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A geo-spatial cluster analysis of dengue vector epidemiology and a quantitative assessment of disease risk vulnerabilities – A case study in Royapuram, Chennai City (2018, 2019)

Beulah Evelyn Lazarus
Ph.D. Researcher with University of Madras
Email: beulah.evelyn.lazarus@gmail.com

S. Sanjeevi Prasad
Assistant. Professor in Geography from University of Madras
Email: sanjeevi.geo.unom@gmail.com

Magesh A
Ph.D Reseacher with University of Madras
Email: Magesha28@gmail.com

Shyam Sundhar.V
University of Madras
Email: shyamsundhar35@gmail.com

Indhiya Selvan.V.N
University of Madras
Email: indhiyaselvan.is@gmail.com

***Abstract*---**In India, dengue cases are rapidly increasing year by year. This study examined the spatial distribution of dengue through the hotspot analysis in Royapuram, Chennai city, India, during 2018 - 2019. This study result indicated that the number of dengue cases infected higher among males than in female's population and the more infected age group was between (15-64) adult population and most of the dengue cases were recorded in this age groups it based on this classification age group is more in number of populations. Spatial distribution of dengue cases was significantly identified the dengue hotspot in Royapuram, Chennai. Hotspot analysis of Dengue epidemiological incidences helped in identification the core vulnerability areas of disease risks. The study also analyzed the external environmental variables like rainfall and mosquito menace strongly determine the dengue cases in the year of 2018 – 2019. It

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***Corresponding author**: Lazarus, B.E.; Email: beulah.evelyn.lazarus@gmail.com*
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was found that there was no positive correlation with of environmental variables on dengue cases. In this study were concluded spatial-temporal analysis hotspot and cold spot were detected using the geospatial technology

***Keywords*---**Dengue cluster-analysis, Geo-spatial analysis, Public health, GIS for health, Hotspot Analysis.

Introduction

Dengue is a Vector-borne viral infection causing severe flu-like illness and sometimes causing a potentially lethal complication called severe dengue (WHO). Dengue outbreaks are occurring in many countries of the world. The incidence of dengue has increased 30-fold over the last 50 years. Up to 50 – 100 million infections are now estimated to occur annually in over 100 endemic countries, putting almost half of the world population at risk (WHO). In India has confirmed dengue cases with cases reported from across the country. Dengue is endemic in India. Transmission occurs year-round in southern areas and from April through November in Northern states (IAMAT2020). Dengue fever is rapidly emerging in India and is now present in both urban and rural areas. The epidemiology of dengue fever in the Indian subcontinent has been very complex and has substantially changed over almost past six decades in terms of prevalent strains, affected geographical locations and severity of the disease (Nivedita gupta et al (2012). Dengue has been widespread in parts of Tamil Nadu in the past two decades. The prevalence of dengue vector and silent circulation of dengue viruses has been detected in rural and urban Tamil Nadu, which is ever-increasing (P.Gunasekaran et al (2011)). Dengue fever is a mosquito-borne disease that mostly happens in tropical and subtropical areas.

The study uses Hotspot analysis, a spatial analysis and mapping technique that geo-statically identifies clustering of spatial phenomena. The spatial phenomena are a depicted as a point in a map and refer to locations of event or objects. Hotspot detection evolved from the study of point distributions or spatial arrangement of points in a space (Chakravorty, 1995). Getis–Ord Gi* statistics identifies different spatial clustering patterns like hotspot, high risk and cold spots over the entire study area with statistical significance (Osei and Duker, 2008; Getis and Ord, 1992). The result expresses the Z – score and p – value of the calculated Gi*, in comparison with the normal distribution of the statistics calculated by simulation (Feser et al., 2005). In before the Getis-Ord-Gi* statistical analysis of incremental spatial auto correlation was analyzed the point distribution. These values represent the statistical significance of the spatial clustering of values, given the conceptualization of spatial relationships and the scale of analysis (distance parameter).The result of the Getis-Ord-Gi* indicates the low values are considered as a cold spot and high values of Z score refer the high hotspot spatial features. For the hotspot analysis, the spatial relationship is fixed distance with a defined threshold limit or distance band. The distance band which exhibits the highest spatial auto correlation (peak z value) is taken for analysis. With fixed distance band option, a moving window conceptual model of spatial interaction is imposed onto the data were each feature is analyzed within

