract
Background & Objectives: Dengue and Chikungunya risk, based on socio-cultural and environmental factors and its possible spatial relationship to be investigated broadly. The aim of study is to explore epidemiology of risk factors of Dengue and Chikungunya prevalence and incidence, mapping the diseases prevalence in the year 2011for future planning containment measures in Western Ghats districts Dindigul HUD, Theni and Madurai.
Methods: Dengue and Chikungunya outbreak reports were obtained from sentinel diseases surveillance centers. Entomological parameters were applied to investigate and monitor fever outbreaks. Meteorological data was obtained from India Meteorological Department for risk factors analysis. ArcGIS modeling was done to generate risk map of Dengue and Chikungunya incidences with four risk levels i.e. very high, high, medium and low in three districts.
Results: 21 Dengue outbreaks, 13Chikungunya outbreaks, 3 mixed outbreaks in Madurai district, 24 Dengue outbreaks, one Chikungunya outbreak, 2 mixed outbreaks in Theni district and 13 Dengue, one Chikungunya and one mixed outbreaks at Dindigul HUD were recorded during 2011. *Aedes albopictus* and *Aedes aegypti* are common vectors in these three districts. The entomological variables are strongly correlated with prevalence of dengue and chikungunya outbreaks (r=0.91). Madurai district reported more Chikungunya outbreaks than other district. Seasonal rainfall maintained breeding sources and outbreaks in all months in Theni district.
Interpretation & Conclusions: Results of this study indicated that socio-economic and socio-cultural variables are highly correlated with prevalence of Dengue and Chikungunya. This risk zone map helps in implementing precautionary and preventive strategies and control incidences of vector borne diseases effectively. Data about these diseases prevalence including location can be incorporated easily in GIS for comprehensive analyses.

Keywords: *Aedes*, Geographical Information System, Dengue Haemorrhagic fever, Container Index, Pupal Index, Integrated Diseases surveillance project, Health Union District.

1. Introduction
Dengue is a mosquito-borne viral infection causing a severe flu-like illness and sometimes causing a potentially lethal complication called severe dengue. World Health Organization currently estimates that 50–100 million cases of Dengue infections occur worldwide every year [1]. Outbreaks of exotic diseases, such as Chikungunya, are now reported in the WHO European Region. Mosquito vectors of Chikungunya caused the first European outbreak in Italy in 2007, with almost 200 cases. CHIKV is a heat sensitive RNA virus (family is Toga viridae and genus is alpha virus). Chikungunya also affects monkeys and it is also suspected that they are a major reservoir for the virus in Africa [2]. As of February 2015, total of 30 chikungunya cases have been reported from U.S. territories (Centre for Disease Control and Prevention, Atlanta, Feb-2015). Before 1970, only nine countries had experienced severe dengue epidemics. Today dengue is endemic in more than 100 countries including African, Americas, Eastern Mediterranean, South-East Asia and the Western Pacific regions. In 2010, 1.6 million cases of dengue were reported in WHO region of the Americas alone, of which 49000 cases were severe dengue. Globalization, the increasing volume of trade and travel, continuing urbanization and environmental/climate change have contributed to the introduction and establishment of the *Aedes* genus mosquitoes in the WHO European region [3]. Dengue cases in Brazil raised by 57 percent in January 2015 due to increase of water crisis in the country's south-eastern region (*Latin American Herald Tribune*, Feb 12, 2015). During last two decades from 1991 to 2010, out of 35 states/Union Territories of India, 31 have

reported Dengue cases in India [4]. There are four distinct, but closely related, serotypes of the virus that cause dengue DEN-1, DEN-2, DEN-3 and DEN-4.Both Dengue and Chikungunya because the two related viral diseases have similar symptoms of acute fever and joint pain, and are transmitted by the same vectors, the mosquitoes *Aedes aegypti (Linn) and Aedes albopictus (Skuse)* (Asian Tiger Mosquito). Dengue fever may transform into dengue hemorrhagic fever and dengue shock syndrome [5]. Disease surveillance, vectors surveillance and monitoring the monsoon periods are the major components in dengue surveillance. The entomological surveillance is used to determine the changes in the geographical distribution and density of vectors, evaluate the control programs and timely intervention. The entomological parameter Pupal Index indicates the intensity of transmission of disease and Container Index provides information on intensity of breeding in affected area. In India all DF/DHF outbreaks have been associated with *Aedes* CI of more than 20% [6]. A Total of 20402 clinically suspected Chikungunya cases have been reported in India during 2011 and of these 4194 was from Tamil Nadu. The number of Dengue cases and deaths reported in India during the year 2011 are 18860 and 169 and of these 2501 cases of Dengue and 9 deaths are from Tamil Nadu [7]. On 18 May 2002, the WHO General Assembly confirmed Dengue fever as a matter of international public health priority through a resolution to strengthen dengue control and research [8]. Recently, Geographical Information System has emerged as an important component of many projects in public health and epidemiology [9]. GIS has been used in the surveillance and monitoring of vector-borne diseases, water-borne diseases, environmental health, analysis of disease policy and planning, health situation in an area, generation and analysis of research hypotheses, identification of high risk health groups, planning and programming of activities, and monitoring and evaluation of interventions [10].

2. Materials and Methods

2.1. Description of Study area

The south Indian districts Dindigul HUD, Theni and Madurai were selected for the study of Dengue and Chikungunya epidemiology. The location of study area is placed in the Western Ghats region, Tamil Nadu, India.

Fig 1: Map showing study area in Tamil Nadu, India.

