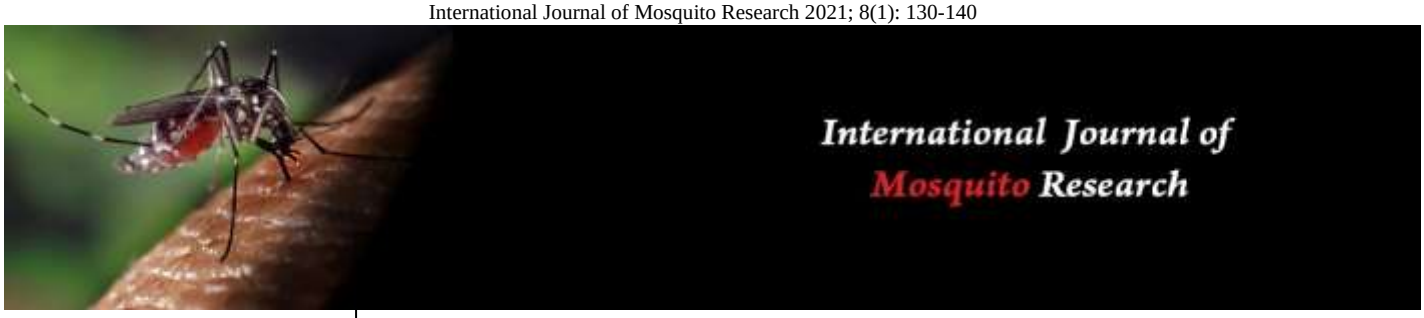

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Spatio-temporal variation of dengue in Kozhikode District, Kerala: A medico geographical study

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Abstract
Dengue is transmitted by several species of mosquito within the genus *Aedes*, principally *A. aegypti*. The Study area of Kozhikode is located between north latitude $11^0$7'22" and $11^0$48'32'' and east longitude $75^0$30' and $76^0$8'20". The purpose of selection of the study area is to investigate the spatial distribution of Dengue and temporal variation of age and sex wise variation between 2016 and 2017 and to detect the endemic regions of dengue fever and its relationship between climate and surrounding environment. Secondary data were analyzed with the help of "Z" score techniques and mapping of the disease using the Arc GIS. The analysis of Dengue fever revealed that there is a high incidence among males (57%). The age structure of the DF patients revealed that 15- 30 age group is the worst affected. The study has identified fluctuation of dengue cases and environmental parameters played a major role in Dengue occurrence.

Keywords: Dengue, geo medical study, spatial distribution, temporal variation, Z score techniques

1. Introduction
Medical Geography is gaining importance in recent times as it deals with the diseases among human being in relation to various risk factors [1-4]. Medical geography studies the impact of climate and location on an individual's health and as well as the distribution of health services [5-9]. Since health and disease are mutually exclusive, disease surveillance and identification of endemic area are basic characteristics in any health programme [10, 11, 12, 13]. Thus spatiotemporal analysis has become a valid methodology of geographical research that can be applied to any aspect studied on the earth surface [14-17]. In the present case, an attempt has been made to consider incidence of dengue disease as the focal theme of geographical research.

Dengue fever (DF) is an infectious tropical disease caused by the dengue virus. Symptoms include fever, headache, muscle and joint pains, and a characteristic skin rash that is similar to measles [18, 19]. Dengue is transmitted by several species of mosquito within the genus *Aedes*, principally *A. aegypti* [20-22]. Dengue virus is now believed to be the most common arthropod-borne disease [23-25]. Dengue is mainly found in the tropics because the mosquitoes require a warm climate [26-28]. A major fear of epidemiologists is that the mosquitoes will develop resistance to cooler climates and then be able to infect people in the temperate climates.

2. Study Area
Kozhikode district, is one of the coastal districts of Kerala, was chosen as the study area.
It is located between north latitude $11^0$7'22" and $11^0$48'32'' and east longitude $75^0$30' and $76^0$8'20" in the Arabian coast of southern state Kerala in India. (Fig 1) It has a total area of about 2344sq.km. The study area experiences generally tropical humid climate with a very hot season and wet or rainy season [29].

3. Materials and Methods
The important tools of analyse for Areographers are cartographic interpretation of the data with the help of quantitative techniques other than maps [30-32]. The collected information mainly includes secondary data and also primary data is collected from the Panchayat Community Health Centre (PCHC).