the context of those neighboring features within the specified distance band (bhunia et al., 2013; saxena et al., 2012). This hotspot study provides exact identification and spatial location of hot and cold spots of dengue cases. The statistical significant pvalue indicates spatial clustering $p<0.01$.

Study area

The Royapuram zone of Chennai City, Tamil Nadu India was selected for the study. The location which is densely populated also have many slums, open-water bodies, stagnant water zones. The location is more vulnerable to dengue than rest of the city. Royapuram zone is a Locality in Chennai city in Tamil Nadu State, India. Royapuram zones geographically lies between 13° 6′ 26″ of the northern latitude and 80° 17′ 43″ of the Eastern longitude. Royapuram is a locality in the northern part of Chennai city. Its covers about an area of 42.33 Sq.km. Chennai zone 5 comprises Royapuram, George Town, Mannadi, Sowcarpet and areas adjoining the government General Hospitals and Chennai Central Station. In this zone there are 1427 roads, out of which 1,370 roads to a length of 220.38 Km are interior Roads, 57 Roads to a length of 37.98 Km are Bus Route Roads which are maintained by GCC. The population is about 6.34 Lakhs that has male population of 50.84% and female population of 49.16%. The most crowded area in the zone is Madhuravoil with a population of 47,537 and the least is Porur with a population of 34,595. Buckingham canal is the only canal which touches the zone in Moolakotharam canal road that travels about 2.75Km and leaves at George Town to zone 9 (Teynampet).

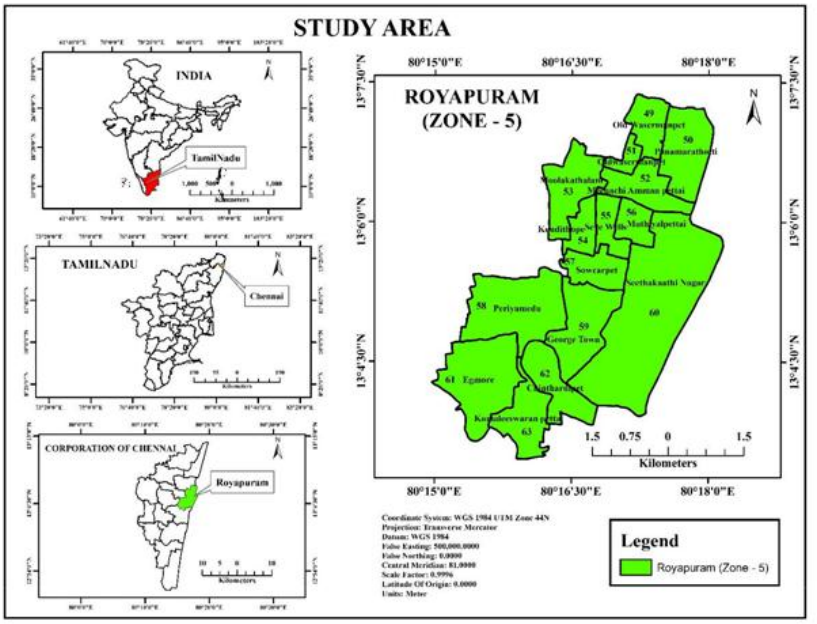

Figure 1. Study Area Map (Royapuram, Chennai)

Aim

The aim of the present study is to analysis the spatial temporal distribution and hotspot detection of dengue cases for study area during the period of 2018 – 2019.

