Original Article

Spatial Mapping the Dengue and Chikungunya Burden in a Rural Area near Bangalore: a Descriptive Cross-Sectional Study

*Ramesh Masthi Nugehally-Raju, Divya Bharathi Gattam

Department of Community Medicine, Kempegowda Institute of Medical Sciences, Rajiv Gandhi University of Health Sciences, Bangalore, India

***Corresponding author:** Dr Ramesh Masthi Nugehally-Raju, E-mail: ramesh.masthi@gmail.com

(Received 25 Apr 2022; accepted 24 Dec 2023)

Abstract

Background: The burden of dengue and chikungunya diseases across geographical regions of India is poorly quantified more so during Covid19 pandemic and from hospital-based studies. The objective was to assess the prevalence of dengue and chikungunya in the study mainly area and to visualize the spatial distribution of dengue and chikungunya cases using the Quantum Geographic Information System (QGIS).

Methods: This descriptive cross-sectional study was conducted among the population in villages coming under a medical college's rural field practice area near Bangalore. A total of 31 villages were selected through a simple random sampling method and 3356 subjects were surveyed through household visits. QGIS was used for spatial mapping of cases.

Results: 3356 subjects were surveyed, and the prevalence of dengue and chikungunya was 1.13% and 0.02%, respectively. The overall prevalence of dengue and chikungunya cases together was 1.16%. All 39 (100%) cases had reported fever and 31 cases (79.5%) reported myalgia followed by arthralgia 22 (56.4%). QGIS supported spatial mapping of the cases and no clustering of cases was found in the study area.

Conclusion: The burden of dengue and chikungunya is under reported, and the surveillance system needs to be strengthened in the rural area. QGIS was found to be useful in the spatial mapping of the cases and there was no clustering of cases observed.

Keywords: Dengue; Chikungunya; Fever survey; Spatial mapping

Introduction

Dengue and chikungunya cause considerable concern because of their widespread endemicity, the minimal success of vector control strategies, the possibility of severe disease, and the consequent social and economic burden (1–4). Globally, the total number of dengue cases increased from 23,283,274 in 1990 to 104, 771,911 in 2017, a fivefold increase (1). In the year 2020, India reported 44,585 cases and 56 deaths due to dengue. Similarly, 43, 424 chikungunya cases were reported in India. Karnataka had recorded 3823 dengue and 16111 chikungunya cases (2–6). Surveillance for dengue and chikungunya in India is conducted through a network of more than 600 sentinel hospitals under the National Vector Borne Disease Control Program (NVBDCP), Integrated Disease Surveillance Program (IDSP), and a network of 52 Virus Research and Diagnostic Laboratories (VRDL) established by Department of Health Research (1). Surveillance is essential for dengue and chikungunya management because it identifies the number and distribution of cases, virus serotypes, and severity of disease in a population. Geographical Information Systems (GIS) allow further investigation of surveillance data through spatial analyses and visualization of patterns and relationships between disease and the environment (7).

http://jad.tums.ac.ir
Published Online: Dec 31, 2023

The burden of dengue and chikungunya disease across geographical regions of India is poorly quantified, complicated by a large number of subclinical infections and most of the information available is from hospital-based studies (1, 8). Estimating the true burden of these diseases remains a challenge (8). There are very few field-based epidemiological studies on dengue and chikungunya disease from rural areas and information from the private sector is usually not forthcoming in disease reporting. The local health authorities reported zero cases of dengue and chikungunya in 2019.

The covid19 pandemic had paralyzed the surveillance and monitoring of diseases and it was presumed that many dengue and chikungunya cases may have been missed. Hence, the current study was taken up to assess the prevalence of dengue and chikungunya in the rural area near Bangalore, to describe the socio-demographic profile and clinical presentation of the cases, and to spatial-map the dengue and chikungunya cases using Quantum Geographical Information System.