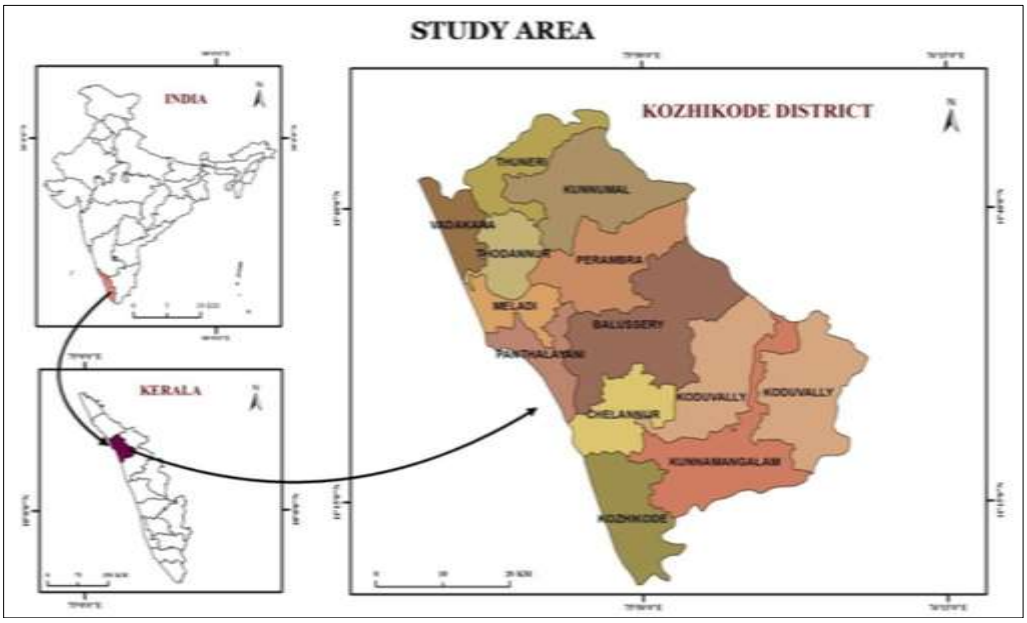

Fig 1: Location of the Study Area

3.1 Techniques

The disease distribution maps were attempted with the help of disease mapping techniques which is derived by using Arc GIS software. Standardized score ("Z" score) technique is one of the method of scale transformation used to analyse the spatial distribution of dengue fever by using Statistical Package for Social Science (SPPSS).

A Z-Score is a statistical measurement of a score's relationship to the mean in a group of scores [33] A Z-score of 0 means the score is the same as the mean. A Z-score can be positive or negative, indicating whether it is above or below the mean and by how many standard deviations.

Z-scores (also called "standard scores") are raw scores that have been adjusted for the mean and standard deviation of the distribution from which the raw scores came. Z-scores are expressed in standard deviation units and represent the number of standard deviations above or below the mean of a given raw score is (e.g., a z-score of 1.0 is one standard deviation above the mean).. A Z-score reflects how many standard deviations below or above the population mean a raw score is. In order to use a Z-score, we need to know the mean μ (mu) and the population standard deviation σ. The Z-score is calculated using the following formula.

$$z = \frac{x - \mu}{\sigma}$$

μ = Mean
σ = Standard Deviation

Where:
X= Experimental Value
μ= Mean
σ = standard deviation

The 'Z' scores form an important tool to identify that certain areas and people will exhibit health diseases and these must react to the responses of related environment like social, physical, economical factors. In calculating the index, the raw data were standardized, so that positive values are designated as 'good' and negative values as 'bad' in relation to the environment health. Accordingly, data used have been transformed into a single indicator.

4. Results and Discussion

4.1 Dengue Fever and Climate

Dengue viruses are transmitted by *Aedes* mosquitoes, which are highly sensitive to environmental conditions. Temperature, precipitation, and humidity are critical to mosquito survival, reproduction, and development and can influence mosquito presence and abundance [34, 35]. The mosquito traits favorable to spreading disease peaked when temperatures reached 29 ºc, but where lower when temperatures were cooler or warmer.

There are a few reasons why climate change may increase Dengue risk. First, the incubation period of the virus shortens in warmer temperatures, which means a mosquito doesn't have to survive as long to have a chance of becoming infectious. Second, the range of the mosquito is increasing due to global warming. Climate is a key factor controlling where a species can live [36].

4.2 Climatic impact on Dengue

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 [37-39]. The dengue viruses may reduce incubation time in mosquitoes from approximately two weeks to one week at temperatures of 32 ºC and above [40]. At higher temperatures, *aedes* mosquitoes emerge from eggs to adults in a shorter period and also experience a shorter incubation period for dengue viruses. The wet season provides ample breeding habitats for *aedes* mosquitoes, although heavy rainfall can potentially flush away larvae or pupae or the immature stage of *aedes*. In the present study the strong correlation between dengue and rainfall is 0.896 and its significance level is 0.01 in Kozhikode. (Table 1)

Table 1: Correlations between Dengue and Rainfall

List of variables		Dengue cases	Rainfall in mm
Dengue	Pearson Correlation	1	0.896**
	Sig. (2-tailed)		0.000
	N	12	12
Rainfall	Pearson Correlation	0.896**	1
	Sig. (2-tailed)	0.000	
	N	12	12
**. Correlation is significant at the 0.01 level (2-tailed).			