Objective

The objectives of the study analysis are:

- To analyze and prepare the spatial distribution of dengue cases maps during the year of 2018 – 2019.
- To analyze the socio-demographic (Age and Gender) disease vulnerability of Dengue Incidences for the year 2018, 2019.
- To determine the relationship between dengue cases and Rainfall during the year of 2018 – 2019.
- To analyze the strength of association between dengue cases and Mosquito menace during the year of 2018 – 2019.
- To analysis the streetwise distribution of dengue cases.
- To detect the identification of hotspot location for dengue cases.

Materials and Methods

The boundary map of Royapuram was prepared and digitizing in ArcGis 10.3 software in the scale of 1:50,000. The location map (fig) dengue cases was also digitized and entomological data was attached with is dengue location point map. Also, this software used for analyze the spatio-temporal distribution of dengue cases classifies based on quantities natural break analysis. The rainfall of the study area was mapped by IDW interpolation technique. The population map was generated for the same process of the spatial distribution of analysis map. The dengue cases in relation to prevailing variables such Rainfall (mm), Mosquito menace (No of complaints) was calculated on monthly basis by using Pearson's correlation method. The data was analyzed using SPSS 25 IBM statistical software. Street wise distribution of the dengue map was prepared and the infected streets were extracted from the arc GIs software. The Getis-Ord-Gi* statistical analysis were done by using the spatial statistical tools in the Arc GIs. It was used to analyze the hotpot detection of dengue cases clustering area in Royapuram. The GIS applications were used assesses to this present study.

The daily dengue incidence data was acquired from the Chennai Corporation (vector control department). This data include information all suspected and confirmed DH/DHF diseases reported during the years of 2018 – 2019 in the Royapuram. It provided each patient's age, gender, home address, and the date of diagnosis confirmed cases in hospitals/institution. The monthly mosquito menace data was also collected from the Chennai Corporation (vector control department). It contains the information of no of complaints in month wise (2018 – 2019). Apart from Disease and Vector datasets, Rainfall data, Census Data and Municipal Administrative datasets were also used for the study. Daily Rainfall (mm) for the years 2018 – 2019 was obtained from State Ground and Surface Water Resource Data Centre in Taramani. The Royapuram (Zone-5) ward wise total population data was collected from the census data of India. The ward wise

name of the street data was retrieved from the Chennai corporation website. This data consists of the name of the streets in entire Chennai corporation zones. The Royapuram zone street vector shape file was retrieved from open street map (OSM) website.

Spatial distribution mapping was performed on the datasets. Location Modeling (R.L. Church, 1999) over large regions using GIS applications was performed. All dengue patients home address was recorded with the Google earth pro, geo referencing aerial photograph were used to improve the identification and the location. The geographic coordinated were integrated into a GIS (ArcGIS 10.3) with the information about the patients identification number, date of onset symptoms, age, gender, and diagnosis details. Getis-Ord Gi* geo-statistic (Hasan Muhsan Khormi and Lalit Kumar, 2011) was used to model and visualize the hot spots and the risk models.