Materials and Methods

This descriptive cross-sectional study was conducted in the villages located in the rural field practice area of the medical college during the last quarter of 2020 at Hosabyrohally rural area near Bangalore, Karnataka, India (12.9491042ºN, 77.4503717ºE to 12.8203031ºN, 77.4514123ºE). The total population of the study area was 80,321. Based on the pilot study prevalence, the proportion was 1.8%, 95% CI, and a confidence width of 1%, the sample size was calculated to be 2717. 15 % was considered as non-responders i.e., 408 and the final sample size= 2717+408= 3125 rounded off to 3200. The 62 villages in the study area were line-listed and 31 villages were selected through simple random sampling using a lottery method to cover fifty percent of the villages. The sample size of 3200 was divided equally among the 31 villages that is 3200/31 =103.2 rounded to 104 subjects per village. A simple random sampling technique was followed for the selection of the villages and multi-stage sampling for the selection of households in the village. The center of the village, road, side of the road, direction of survey and the first household to be surveyed were randomly selected. The adjacent household was subsequently surveyed and continued until the required sample size was met (some villages had more than 104 individuals surveyed, and the last household visited had more individuals). Finally, a total of 3356 individuals were surveyed from 720 households. All the members of the household who gave consent to participate in the study were included. Information about dengue and chikungunya disease in the past year was obtained and the medical records were checked for confirmation. While severely ill subjects and cases with no medical records of dengue/chikungunya were excluded.

A free mobile data-gathering platform called Epicollect 5 (version 4.2.0) was used for the collection of data from an adult responsible respondent and entries were geotagged by adding locations (9). GPS coordinates were collected in front of the households using smartphones and spatial mapping was conducted using the quantum geographic information system (QGIS) (10).

The data was analyzed using R studio (version 1.1.463) and R commander statistical packages (11). Shapiro-Wilk test was used to test the normality of data. Frequencies, percentages, and proportions were generated for the different variables, and the Z test was applied. The association between dengue and chikungunya disease and background variables such as gender, education, occupation, religion, type of family, and socioeconomic status was measured using univariate and multivariate logistic regression. Odds ratios, adjusted odds ratios, and confidence intervals were computed. The stand-

http://jad.tums.ac.ir
Published Online: Dec 31, 2023

ard of living Index (SLI) scale was used for socio-economic status classification of cases (12).

Ethical clearance was obtained from the institutional ethics committee ref no.: IEC/d-103/2019. ICMR guidelines for research studies were followed. Signed informed consent from the subjects and confidentiality of data was maintained. The study was conducted during the covid19 pandemic following all Covid Appropriate Behavior.

Results

A total of 3356 subjects were surveyed, 1675 (49.9%) were males and 1681 (50.1%) were females. The median age of the subjects was 30 (Interquartile range: 18, 45). The majority 2924 (87.1%) of the study subjects were Hindus, 21.7% were educated up to High school, 39% were employed, 64.1% of subjects belonged to nuclear families, 80.8% of them were residing in pucca households and 72.8% of households belonged to high socioeconomic status as per SLI.

Prevalence of Dengue and Chikungunya

A total of 108 (3.2%) subjects had a history of febrile illness. The majority 38 (1.13%) [95% CI (0.77–1.49)] were dengue-confirmed cases and only l chikungunya-confirmed case. Overall, the prevalence of confirmed dengue and chikungunya cases together was 39 (1.16%) [95% CI (0.80–1.52)]. 6 (0.18%) of them were diagnosed with COVID-19 and the remaining cases were due to other causes of fever. There was no cross infection among dengue, chikungunya and COVID- 19 cases.

Out of the 38 dengue cases, the majority of cases (44.7%) were in the age group of 20–39 years, followed by 8 (21.1%) cases in the age group of 40–59 and least 2 (5.3%) was observed in the age group ≤5 years as depicted in Table 1. The youngest case was 2 years old and the oldest was 70 years. The median age was 28 years (Interquartile range: 19.5,40). 27 (71%) cases were males and 11 (29%) were females.