Madurai: The Geographical location of Madurai lies in North Latitude between 9º 30.00 and 10º 30.00, East Latitude between 77º 00.00 and 78º 30.00. The population of Madurai district is 25, 62,279 and rural population is 11, 29,028 and urban population is 14, 33,251 and the area is 3741.73 sq.km. There are 13 Blocks, one Municipal Corporation, 6 Municipalities and 1137 villages in the Madurai district. 11 Government Hospitals, 18 Government Dispensaries, 314 Health Sub Centres, 56 Government Primary Health Centres, 6 Indian Medicine Government Hospitals, 10 Indian Medicine Dispensaries, 2 Government Homeopathy Hospitals, 29 Private Hospitals and two Medical College Hospitals are available for public health services. During the year 2011 South west monsoon 190.5mm, North East monsoon 609.8mm and in summer 103.3mm rainfall was recorded, the maximum and minimum temperature was 36.8ºC and 21.1ºC and maximum and minimum humidity was 78.5% and 47% respectively.

Theni: The geographical position lies in North Latitude between 9, 30, 00" and 10, 30, 00" and in East Longitude between 77, 00, 00" and 78, 30,00". The population of this district is 12,45,899 and area is 3242.3 sq.km. The rural and urban population is 1,56,719 and 1, 18,393, respectively. Theni district has 8 Blocks, 130 villages and 6 Municipalities. For the public health services 6 Government Hospitals, 29 Government Primary Health Centres, 162 Health Sub Centres, 7 Indian Medicine Hospitals, 6 Government Dispensaries, One Government Homeopathy hospital, 19 Private Hospitals and One Government Medical college hospital available in this district. During the year 2011 South west monsoon 292mm, North East monsoon 757.9mm and in summer 121.1mm rainfall was recorded, the maximum and minimum temperature was 35.1ºC and 19.4ºC and maximum and minimum humidity was 82.5% and 51.7% respectively.

Dindigul HUD: The geographical location is situated in North Latitude between 10º 05' and 10º 09' and in East Longitude between 77º 30' and 78º 20'. The population of this district is 10, 62,447 and area is 4236 sq.km. There are 7 Blocks, 358 villages and One Municipality in this district. 4 Government Hospitals, 30 Government Primary Health Centres, 146 Health Sub Centres, 4 Government Indian Medicine Hospitals and 18 Private Hospitals available for the Public health services. During the year 2011 South west monsoon 180mm, North East monsoon 617.1mm and in summer 110.2mm rainfall was recorded, the maximum and minimum temperature was 37º C, 20º C and maximum humidity was 81.5% and minimum humidity was 52%.

2.2. Diseases surveillance

All fever cases with the signs and symptoms of Dengue and Chikungunya were screened serologically. The positive case reports were obtained from the sentinel disease surveillance centres (IDSP). The serological result was positive for Dengue and Chikungunya based on NS1 antigen and immunoglobulin M (IgM) antibodies in IgM capture enzyme-linked immunosorbent assay [11].

2.3. Entomological Surveillance

Entomological surveillance is an important tool to forecast and monitor the fever outbreak [12]. The Entomological parameter/indices were obtained from concerned Zonal entomological wing. The following indices were used to assess the risk level of *Aedes* larval and pupal infestation i.e., Optimal index <1%, Good index 1-5%, Alaram index 5-10% and Emergency index >10% [13].

$$\text{Container Index} = \frac{\text{No. of positive containers for } \textit{Aedes} \text{ larvae or pupae}}{\text{No. Of containers verified for } \textit{Aedes} \text{ larvae or pupae}} \times 100$$

$$\text{Pupal Index} = \frac{\text{No. of } \textit{Aedes} \text{ Pupae per house}}{\text{No. of houses inspected for } \textit{Aedes} \text{ Pupae}} \times 100$$

2.4. Geo Information System

ArcGIS (version 9.3.1) modelling was done to generate risk map of Dengue and Chikungunya diseases prevalence with four risk levels i.e. very high, high, medium and low at block levels in Dindigul HUD, Theni and Madurai districts.

2.5. Statistical analysis

Correlation is an appropriate technique to find significant risk factors contributing to Dengue and Chikungunya outbreaks (SPSS version 16.0, SPSS Inc., Chicago, IL, USA). Correlation between the two variables i.e., fever outbreaks and Container index is 0.92 and fever outbreaks and Pupal index is 0.89. Both were strongly correlated in Dindigul HUD. Correlation between fever outbreaks and Container index is 0.91 and fever outbreaks and Pupal index is 0.88. Again both were strongly correlated in Theni district. In Madurai district fever outbreaks and Container index (0.60) and fever outbreaks and Pupal index (0.64) were moderately correlated.

3. Case definition of dengue

According to the IDSP manual, dengue is defined as an acute febrile illness of 2-7 days duration with two or more of the following symptoms: headache, retro-orbital pain, myalgia, arthralgia, rash, hemorrhagic manifestations and leukopenia [14].

4. Case definition of Chikungunya

According to the World Health Organization Chikungunya is characterized by an abrupt onset of fever frequently accompanied by joint pain. Other common signs and symptoms include muscle pain, headache, nausea, fatigue and rash. The joint pain is often very debilitating, but usually lasts for a few days or may be prolonged to weeks. Hence the virus can cause acute, sub acute or chronic disease. But in older people, the disease can contribute to the cause of death [15].