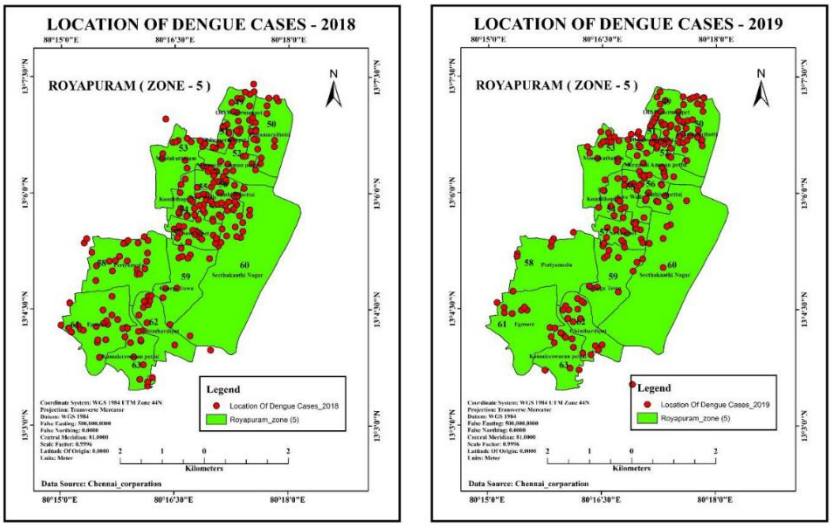

Figure 2. Location of Dengue Vector Epidemiology

Analysis of the spatial distribution of dengue was mapped at 1:45,000 scale ward wise by using a GIS technique in ArcGIS 10.3 Software. GIS is one of the important tool to analysis the spatial distribution of health issues. The spatial distribution map was classified based on the quantities analysis of the natural breaks in GIS (Momi Das, Reji Gopalakrishnan, 2011).

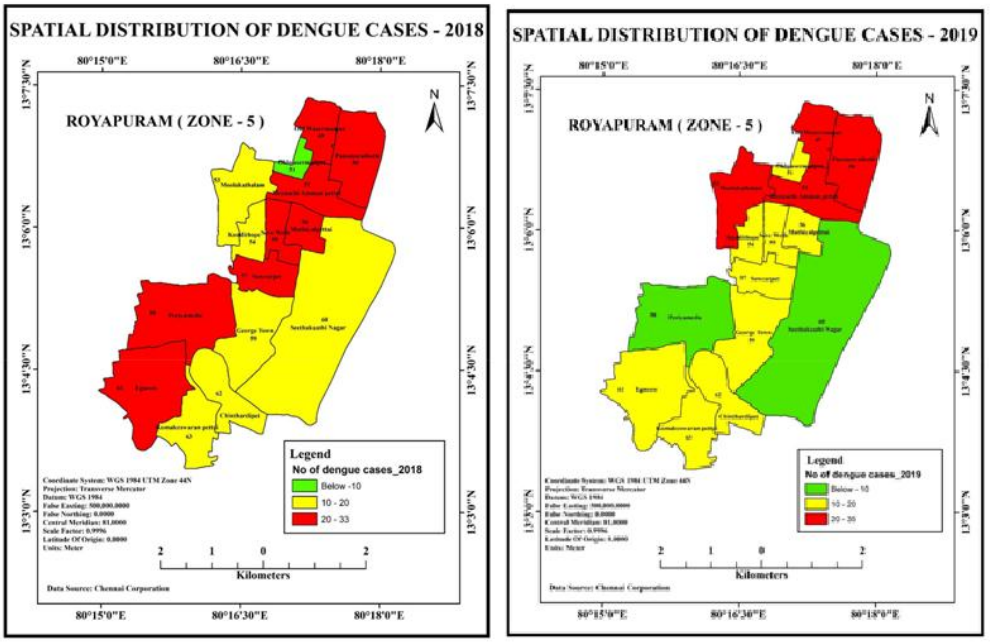

Figure 3. Spatial Distribution (Class-Interval) of Dengue Vector Epidemiology

The socio-demographic analysis revealed that men were at a higher risk on dengue disease vulnerability than the female residents in the study area. Adult population between the age group 14 years to 64 years had more disease incidences than children and senior residents.