From the table 2 it is clear of the climatic impact of dengue especially their positive correlation between dengue fever cases and rainfall. In the year of 2017 the dengue cases is more frequent during the months between June – September and in the same months the occurrence of rainfall is also high compared to other months. (Fig: 2)

Table 2: Rainfall and Dengue fever-2017

Sl. No.	Month	Dengue Cases	Dengue Cases In %	Dengue Cases in Z score value	Rainfall(mm)	Rainfall mm In %	Rainfall in Z score value
01	January	9	0.065	-.73363	2	0.065	-.88361
02	February	9	0.065	-.73363	2	0.065	-.88361
03	March	15	1.107	-.69124	11	0.359	-.85221
04	April	19	1.403	-.66298	84	2.742	-.59751
05	May	71	5.243	-.29557	242	7.900	-.04623
06	June	238	17.577	.88436	815	26.607	1.95302
07	July	442	32.644	2.32572	770	25.138	1.79601
08	August	288	21.270	1.23764	472	15.409	.75626
09	September	171	12.629	.41098	238	7.770	-.06019
10	October	45	3.323	-.47928	230	7.508	-.08810
11	November	26	1.920	-.61352	172	5.615	-.29047
12	December	21	1.550	-.64885	25	0.816	-.80336

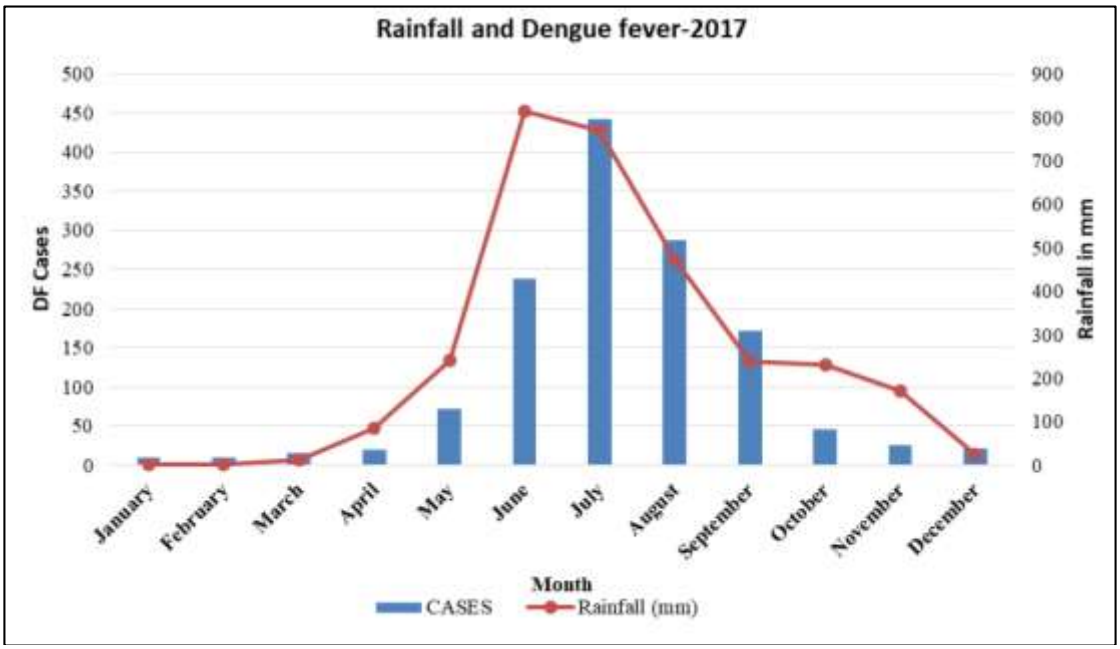

Fig 2: Month wish Dengue Cases

The rubber plantation area is the main reason in the proliferation of mosquitoes. The half coconut shells used by the rubber growers to collect milk from the tree turn a breeding ground for mosquitoes during rainy days. So rainy season or rainfall and stagnation of water helped the mosquitoes to breed and increase the number of cases of dengue fever in 2017.