5. Epidemiology of risk factors

Frequency of cleaning of water storage containers

The frequency of cleaning of water storage containers made a positive contribution to Dengue and Chikungunya incidences. The *Aedes* mosquito is a domestic breeder and breeding can occur in water storage containers, which are not emptied and cleaned for sufficiently long periods. The *Aedes* eggs are normally laid on the damp walls of both artificial and natural containers and they could resist desiccation for several weeks to several months. The eggs hatch when submerged in water. Since water is essential during the first 8 days in the life of mosquitoes, therefore if the frequency of cleaning is more than 8 days, this could contribute to an increase in the abundance of adult mosquitoes and the risk of virus transmission [16]. Whereas, changing water and emptying water storage containers once or twice a week will greatly reduce the risk of Dengue and Chikungunya. It was observed in the study area Dindigul HUD the pit taps were main source for breeding (40%), in Madurai district plastic drums (35%), and in Theni district cement cisterns (40%) and those containers were used to store water for domestic purposes, i.e. washing, bathing, etc., were cleaned infrequently(Fig.1). These containers were providing ideal oviposition sites for mosquitoes and subsequent sticking of the eggs and also maintaining transovarial transmission [17]. The eggs would then hatch and develop into mosquitoes when inundated.

Use of water evaporation cooler and refrigerator

The uses of water evaporation coolers generally start with the onset of summer months. Coolers and refrigerator become excellent places for *Aedes* mosquito breeding and can lead to widespread transmission of Dengue and Chikungunya fever. The cooler and refrigerator play an important role in the breeding of secondary foci [18]. With the onset of monsoons, the breeding of *Aedes* larvae spreads from its mother foci to secondary foci. Refrigerator water collection tray has maintained breeding in all months. Dindigul municipality contributed 12%, Madurai Corporation and Theni municipalities contributed 21% and 17% respectively.

Uncovered water storage containers

Open water storage containers provide ideal breeding places for *Aedes* mosquitoes. During the survey it was observed that portable cement tanks, metallic/plastic drums overhead/underground tanks, mud pots and grinding stones were used to store clean water within premises. Most domestic water storage containers were kept uncovered except underground tanks. 9%, 11% and 7% breeding habitat of grinding stones contributed by Dindigul HUD, Theni and Madurai districts respectively. The regression model indicates that the presence of uncovered water containers makes a positive contribution to Dengue and Chikungunya incidences [19]. It is interesting to note that the epidemic occurred in the summer months when there was scarcity of water. This scarcity could result in increased storage of water, thereby increasing the risk of Dengue and Chikungunya incidences and thus holding a positive correlation.

Housing pattern

A review of the available literature indicated that in a crowded area, many people living within the short flight range of the vector from its breeding source could be exposed to transmission even if the indices were low [20]. Therefore, higher population density and interconnection of houses could lead to more efficient transmission of the virus and thus increased exposure to infection. The transmission of the disease is normally limited by the flight distance of *Aedes spp* during its lifetime. The flight distance of *Aedes spp* could range from a few metres to more than 50 metres in a closed urban environment. In urban environment where interconnections are not very common, the independent nature of houses limits the flight range of *Aedes spp* and reduces the transmission of the disease. The connectivity of houses had a negative correlation with dengue incidence. The Madurai Corporation and Municipalities in Theni and Dindigul districts have thick population households and contributed more fever outbreaks.

Frequency of solid waste removal

Frequency of garbage removal was the important contributing factor, which influenced in a negative direction. The presence of solid wastes around the households, such as cans, car parts, bottles, old used tyres and other junk material found in several houses, created potential breeding sites. Dumping of solid waste for long periods of time such as15-20 days supported the breeding of *Aedes spp* and increased the transmission of disease. If the frequency of collection and disposal of solid waste by local bodies increases, it would control the *Aedes* breeding and thus would reduce transmission [21]. Solid waste contributed more breeding habitats in all villages in three districts during pre and post monsoon periods. 28%, 27% and 18% old used tyres recorded as breeding site in Dindigul, Madurai and Theni districts respectively.

Frequency of water supply

The frequency of water supply was negatively correlated to incidences of dengue. Water supply in most houses, especially during summer was inadequate and not reliable. Water scarcity resulting in increased and prolonged storage of water for domestic use in various types of containers, subsequently becomes the cause of breeding of *Aedes* mosquitoes [22]. Water storage practices in the area due to irregular water supplies were possible cause for higher vector concentration in the houses thus increasing dengue transmission. It means more infrequent the supply of water, more practice of water storage and more the presence of vectors, thus increasing the growth transmission and risk of Dengue and Chikungunya infection. Water scarcity common in Dindigul and Madurai districts and it leads to practice of water storage for domestic purposes.

6. Results

6.1. Morbidity report

Fever outbreaks 15, 27 and 37 were recorded at Dindigul HUD, Madurai and Theni districts respectively during 2011 and all fever cases were screened for Dengue and Chikungunya. 13Dengue outbreaks were recorded in Dindigul HUD, 21 at Madurai and 24 at Theni district. 13Chikungunya outbreaks were recorded at Madurai district and one each in Theni and Dindigul HUD. Mixed outbreak (Dengue and Chikungunya) was recorded in Chinnalapatti at Dindigul HUD, Alanganallur, Mellur and Sellur in Madurai and Kottur and Uthamapalayam in Theni district (Fig.2). More fever outbreaks were recorded at Auntipatti, Periyakulam and Dombucherry in Theni district, Vathalagundu, Nilakottai and Thadikombu in Dindigul HUD, Thiruparankundram, Alanganallur and Madurai Corporation in Madurai district (Fig.3, 4, 5). Dengue mortality was recorded at Chinnalapatti and Kannivadi during 2011 at Dindigul HUD. Fever outbreaks and also Dengue cases were recorded in all months due to seasonal rainfall in and also Dengue cases reported in all months in Theni district (Fig.5).