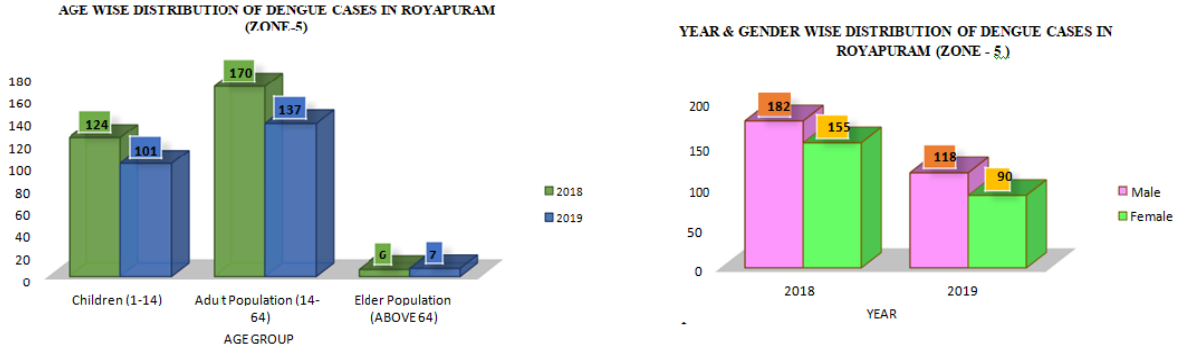

Figure 4. Socio-Demographic (Age/Gender) Distribution of Incidences

The rainfall data from (2018 – 2019) was retrieved from state ground and surface water resources data centre. The total annual rainfall was used to generate spatial rainfall pattern in ARCGIS by IDW method of interpolation. The rainfall map was further classified into three classes based upon dengue risk level. The spatio-temporal pattern of Dengue incidences and the rainfall variability was

mapped using GIS and spatial statistics for elaborating a dengue fever surveillance strategy (Annelise Tran, Xavier Deparis, Philippe Dussart, Jacques Morvan, Patrick Rabarison, Franck Remy, Laurent Polidori, and Jacques Gardon, 2011).

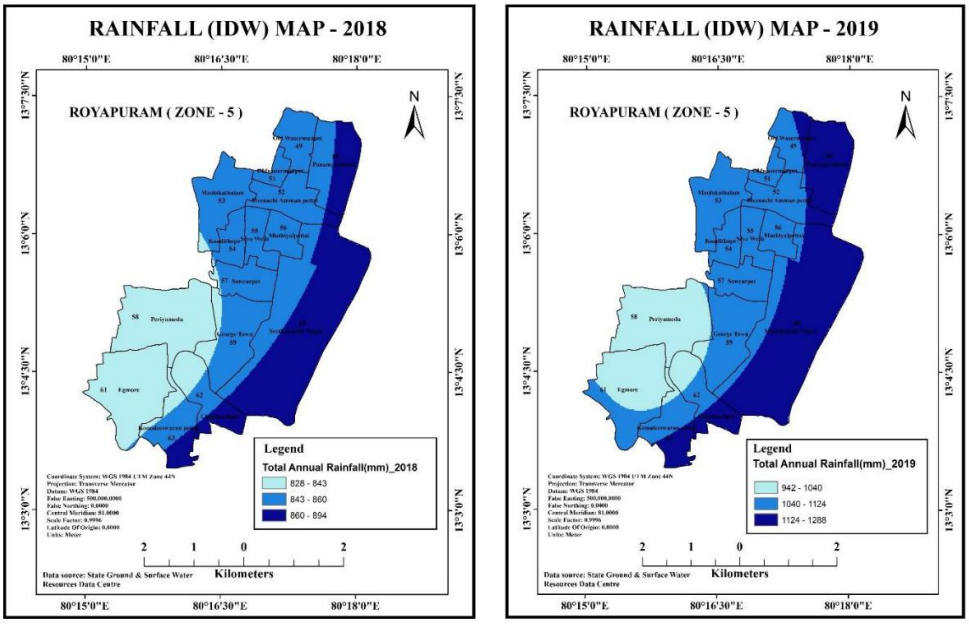

Figure 5. Rainfall Variability of (Royapuram, Chennai)

The Royapuram street shape file was extracted from the Opens street map website, the spatial polyline feature datasets. The counts number of the indigenous dengue cases was aggregated to counts at the street – level. The location of all cases was matched to the street – level vector map based on their home address. This was performed to assess the spatial density of Ades Mosquito distribution in the most vulnerable streets of the study area (S Aziz, R M Aidil, M N Nisfariza, R Ngui, Y A L Lim, W S Wan Yusoff, R Ruslan, 2014).