5. Temporal variation of dengue in Kozhikode

Dengue viruses are transmitted by *Aedes* mosquitoes, which are highly sensitive to environmental conditions [41]. Kozhikode is unaffected by dengue fever till 2002. (Fig 3). It was first reported in 2003 with 77 cases and 2 deaths [42]. Then the condition of dengue become routine in a fluctuated rate but in 2006 dengue fever became an outbreak in

Kozhikode district with the number of cases as 151 and 1death. In 2017 there were 1354 cases and 7 deaths. (Table 3)

Table 3: Temporal Variation of Dengue fever

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dengue Fever case	77	12	22	13	44	27	11	47	38	44	167	276	587	151	1354
Death	2	1	-	1	2	-	-	2	-	-	-	-	5	1	7

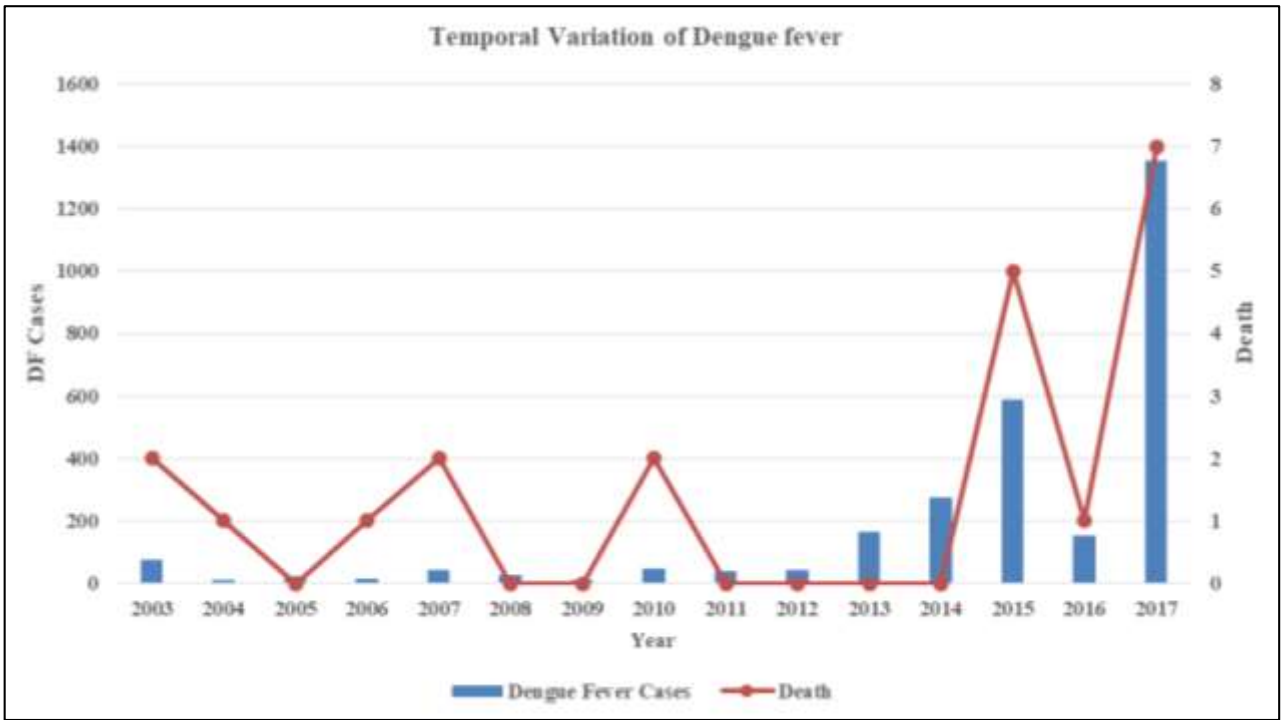

Fig 3: Temporal variation of dengue fever 2003-2017

The map (Fig 4) shows the spatial distribution of dengue fever in 2016 and 2017 through buffering in each block, if it is general hospital, district hospital, and Taluk hospital and community health centre.