The proportion of dengue cases reported was 1.61% and 0.6% in males and females respectively (Z= 2.6215, P= 0.0088). 10 (26.3%) cases were educated up to high school followed by 8 (21.1%) primary school and at least 2 (5.1%) were preschool children. 7 (18.4%) each were semi-skilled workers and homemakers. Maximum 29 (76.3%) cases were Hindus followed by 8 (21.1%) Muslims and at least 1 (2.6%) Christian. 15 (39.5%) cases belonged to nuclear family and 14 (36.8%) belonged to joint family. 30 (78.9%) belonged to high SLI and 8 (21.1%) belonged to medium SLI. 35 (92.1%) resided in pucca households and 3 (7.9%) in semi-pucca households. A maximum of 29 (1.51%) cases sourced their water from public sources and 9 (0.5%) from private sources (Z= 2.8106, p= 0.0049).

All 38 (100%) dengue cases had reported fever, 31 (81.6%) had myalgia, followed by 21 (55.3%) arthralgia, 19 (50.0%) headache, 10 (26.3%) retro-orbital pain and 5 (13.2%) photophobia. There were no cases of hemorrhagic manifestations. The majority of 26 (68.5%) dengue cases were treated on an outpatient basis, 19 (70.4%) at private healthcare facilities and 7 (63.7%) at Government health facilities (Z= 3.6707, p= 0.0002). 12 (31.5%) cases required admission for treatment, 4 (36.3%) cases were admitted to a Government health facility, and 8 (29.6%) cases in private health care facility.

There was only 1 confirmed case of chikungunya reported. The case was a 30-year-old female, educated up to high school, Hindu by religion, nuclear family, and belonging to medium SLI. The symptoms observed were fever, severe joint pain, and headache. The case was treated at a Government health facility as an in-patient.

By univariate logistic regression analysis, gender and water source were found to be statistically significant as depicted in Table 2. Finally, to assess the overall effect of variables on dengue and chikungunya status, the Binominal Logistic Regression Model was

http://jad.tums.ac.ir
Published Online: Dec 31, 2023

applied [Akaike Information Criterion (AIC)-416.56]. It was observed that the risk of dengue and chikungunya was found to be significantly associated with gender [AOR= 2.2, 95% CI (1.1–4.5)] and use of public water source [AOR= 2.8, 95% CI (1.3–5.9)].

GPS and QGIS were used to spatial map dengue and chikungunya cases in the study area as described in Fig. 1. The red dots indicate dengue cases and the blue dot represents the chikungunya cases. It was observed that dengue and chikungunya cases were uniformly distributed across the study area and no clustering of cases in one area.

Table 1. Age and sex-wise distribution of dengue cases (n=38), Bangalore district of India, 2020

Age (in years)	Male	Female	Total
1–4	2 (07.4)	-	2 (5.3)
5–9	4 (14.8)	-	4 (10.5)
10–19	2 (07.4)	2 (18.2)	4 (10.5)
20–39	10 (37.0)	7 (63.6)	17 (44.7)
40–59	6 (22.3)	2 (18.2)	8 (21.1)
≥ 60	3 (11.1)	-	3 (7.9)
Total	**27 (100.0)**	**11 (100.0)**	**38 (100.0)**

(Figures in parenthesis indicate percentages)

Table 2. Univariate analysis of dengue/chikungunya cases and sociodemographic characteristic (n=3356), Bangalore district of India, 2020