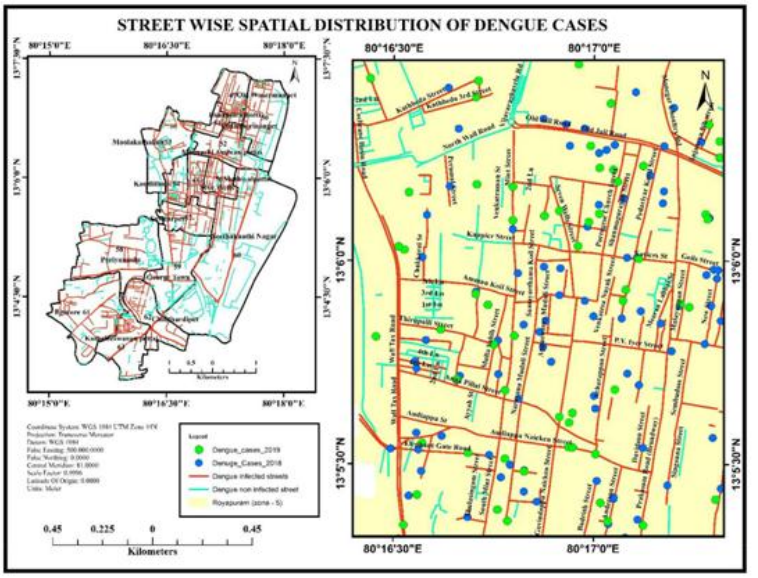

Figure 6. Street-Wise Spatial Distribution of Dengue Vector Epidemiology

Results and Discussions

The location with high and low cluster of dengue cases abundance were identified with the Z score assessed or calculated by Getis-Ord-Gi (Hasan Muhsan Khormi and Lalit Kumar, 2011). The spatial clustering of dengue cases 2018 and 2019(fig). The dark read and light red color indicate hotspots of dengue cases (Z score Getis –Ord >2.58 statistically significant. The blue and light blue color represents cold hotspot areas in this study area (Z score Getis –Ord <-2.58 statistically significant. In Royapuram (zone – 5), six hotspot ward in 2019 [Moolakathalam (99% confidenence; $p<0.01$), Kondithope and Old Wasermanpet (95%confidence), Seven-wells, Meenachi Amman pettai and Panamarathotti (90%confidence)] were identified. In 2018 there were five hotspot was detected this analysis. Chinthadirpet, Egmore, Meenachi amman pettai, George Town and Muthiyalpettai (99%confindence), Seven-wells and Oldwasermanpet (95% confidence level). Surrounding neighbors' areas of Chinthadirpet and Egmore (90% confidence of dengue hotspot). It is important to note that the standard deviations are very high hotspot wards as they have different rates of dengue cases.