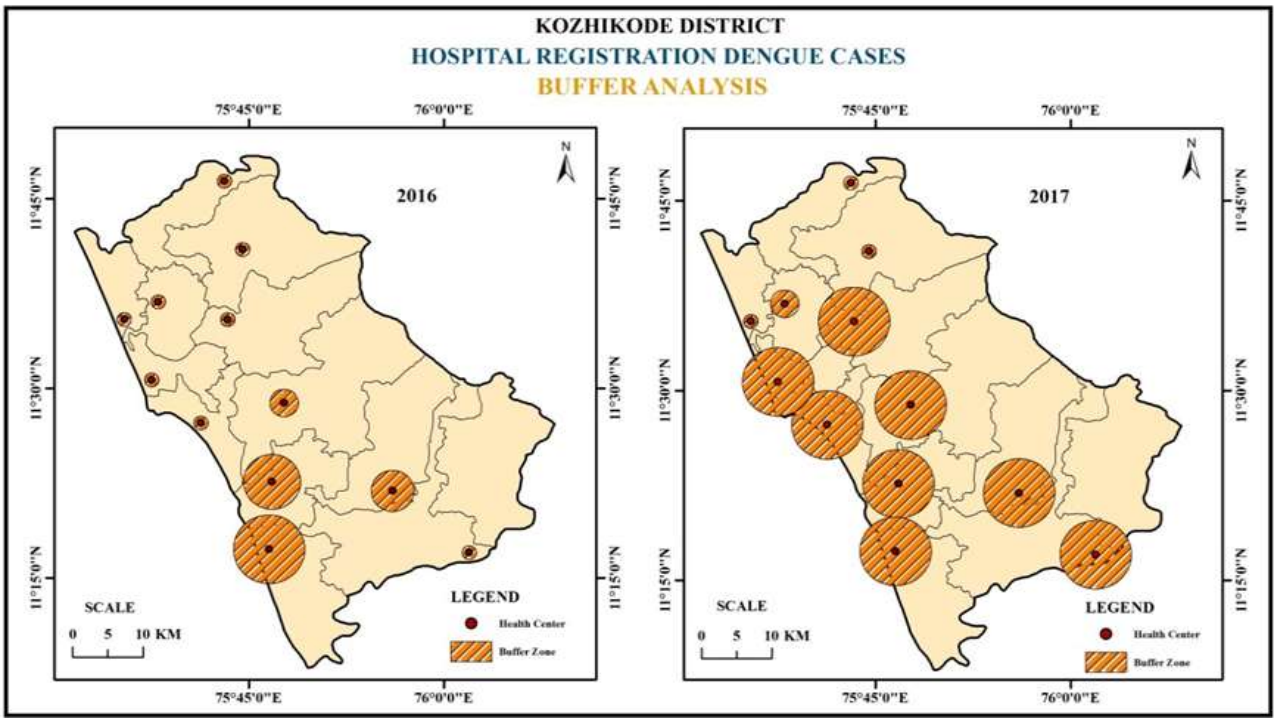

Fig 4: Various hospital registration dengue cases in Kozhikode district

5.1 Sex Variation in Dengue Fever

In Kozhikode district both male and female cases are reported

in 2016 and 2017. Male cases are little more than female cases (Fig: 5). When compared for both years .This is mainly because of freedom of activities in public place, environment related jobs etc. [43] lead to increase in chances to be bitten by *Aedes aegypti* mosquitoes.