Variable		Dengue		Odds Ratio 95% CI	P value
		No	Yes		
Age	**> 20 years**	2418 (72.9)	29 (74.4)	1.0 [0.5–2.2]	0.8
	Children/ adolescent	899 (27.1)	10 (25.6)	-	-
Gender	**Female**	1669 (50.3)	12 (30.8)	-	-
	Male	1648 (49.7)	27 (69.2)	2.2 [1.1–4.5]	0.01
Education	**Middle/ High School**	1631 (49.2)	14 (35.9)	0.1[0.05–0.65]	0.07
	Children/ Primary School	699 (21.1)	10 (25.6)	0.3 [0.08–1.1]	0.05
	Illiterate	64 (1.9)	3 (7.7)	-	-
Religion	**Hindu**	2894 (87.2)	30 (76.9)	0.4 [0.2–1.0]	0.06
	Muslim/ Christian	423 (12.8)	9 (23.1)	-	
Type of family	**Nuclear**	2131 (64.2)	16 (41.0)	0.5 [0.2–1.2]	0.1
	Joint	630 (19.0)	14 (35.9)	1.6 [0.6–3.9]	0.2
	3 Generation	556 (16.8)	9 (23.1)	-	-
SES	**High**	2565 (77.3)	30 (76.9)	0.9 [0.4–2.0]	0.8
	Medium/Low	752 (22.7)	9 (23.1)	-	-
Type of household	**Pucca**	2675 (80.6)	36 (92.3)	2.8 [0.8–9.3]	0.07
	Kaccha/Semi-Pucca	642 (19.4)	3 (7.7)	-	-
Type of roof	**Cement roof**	2376 (71.6)	28 (71.8)	1.0 [0.5–2.0]	0.9
	Thatch/Sheet roof	941 (28.4)	11 (28.2)	-	-
Type of wall	**Brick with cement**	3170 (95.5)	38 (97.4)	1.7 [0.2–12.9]	0.5
	Brick with mud	147 (4.5)	1 (2.6)	-	-
Water source	**Private**	1513 (45.6)	9 (23.1)	-	-
	Public	1804 (54.4)	30 (76.9)	2.8 [1.3–5.9]	0.007

(Figures in parenthesis indicate percentages)

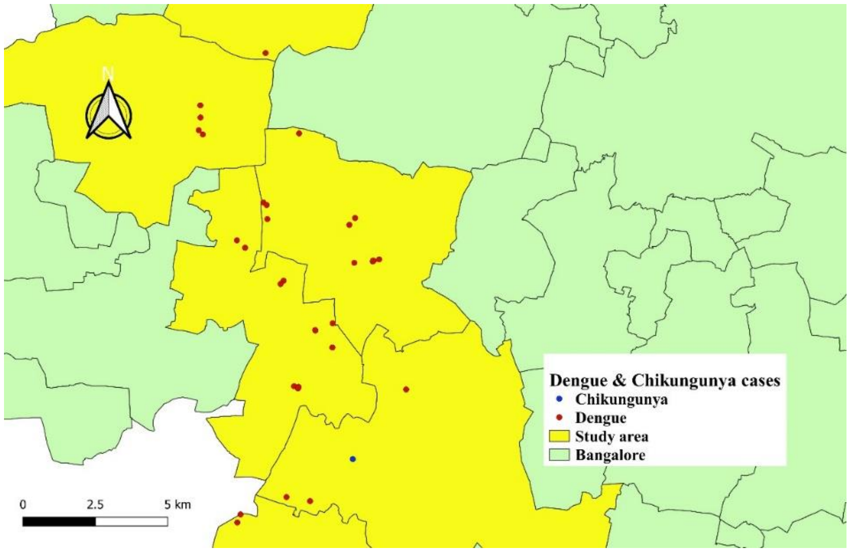

Fig. 1. Spatial distribution of dengue and chikungunya cases in the study area.

(The yellow shaded area is the study area as depicted in the map.)

Discussion

As per the National Vector Borne Disease Control Program (NVBDCP) estimates, dengue prevalence was estimated to be 0.2% and another researcher had reported 1.8% in Delhi which is lower and higher than the present study findings (13, 14). The prevalence of dengue was estimated to be 9.4% in Sudan and 9.5% in Tanzania higher than observed in the present study (15, 16). These differences in reporting of cases could be explained due to different study settings, different study periods, and differences in sampling techniques and may be due to covid 19 pandemic. Only confirmed dengue cases were surveyed in the current study and asymptomatic cases may have been missed and may not have got tested due to covid 19. Pandemic-associated lockdowns could have influenced the number of cases reported because of a reduction in the movement of people and the non-availability of regular healthcare services. However, the local health authorities reported only 3 cases during the same period indicating under-reporting of cases.