6.2. Entomological report:

Overall, all blocks in three districts reported above emergency index during the fever outbreaks. In Dindigul HUD Vathalagundu reported more fever outbreaks and also recorded above the emergency index (CI-19.5, PI-19). Container Index was high in Chinnalapatti and Dindigul Municipality (21.5, 20). Pupal Index was high in Dindigul municipality, Nilakottai and Chinnalapatti (27, 28, 24) (Fig.3). In Theni district CI was high in Kombai, Gudalur and Auntipatti. High PI was recorded at Bodi, Theni and Cumbam municipalities. More fever outbreaks were reported from the Auntipatti, Periyakulam and Dombucherry and also recorded high PI (Fig.4). In Madurai district Alanganallur, Elumalai and Kallenthiri blocks reported high Container Index. The high PI causes for the fever outbreaks in Madurai Corporation, Thiruparankundram and Alanganallur blocks (26, 19, 24). Theni district received good rainfall to maintain breeding sources and emergency index during 2011. GIS mapping reported that Aundipati block was a very high risk zone for Dengue incidence (Fig.7). Vathalagundu block and Madurai Corporation were notified very high risk zones for Dengue and Chikungunya incidence (Fig.8, 9, 10).

Fig 2: *Aedes* breeding habitats at DindigulHUD, Madurai and Theni districts.

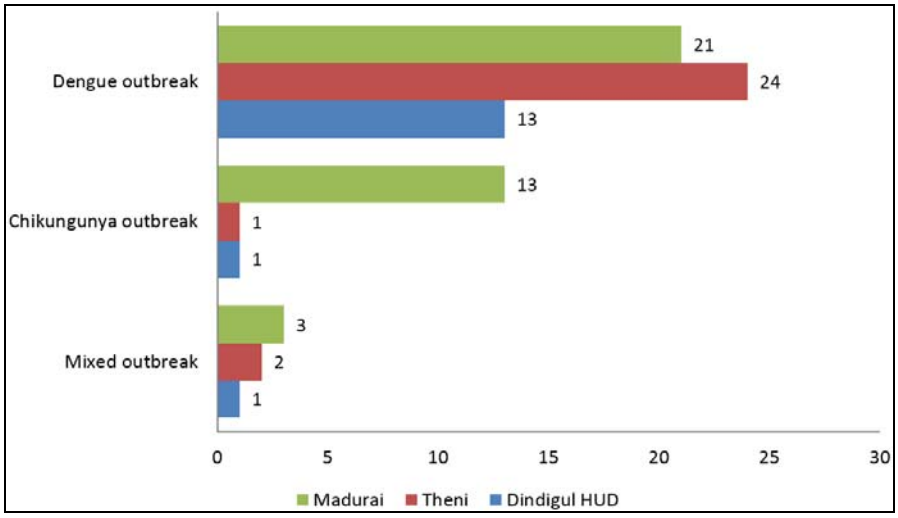
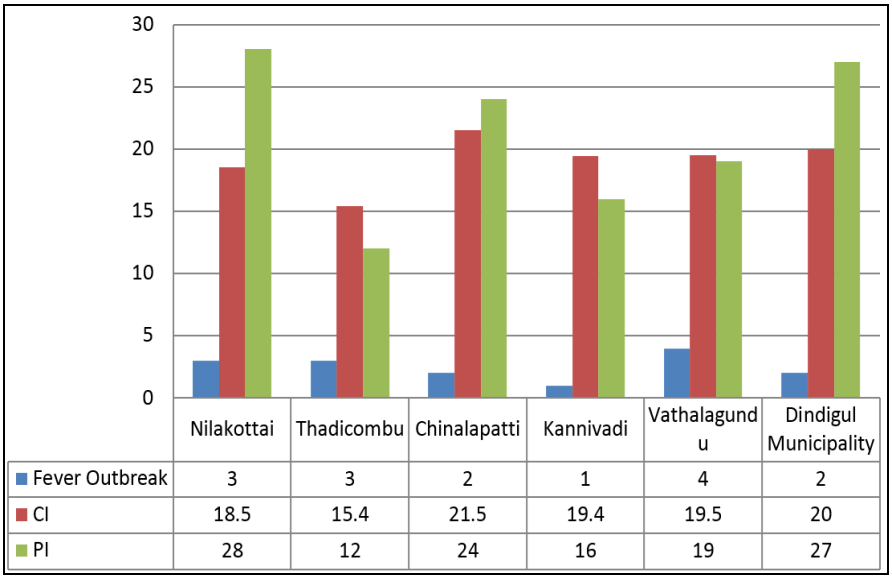
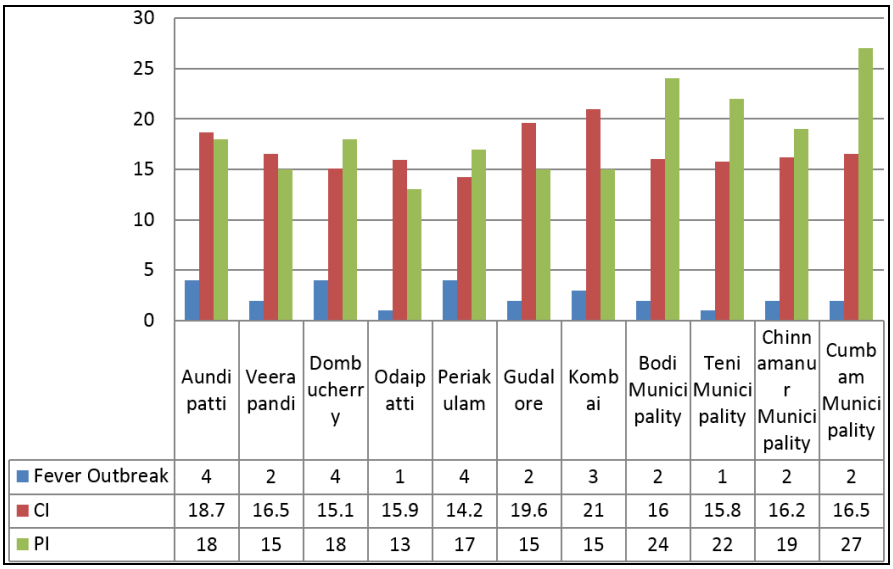


Fig 3: Status of Vector Borne Diseases at District level in 2011.