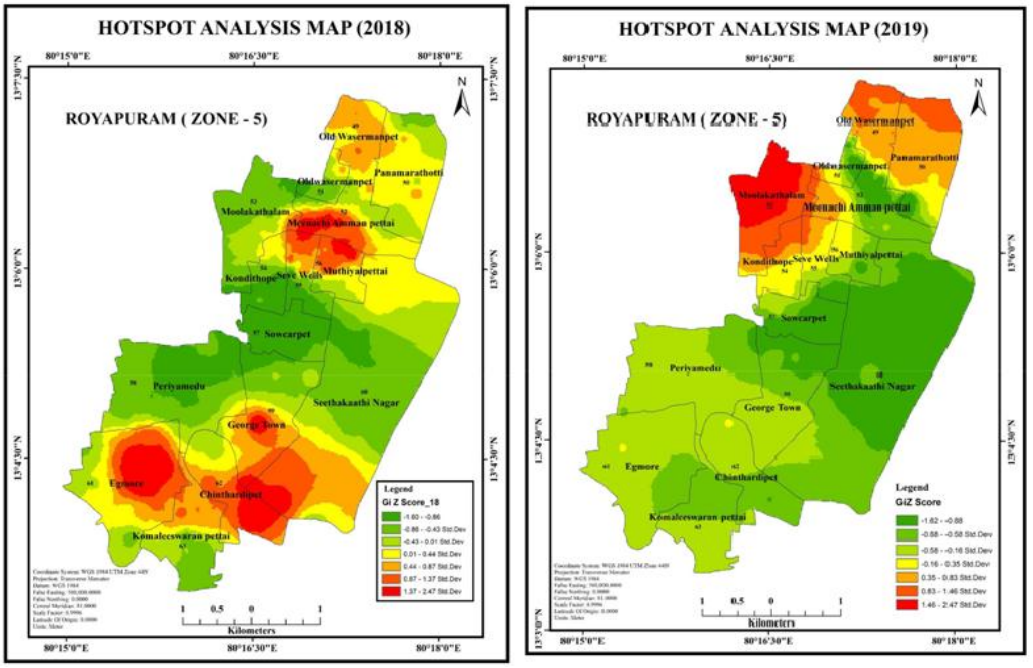

Figure 7. Hot-Spot Clusters of Dengue Vector Epidemiology

Based on number of total dengue cases all wards (n=15) were grouped in three categories (table) Low endemic areas with dengue cases between 0 – 10, Medium endemic areas with cases between 10– 20, high endemic areas with cases above 20(20 – 35). This result shows the spatial distribution of dengue (Momi Das, Reji Gopalakrishnan, 2011) cases among zone in Royapuram from 2018 – 2019. During 2018 (fig), the high endemic areas are Old Wasermenpet (49), Panamarathotti (50), Meenachi amman pettai (52), Seven-wells (53), Muthiyalpettai (56), Sowcarpet (57), Periyamedu (58), Egmore (61), Moderate endemic areas are Moolakathalam (53), Kondithope (54), George Town (59), Seethakaathi Nagar (60), Chinthardipet (62), Komaleeswaran Pettai (63) and low endemic area is an Old Wasermanpet (51). In the year 2019, Oldwasermanpet(49), Panamarathotti (50), Meenachi Amman Pettai (52), Moolakathalam (53) are high endemic areas, Whereas Old Wasermenpet (51), Kondithope (54), Sevenwells (55), Muthiyalpettai (56), Sowcarpet (57), George Town (59), Egmore (61), Chinthardipet (62), Komaleeswaran pettai (63) and the Low endemic areas are Periyamedu (58), Seethakathi Nagar (60).

Conclusion

A spatial analysis examination of the population groups (Katty C. Castilloa, Birthe Körbla, Anna Stewartb, Javier F. Gonzalezc, Facundo Poncec, 2011) relative to the gender and age reveled the vulnerable epidemiological groups. The epidemiological data shows that 545 dengue cases were reported in the zone of Royapuram during the period of 2018 – 2019. The result shows (table) the majority of the dengue cases were reported in males than in female population (fig). The data distinctly indicates (table) that dengue is quite prevalent in all age groups, but it was founded to be more in the age group of Adult population (15-

64) compared to other age groups, these age groups were mostly affected in 2 years.

In this result shows the number of people affected by dengue is 0.085 percent of the total population. 15 wards wise total population is 634742 with the percentage of the male is 50.84% and female percentage of 49.16%. In the dengue total cases which mean one case represented one person. The total number of dengue cases that were analyzed in this study was 545 cases with the male percentage of 55.05% and female 44.95%.

In this study, calculated Pearson correlation coefficients between rainfall (mm) and dengue epidemic found that there was significant positive correlation between the incidences of dengue cases (Chia-Hsien Lin and Tzai-Hung Wen, 2011). The dengue cases and rainfall (mm) gave a Pearson correlation (r) value of 0.711 for the year 2018 and (r) value of 0.673 for the year 2019, which indicates a strong positive association between the two variables. The dengue cases and Mosquito Menace gave a Pearson correlation (r) value of 0.711 for the year 2018 and (r) value of 0.673 for the year 2019, which indicates a strong positive association between the two variables.

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