Chajhlana SPS et al. (17) and Dutta et al. (18) had shown that more males were affected similar to the findings of the present study. In a study conducted by Balasubramaniam et al. (19), fever was the most common symptom observed similar to the present study. The majority (85%) of cases belonged to the Hindu religion by Fayaz Ahammad et al. (20) similar to the present study. Mishra et al. (21) observed 68.3 % belonged to the nuclear family is in discordance with the present study. In a systematic review by Mulligan et al. (22) nine of the 12 studies showed dengue is associated with low socioeconomic status. This is in discordance with the present study findings and could be due to the different scales used to capture socioeconomic status. Dengue outbreak has been linked with household structure. A multicentric study by Garga et al. (23), suggested associations with household water storage/supply and type of housing with dengue, and Schimidt et al. (24) in Vietnam reported that households with no tap water had a peak in dengue fever rates similar to findings of the present study.

Lack of a reliable water source in the immediate vicinity of a household requires storing of water for convenience and in anticipa-

http://jad.tums.ac.ir
Published Online: Dec 31, 2023

tion of shortages, providing breeding sites for mosquitoes. The most common clinical symptoms reported were fever (99.1% to 100%), myalgia (65–70%), headache (55.5%), nausea (39.1 %), skin rash (53.6%), mucocutaneous hemorrhagic manifestations (58.2%), and ocular pain (20%) in some other studies, similar to the finding of the present study (25–28). However, studies from other parts of India had clinical presentations that were different (19, 29). 77.7% of the affected persons sought treatment from private clinics and 18.4% took treatment from the Government health setup (30). The cases preferred visiting the private health care provider and these cases are not reported to the local government health care provider.

Chikungunya prevalence was reported to be between 4.2–7.5% in Tanzania (31, 16). The low prevalence in the present study could be attributed to small sample size, geographical location, less awareness about the disease, asymptomatic, atypical presentation, diagnostic tests not being sensitive enough to pick up the disease, and disease actually having a low prevalence.

Spatial analysis is vital in mapping the spread of various diseases and assists in policy making, especially in the era of the COVID-19 pandemic. The spatial variations through QGIS was shown in temporal trends of dengue incidences in Tamil Nadu (32). Animal bites were mapped through GPS and google earth (33). A GIS-based malaria information system was used in South Africa for appropriate malaria control measures (34). QGIS, GIS, and other software have been used for mapping, forecasting, and disease prevention and control measures. QGIS mapping of dengue and chikungunya by the health authorities will help to identify gaps and plan for appropriate prevention and control strategies. Limitations – Recall and Information bias about fever episodes, dengue, and chikungunya disease by the subjects or cases. The survey was conducted during the COVID-19 pandemic, and the results obtained may or may not be the true estimate.

Conclusion

The prevalence of Dengue and Chikungunya was found to be 1.1% [95% CI (0.77–149)] and 0.02% [95% CI (0.00–0.09)] respectively. The burden of dengue and chikungunya is underreported, and the surveillance system needs to be strengthened in the rural area. Behavioral change and communication (BCC) strategies by the concerned authorities to increase awareness regarding Dengue and Chikungunya for prevention and control of the disease. QGIS can be used to spatial map the cases, identify clusters, and microplanning of control measures.

Acknowledgements

The authors would like to thank all study participants, and field workers for their support in the conduct of the study.

Conflict of interest statement

The authors declare there is no conflict of interests.