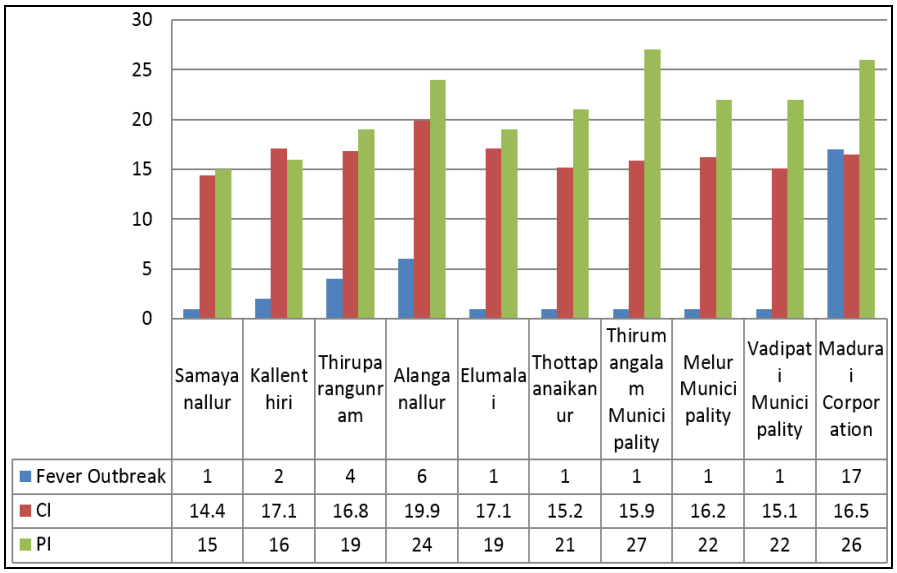
	Nilakottai	Thadicombu	Chinalapatti	Kannivadi	Vathalagundu	Dindigul Municipality
Fever Outbreak	3	3	2	1	4	2
CI	18.5	15.4	21.5	19.4	19.5	20
PI	28	12	24	16	19	27

Fig 4: Block level impact of fever outbreaks at Dindigul HUD in 2011.



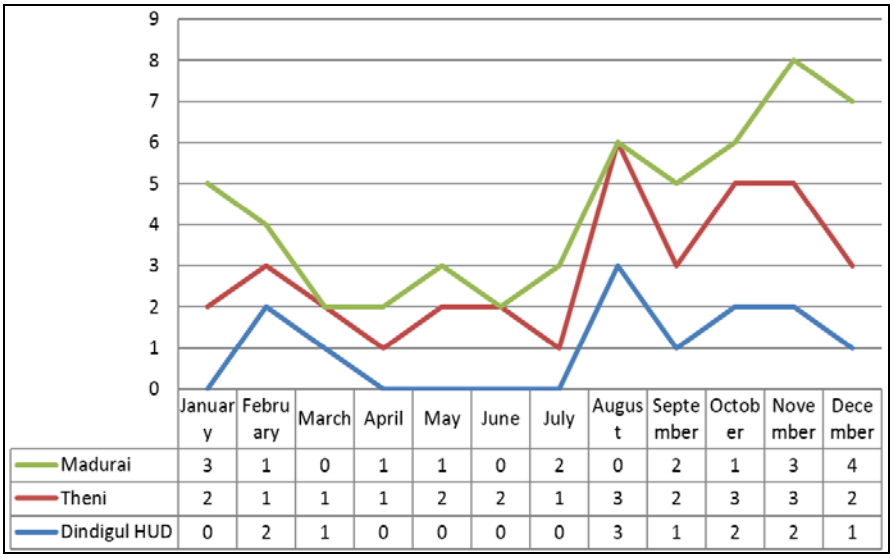
	Aundi patti	Veera pandi	Domb ucherry	Odaip atti	Periak ulam	Gudal ore	Komb ai	Bodi Municipality	Teni Municipality	Chinn amanur Municipality	Cumb am Municipality
Fever Outbreak	4	2	4	1	4	2	3	2	1	2	2
CI	18.7	16.5	15.1	15.9	14.2	19.6	21	16	15.8	16.2	16.5
PI	18	15	18	13	17	15	15	24	22	19	27

Fig 5: Block level impact of fever outbreaks at Theni district in 2011.



	Samaya nallur	Kallent hiri	Thirupa rangunr am	Alanga nallur	Elumala i	Thottap anaikan ur	Thirum angala m Municipality	Melur Municipality	Vadipat i Municipality	Madura i Corpor ation
Fever Outbreak	1	2	4	6	1	1	1	1	1	17
CI	14.4	17.1	16.8	19.9	17.1	15.2	15.9	16.2	15.1	16.5
PI	15	16	19	24	19	21	27	22	22	26

Fig 6: Block level impact of fever outbreaks at Madurai district in 2011



	January	February	March	April	May	June	July	August	September	October	November	December
Madurai	3	1	0	1	1	0	2	0	2	1	3	4
Theni	2	1	1	1	2	2	1	3	2	3	3	2
Dindigul HUD	0	2	1	0	0	0	0	3	1	2	2	1