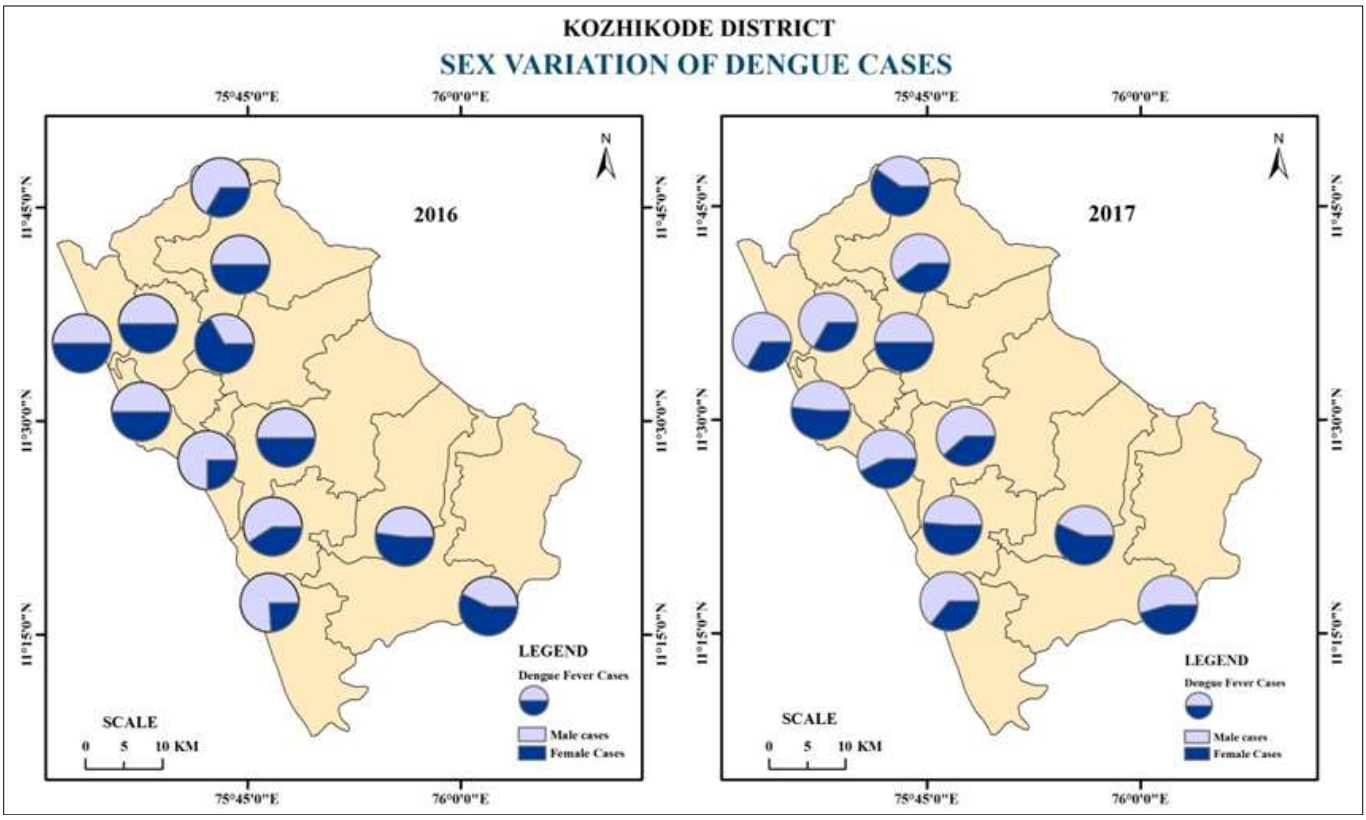

Fig 5: Meal Female variation of dengue cases 2016 and 2017

5.2 spatial distribution of dengue –male cases 2016 and 2017

The variables are dengue fever cases of male, female cases and total cases in both 2016 and 2017is shown in Table 4.

The Standard deviation value of Dengue male cases 2016 is 12.5 and the mean value is 7.8 (Table 5) and the maximum value recorded is 44.00. Minimum value is detected as 1.00 and low distribution of male cases of dengue is comparatively more.

Table 4: Regional Variation and Case Identification of Dengue fever

Block	2016			2017		
	Z Score Value			Z Score Value		
	Male	Female	Total	Male	Female	Total
Vadakara	-0.54	-0.74	-0.62	-0.58	-0.61	-0.60
Thodannur	-0.54	-0.74	-0.62	-0.56	-0.60	-0.58
Thuneri	-0.46	-0.74	-0.56	-0.58	-0.58	-0.59
Kunnumal	-0.54	-0.74	-0.62	-0.57	-0.60	-0.59
Perambra	-0.54	-0.55	-0.56	-0.45	-0.42	-0.44
Meladi	-0.54	-0.74	-0.62	-0.46	-0.42	-0.45
Panthalayani	-0.38	-0.74	-0.51	-0.26	-0.28	-0.27
Balussery	0.02	0.61	0.20	0.19	0.05	0.13
Chelannur	0.66	1.19	0.85	1.50	2.39	1.91
Koduvally	0.34	1.58	0.73	-0.48	-0.41	-0.45
Kunnamangalam	-0.38	-0.16	-0.33	-0.33	-0.32	-0.33
Kozhikode	2.91	1.77	2.67	2.57	1.79	2.27

Table 5: Descriptive statistics value

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Dengue Male Cases 2016	12	1	44	7.8	12.5
Dengue Female Cases 2016	12	1	14	4.8	5.2
Dengue Total Cases 2016	12	2	58	12.6	17.0
Dengue Male Cases 2017	12	2	339	64.0	107.1
Dengue Female Cases 2017	12	1	236	48.8	78.5
Dengue Total Cases 2017	12	3	528	112.8	182.7

According to 'Z' score value the maximum incident rate represented the southern area mainly the south coastal area (Fig 6). The disease decreases towards northern parts of the district. According to Z score value the map shows that Kozhikode block (2.91) is extremely affected. The area including blocks like Balussery (0.34), Chelannur (0.66) and Koduvally (0.34) are highly affected areas. The moderate affected areas are Kunnamangalam (-0.38) Panthalayani (-0.38) and Thuneri (-0.46). The incident rate was low in blocks such as Vadakara (-0.54), Thodannur (-0.54), Kunnumal (-0.54), Perambra (-0.54) and Meladi (-0.54).

The Standard deviation value of Dengue male cases in 2016 is (12.5), the mean value (7.8) (Table 5) and the maximum value recorded is (44.00). Minimum value detected is (1.00) and low distribution of male cases of dengue is comparatively more.