References

1. Ganeshkumar P, Murhekar MV, Poornima V, Saravanakumar V, Sukumaran K, Anandaselvasankar A, John D, Mehendale SM (2018) Dengue infection in India: A systematic review and meta-analysis. PLoS Negl Trop Dis. 12(7): e0006618.
2. World Health Organization (2021) Chikungunya fact sheet. 2021 [Internet]; [cited 2022 Jan 6]. Available at: https://www.who.int/news-room/fact-sheets/detail/chikungunya
3. World Health Organization (2022) Dengue and severe dengue. 2022 [Internet]; [cited 2022 Jan 6]. Available at:

https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue.
4. Agrupis KA, Ylade M, Aldaba J, Lopez AL, Deen J (2019) Trends in dengue research in the Philippines: A systematic review. PLoS Negl Trop Dis. 13(4): e0007280.
5. Puntasecca CJ, King CH, LaBeaud AD (2021) Measuring the global burden of chikungunya and Zika viruses: A systematic review. PLoS Negl Trop Dis. 15(3): e0009055.
6. National Center for Vector Borne Diseases Control (NCVBDC) (2021) Chikungunya Situation In India (2021). Available at: https://nvbdcp.gov.in/index4.php?lang=1andlevel=0andlinkid=486andlid=3765. (access 06 Jan 2022)
7. Duncombe J, Clements A, Hu W, Weinstein P, Ritchie S, Espino FE (2012) Review: Geographical information systems for dengue surveillance. Am J Trop Med Hyg. 86(5): 753–755.
8. Fritzell C, Rousset D, Adde A, Kazanji M, Van Kerkhove MD, Flamand C (2018) Current challenges and implications for dengue, chikungunya and Zika seroprevalence studies worldwide: A scoping review. PLoS Negl Trop Dis. 12(7): e0006533.
9. Aanensen DM, Huntley DM, Menegazzo M, Powell ChI, Spratt BG (2014) EpiCollect+: linking smartphones to web applications for complex data collection projects. F 1000Res. 3: 199.
10. QGIS Development Team (2021) QGIS Geographic Information System. Open Source Geospatial Foundation Project. [Internet]; [cited 2022 Jan 6]. Available at: http://qgis.osgeo.org
11. R Core Team (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [Internet]; [cited 2022 Jan 6]. Available at: https://www.R-project.org/.
12. Ministry of Health and Family Welfare. National Family Health Survey (2021) Background characteristics of households and villages (2021). New Delhi Government of India. Available at: http://rchiips.org/nfhs/data/bh/bhchap2.pdf. (access 06 Jan 2022)
13. National Center for Vector Borne Diseases Control (2015) Dengue/DHF Situation in India (2015). Available at: https://nvbdcp.gov.in/index4.php?lang=1 andlevel=0 and linkid=431andlid=3715. (access 06 Jan 2022)
14. Vikram K, Nagpal BN, Pande V, Srivastava A, Saxena R, Anvikar A, Das A, Singh H, Anushrita, Gupt SK, Tuli NR, Telle O, Yadav NK, Valecha N, Paul R (2016) An epidemiological study of dengue in Delhi, India. Acta Trop. 153: 21–27.
15. Soghaier MA, Himatt S, Osman KE, Okoued SI, Seidahmed OE, Beatty ME, Elmusharaf K, Khogali J, Shingrai NH, Elmangory MM (2015) Cross-sectional community-based study of the socio-demographic factors associated with the prevalence of dengue in the eastern part of Sudan in 2011. BMC Public Health. 15(558): 1–6.
16. Hertz J, Munishi OM, Ooi EE, Howe S, Lim WY, Chow A, Morrissey AB, Bartlett JA, Onyango JJ, Maro VP, Kinabo GD, Saganda W, Gubler DJ, Crump JA (2012) Chikungunya and dengue fever among hospitalized febrile patients in northern Tanzania. Am J Trop Med Hyg. 86(1): 171–177.
17. Chajhlana SPS, Mahabhasyam RN, Varaprasada MSM, Anukolu RSR (2017) Socio demographic and clinical profile of dengue fever cases at a tertiary care hospital, Hyderabad, Telangana. Int J Community Med Public Health. 4: 2027–2030.
18. Dutta P, Khan SA, Phukan AC, Hazarika S, Hazarika NK, Chetry S, Khan AM, Kaur H (2019) Surveillance of Chikungunya virus activity in some North-eastern states of India. Asian Pac J Trop Med. 12: 19–25.
19. Balasubramaniam SM, Krishnakumar J, Ste-