Fig 7: Month wise Dengue outbreaks in districts on 2011

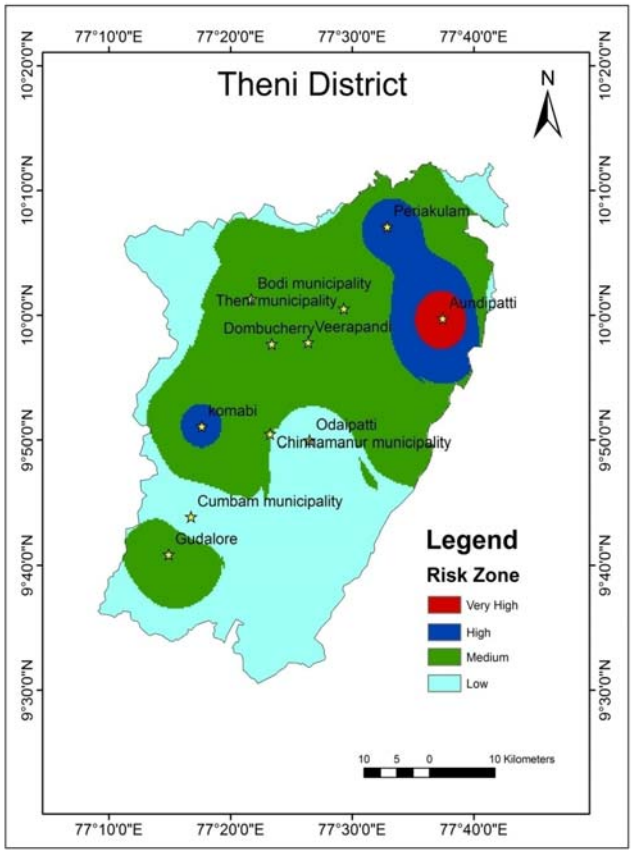


Fig 8: Mapping of Dengue risk zone in Theni district at 2011.

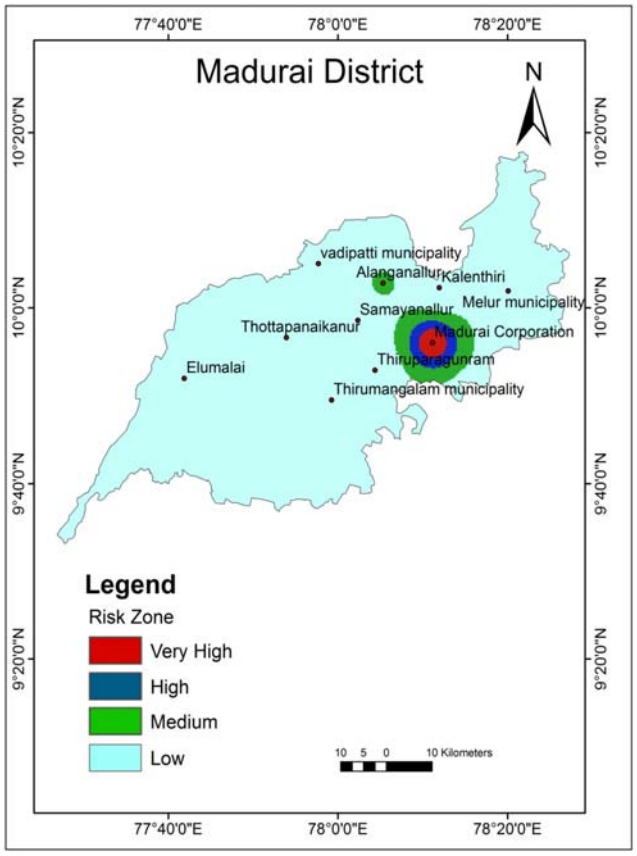


Fig 10: Mapping of Dengue risk zone in Madurai district at 2011.

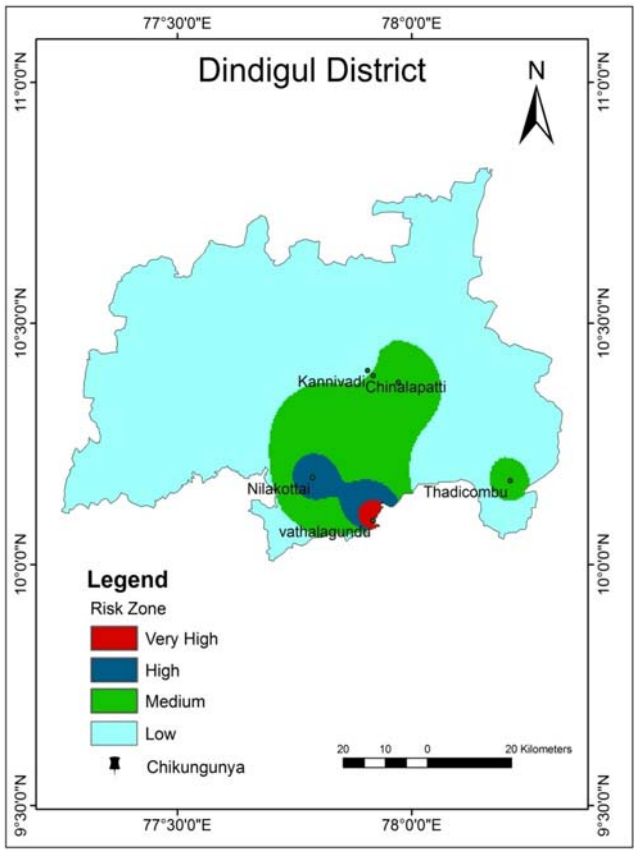


Fig 9: Mapping of Dengue risk zone in Dindigul HUD at 2011.