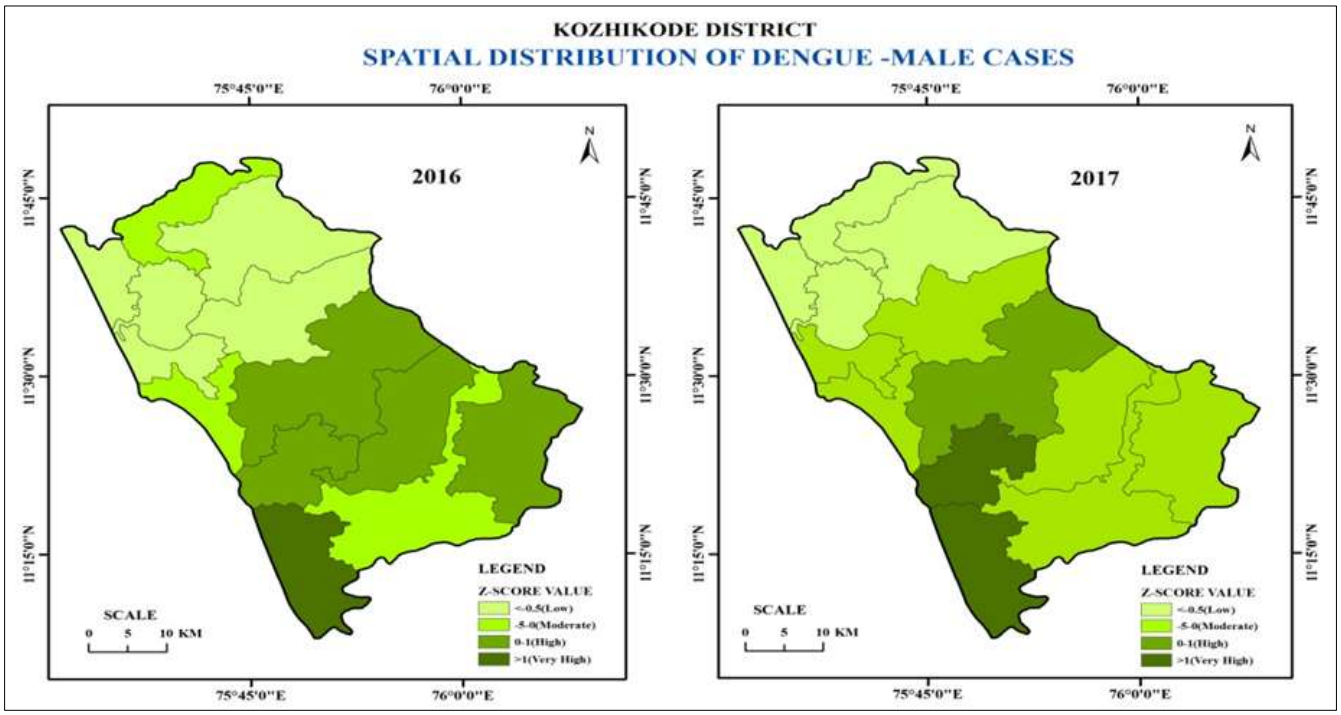

Fig 6: Spatial Distribution of Dengue –Male Cases 2016 And 2017

The male incident rate of dengue fever has increased in 2017 when compared to 2016 (Fig: 6).The maximum incident rate recorded in Kozhikode (2.57) and Chelannur (1.5) block. The areas which exhibit a high prevalence rate in Balussery block (0.19). Moderate rate was found in the blocks of Kunnamangalam (-0.33) Koduvally (-0.48) Panthalayani (-0.26) Meladi (-0.46) Perambra (-0.45). The incident rate is low in northern part of the district especially in blocks like Vadakara (-0.58) Thodannur (0.56) Thuneri (-0.58) and Kunnumal(-0.57). The main reason for the increasing trend is unpredictable rainy season and after effect of mosquito breeding in rubber and coconut plantations due to fresh water stagnation [44-46] Most of the male labours in the plantation are affected by dengue fever. The Standard deviation value of Dengue male cases in 2017 is (107.1), the mean value (64.00) (Table 5) and the maximum value recorded is (339.00). Minimum value is detected (2.00) and low distribution of male cases of dengue is comparatively less. Majority of the area have moderate range of dengue male cases distributed.

5.3 Spatial Distribution of Dengue – Female Cases 2016 And 2017

'Z' score analysis help to identify the spatial distribution of dengue fever in female cases during the year 2016. When compared with male cases, female cases are very low in this year. The maximum rate is found in southern and central part of the district and number of cases decreasing toward northern part of the district.

Blocks such as Kozhikode (1.77), Koduvally (1.58) and Chelannur (1.19) are extreamily affected areas. The area of Balussery block (0.61) is highly affected. Moderate Spatial distribution of Dengue female cases found in Kunnamangalam block (0.16). The incident rate of female dengue fever cases is low in the blocks of Vadakara (-0.74), Thodannur (-0.74), Thuneri (-0.74), Kunnumal (-0.74), Perambra (-0.55) Meladi (-0.74) and Panthalayani (-0.74) (Fig 7).

The maximum standard deviation value of dengue female cases 2016 is representing (5.2). Maximum value is identified as (14.00). The minimum value is recorded as (1.00). The mean value is identified with the value (4.8), (Table 3).The spatial analysis of dengue fever of female cases in Kozhikode district during the year 2017 shown in (Fig7). From the map it is clear that the number of female cases have a huge variation or outbreak between 216 and 2017.