phen T, Gaur R, Appavoo NC (2011) Prevalence of Chikungunya in urban field practice area of a private medical college, Chennai. Indian J Community Med. 36: 124–127.
20. Fayaz-Ahammad S, Manohar B, Mahaboob Basha S, Durga Prasad TS, Rubeena Begum Hakeem, Sripraharshita G (2016) Clinico-demographic profile of dengue fever in a south indian tertiary care teaching hospital. World journal of pharmacy and pharmaceutical sciences. 5(1): 1603–1609.
21. Mishra S, Agrahari, Shah DK (2017) Intervention and effect of coconut water on Dengue Patients. Int J Innov Res Adv Stud. 4(1): 34–37.
22. Mulligan K, Dixon J, Sinn CL, Elliott SJ (2015) Is dengue a disease of poverty? A systematic review. Pathog Glob Health. 109(1): 10–18.
23. Garg S, Chakravarti A, Singh R, Masthi NR, Goyal RC, Jammy GR, Ganguly E, Sharma N, Singh MM, Ferreira G, Moureau A, Ojha S, Nealon J (2017) Dengue serotype-specific seroprevalence among 5 to 10 year old children in India: a community-based cross-sectional study. Int J Infect Dis. 54: 25–30.
24. Schmidt WP, Suzuki M, Thiem VD, White RG, Tsuzuki A, Yoshida LM, Yanai H, Haque U, Tho le H, Anh DD, Ariyoshi K (2011) Population density, water supply, and the risk of dengue fever in Vietnam: cohort study and spatial analysis. PLoS Med. 8(8): e1001082.
25. Ashraf S (2021) Retrospective Study of Fatal Dengue Hemorrhagic Fever in Lahore City. Texila Int J Public Heal. 4(4): 686–705.
26. Rajendran G, Amalraj D, Das LK, Ravi R, Das PK (2006) Epidemiological and entomological investigation of dengue fever in Sulurpet, Andhra Pradesh, India. Dengue Bull. 30: 93–98.
27. Kumar A, Rao CR, Pandit V, Shetty S, Bammigatti C, Samarasinghe CM (2010) Clinical manifestations and trend of dengue cases admitted in a tertiary care hospital, udupi District, karnataka. Indian J Community Med. 35(3): 386–390.
28. Itoda I, Masuda G, Suganuma A, Imamura A, Ajisawa A, Yamada K, Yabe S, Takasaki T, Kurane I, Totsuka K, Negishi M (2006) Clinical features of 62 imported cases of dengue fever in Japan. Am J Trop Med Hyg. 75(3): 470–474.
29. Abrol A, Dewan A, Agarwal N, Galhotra A, Goel NK, Swami HM (2006) A Clinico-Epidemiological Profile of Dengue Fever Cases in a Peri-Urban Area of Chandigarh. Internet J Epidemiol. 5(1): 1–5.
30. Kumar H, Mansoor SM (2015) A Study of Clinico-Demographic Profile of Dengue Cases in A Teaching Hospital. Natl J Lab Med. 4(3): 1–5.
31. Kajeguka DC, Kaaya RD, Mwakalinga S, Ndossi R, Ndaro A, Chilongola JO, Mosha FW, Schiøler KL, Kavishe RA, Alifrangis M (2016) Prevalence of dengue and chikungunya virus infections in north-eastern Tanzania: a cross sectional study among participants presenting with malaria-like symptoms. BMC Infect Dis. 16 (183): 1–9.
32. Jaisankar R, Kesavan J (2019) A study on spatial variations in temporal trends of dengue incidences in Tamil Nadu, India. Int J Sci Technol Res. 8(9): 788–792.
33. Masthi NRR, Vairavasolai P (2016) Estimation of animal bites using GPS and google earth in an urban low income area of Bengaluru, South India. APCRI Journal. 17(2): 1–5.
34. Martin C, Curtis B, Fraser C, Sharp B (2002) The use of a GIS-based malaria information system for malaria research and control in South Africa. Health Place. 8 (4): 227–236.