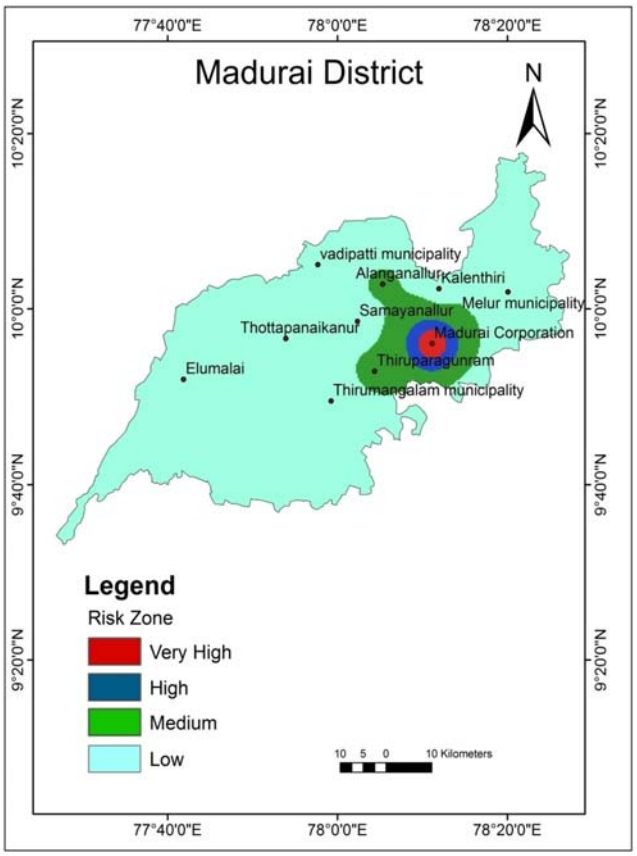


Fig 11: Mapping of Chikungunya risk zone in Madurai district at 2011.

7. Discussion

Dindigul HUD, Madurai and Theni districts are well prone for vector borne diseases and favourable bionomic maintained Dengue and Chikungunya transmission [23]. In Theni district before 2011 Dengue and Leptospirosis mixed outbreak was reported in 2002 and massive Chikungunya outbreak were reported in 2006 and 2010 and 17 Dengue fever outbreaks were recorded in 2010 [24]. In Dindigul HUD a massive Chikungunya outbreak was reported on 2006, seven Dengue fever outbreaks and three Chikungunya outbreaks and also one Dengue death was recorded in 2010. A massive Chikungunya outbreak was recorded at Madurai district on 2006. Previous morbidity data suggests that Dengue and Chikungunya diseases transmission is constantly maintained among the population in all three districts. The seasonal rainfall, temperature, humidity, sanitation, water supply, solid waste removal, thick household population and lack of awareness maintained container and pupal indices throughout the year 2011 and also reported Dengue and Chikungunya outbreaks in Theni district. Moderate rainfall and high water scarcity reduced the breeding habitats and also fever outbreaks in Dindigul HUD during 2011. At Madurai moderate rainfall, infrequent water supply, storage of water, thick household population and lack of awareness increased indices and Dengue and Chikungunya outbreaks during 2011. In this study we noted that schools were the hot spot for Dengue and Chikungunya diseases [25]. Life style also contributed risk of diseases transmission. Almost in all districts people maintained water in well constructed pit taps in their houses [26]. Vathalagundu block has established high intensity of breeding and disease transmission due to water scarcity, poor solid waste removal, thick household population and poor awareness about diseases. High risk of disease transmission contributed more fever outbreaks at Nilakottai block, because of water scarcity and lack of awareness about diseases but in Thadikombu and Dindigul municipality poor solid waste removal was valuable reason for the fever outbreak. Thadikombu reported Chikungunya outbreak during 2011. Dengue mortality reported at Chinnalapatti block with high intensity of breeding and disease transmission and high risk of CI and PI were maintained due to infrequent water supply and pit tapes. In Theni district all municipalities had maintained high intensity of disease transmission due to poor solid waste disposal, indiscriminate water storing practice and poor water sanitation. Andipatti, Periyakulam and Kombai blocks reported more fever outbreaks due to thick household population, poor water sanitation and pit tapes. Cumbam block had maintained high risk of disease transmission, because this block is situated near western Ghat forest and obtaining good rainfall. This rainfall contributed more breeding habitats and Chikungunya outbreak reported during 2011 [27]. More Dengue and Chikungunya outbreaks reported at Madurai Corporation due to thick household population, water scarcity and also urbanization. Thiruparankundram and Alanganallur blocks maintained high intensity of breeding and disease transmission, because of poor solid waste disposal, thick population, tourist spot and lack of awareness about diseases. Sellur, Athikulam and Alanganallur in Madurai Corporation reported significant Chikungunya outbreaks during 2011. All municipalities in Madurai district established high intensity of disease transmission due to urbanization [28]. Moderate density can also transmit Dengue and Chikungunya diseases (r=0.60, 0.64). This study also noted the loss of household properties for treatment of dengue and chikungunya [29]. Each patient had spent total cost INR 40000 for treatment of Dengue and Chikungunya at private hospitals during 2011. This study sought to confirm the co-infection and co-circulation of the Dengue and Chik viruses in Thadikombu at Dindigul HUD, Cumbam at Theni district and Corporation, Thirumangalam, Melur, Thiruparankundram and Alanganallur at Madurai district [30]. Arc GIS tool generated risk places in three districts for future references and early planning to interruption in disease transmission [31]. Quantification of the disease burden in both monetary and human terms is a key tool for health policy-makers. That tool allows them to assess trends over time, to compare dengue and chikungunya against other diseases, and to compare one geographical area with another.

8. Acknowledgements

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9. Conflicts of interest

All authors declare no conflicts of interest.

10. References

1. WHO-Dengue guidelines for diagnosis, treatment, prevention and control, New edition-2009 and a Global Strategy for dengue prevention and control, 2012–2020.
2. Dayaraj Cecilia: Current status of dengue and chikungunya in India, WHO South-East Asia Journal of Public Health, January-March 2014; 3(1):22-27.
3. Summary of the dengue situation in the Western Pacific region Manilla, World Health Organisation Western Pacific Regional Office, 2001, 9.
4. Mid Term Plan, Prevention and control of Dengue and Chikungunya, Directorate of National Vector Borne Diseases Control Programme, Government of India, 2011-2013.
5. Natasha Evelyn Anne, Murray, Mikkel B Quam, Annelies and Wilder-Smith: Epidemiology of dengue: past, present and future prospects, Clinical Epidemiology 2013; (5):299-309.
6. Parasuraman Basker, Subramaniam Sridharan. Study on Entomological Surveillance and its significance during a Dengue outbreak in the District of Tirunelveli in Tamil Nadu, India. Osong Public Health Res Perspect 2013; 4(3):152-158.
7. Annual report of ICMR-Dengue and Chikungunya reports, Government of India, 2012-2013.
8. WHO/TDR: Dengue/Dengue Haemorrhagic Fever, A summary of research and control in South East Asia. New Delhi, WHO-Southeast Asia regional office, 2000.
9. Aileen Y Chang, Maria E Parrales, Javier Jimenez, Magdalena E Sobieszczyk, Scott M Hammer, David J Copenhaver. Combining Google Earth and GIS mapping technologies in a dengue surveillance system for developing countries, International Journal of Health geographic, 2009; 8(49):1-11.
10. Carter JR. Perspectives on sharing data in geographic information systems, *Photogrammetric Engineering and Remote Sensing* 1992; 58(11):1557-1560.
11. Saini S, Anagha G Kinikar, Sachin Deorukhkar, Deepika Bhalerao, Roushani SB. Epidemiology and seropositivity of dengue fever cases in a rural tertiary care hospital of western Maharashtra, India, International Journal of

Biomedical And Advance Research 2013; 4(7):473-477.
12. Dev V, Khound K, Tewari GG. Dengue vectors in urban and suburban Assam, India: entomological observations, WHO South-East Asia Journal of Public Health January-March 2014; 3(1):51-59.
13. John Wilson, Sevarkodiyone SP. Breeding Preference Ratio of Dengue and Chikungunya Vectors in Certain Rural Villages of Virudhunagar District, Tamil Nadu, South India, World Applied Sciences Journal 2014; 30(6):787-791.
14. Prevention and control of dengue and dengue haemorrhagic fever, 29. New Delhi: WHO, SEARO, 1999, 1-134.
15. Update on Chikungunya: October Ministry of Health and Family Welfare, Government of India, 2006.
16. Alex Eapen, John Ravindran K, Dash AP. Breeding potential of *Aedesalbopictus* (Skuse, 1895) in Chikungunya affected areas of Kerala, India, Indian J Med Res 2010; 132(6):733-735.
17. Rajesh K, Dhanasekaran D, Tyagi BK. Survey of container breeding mosquito larvae (Dengue vector) in Tiruchirappalli district, Tamil Nadu, India. Journal of Entomology and Zoology Studies 2013; 1(6):88-91.
18. Kabra SK, Jain Y, Pandey RM, Madhulika Singhal T, Tripathi P, Broor S *et al.* Dengue haemorrhagic fever in children in the 1996 Delhi epidemic. Trans R Soc Trop MedHyg 1999; 93:294-298.
19. Strickman D, Sithiprasasna R, Kittayapong P, Innis BL. Distribution of dengue andJapanese encephalitis among children in rural and suburban Thai villages. Am J Trop Med Hyg 2000; 63:27-35.
20. Krishna Prasad Bandari, Raju PLN, Sokhi BS. Application of GIS modelling for Dengue fever prone area based on socio-cultural and environmental factors-A case study of Delhi city zone, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B8. Beijing, 2008, 165-170.
21. Banarjee S, Aditya G, Saha GK. Household disposables as breeding habitats of dengue vectors: Linking wastes and public health, waste manage. Jan 2013; 33(1):233-9.
22. Keating J. An investigation into the cyclical incidence of dengue fever. Soc Sci. Med 2001; 53:1587-1597.
23. Balaji T, Thenmozhi V, Tyagi BK. A focal outbreak of Dengue in Dindigul district in 2012. Journal of Basic Applied Biology, 2013; 7:1-6.
24. Lalitha Kabilan, Arunachalam N, Paramasivan R, Tewari SC. A insular outbreak of febrile illness due to dengue virus infections in a rural south Indian (Tamil Nadu) village. Centre for Research in Medical Entomology Annual Review Bulletin, 2003, 150-154.
25. Bharathi N, Karthekayen S, Ramakritinan CM. Prevalence and risk factors of dengue vector infestation in schools at Dindigul HUD, Tamil Nadu, India, International Journal of fauna and Biological studies 2015; 2(2):38-42.
26. Thirion J, Hayes J, Seca C, Mendez J, Ramirez B, Robinson J *et al.* Texas lifestyle limits transmission of denguevirus. Emerg Infect Dis 2003; 9:86-89.
27. Katyal R *et al.* Seasonal variations in *Aedesaegypti* population in Delhi, India. Dengue Bulletin 1996; 20:78-81.
28. Muniaraj M, Fading chikungunya fever from India: beginning of the end of another episode, Indian J Med Res 2014; 139:468-470.
29. Donald S Shepard. Cost and burden of Dengue and Chikungunya from the Americas to Asia. Dengue Bulletin 2010; 34:1-5.
30. Pradip V Barde1, Mohan K Shukla1, Praveen K Bharti1, Bhupesh K Kori1, Jayant K Jatav2, Neeru Singh. Co-circulation of dengue virus serotypes with chikungunya virus in Madhya Pradesh, central India, WHO South-East Asia Journal of Public Health, January-March 2014; 31:36-40.
31. Nazri1 CD, Hashim A, Rodziah I, AbuHassan A, Abu Yazid. Utilization of Geoinformation Tools for Dengue Control Management Strategy: A Case Study in Seberang Prai, Penang Malaysia, International Journal of Remote Sensing Applications 2013; 3:11-17.