The spatial distribution of dengue female cases found in the blocks Chelannur (2.39) have high number of female dengue fever cases are occur and Kozhikode(1.79).(fig 8) The highly distributed area is Balussery block (0.05). Moderately distributed areas include blocks like Kunnamangalam (-0.32), Koduvally (-0.41) Panthalayani (-0.28), Meladi (-0.4) and Perambra (-0.42). The incident rate is low in the areas of Vadakara (-0.61), Thodannur (-0.6), Thuneri (-0.58) and Kunnumal (-0.6).The maximum value of female cases in 2017

(236.00), the minimum value of female cases of dengue fever is (1.00) and the mean value is found (48.8). The standard deviation value is found (78.5) (Table 4).

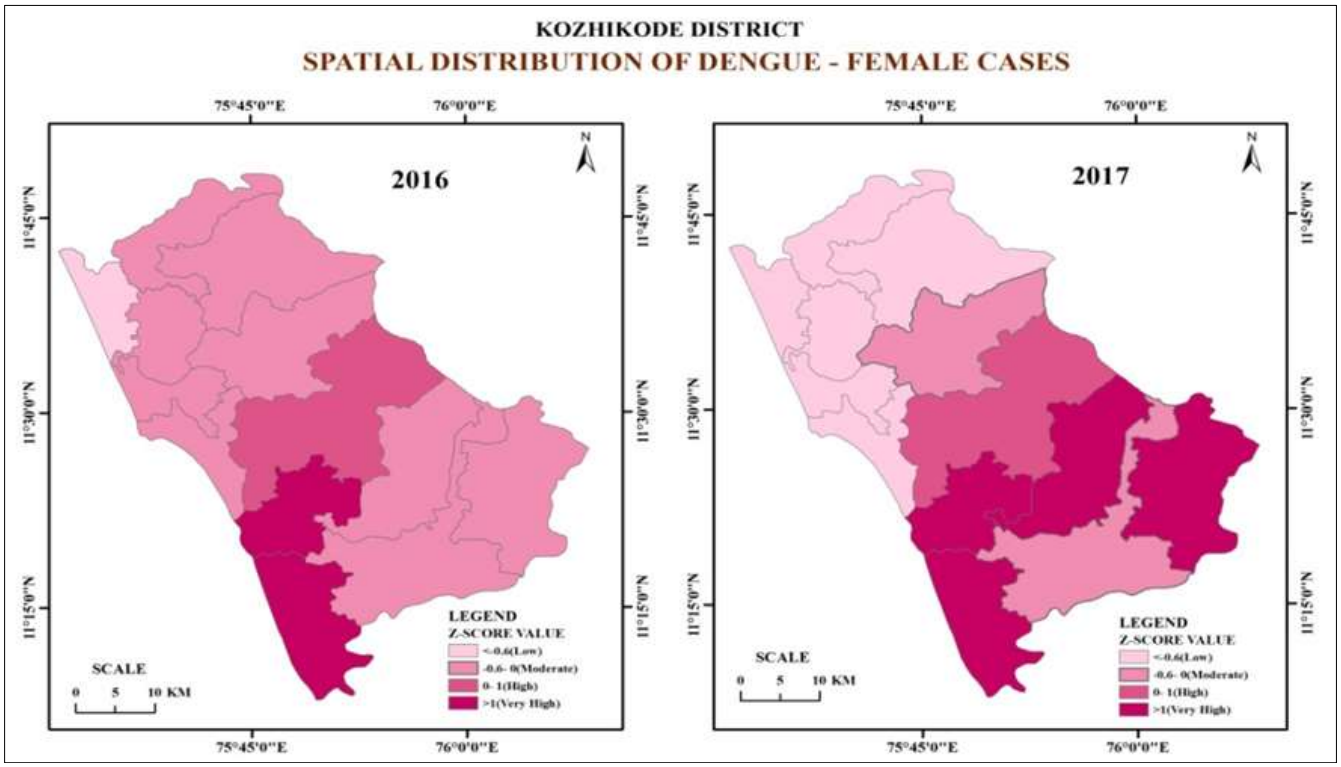

Fig 7: Spatial Distribution of Dengue –Male Cases 2016 And 2017

5.4 Spatial Distribution of Total Dengue Cases 2016 and 2017

The 'Z' score analysis techniques help to understand the spatial distribution pattern of total dengue fever cases in Kozhikode district of 2016 as shown (Table 4). In this year comparatively the dengue cases are low. The maximum rate of incidence was recorded in the coastal urban area of the district.

From the map Fig 8 it is clearly observed that Kozhikode block(2.69) which is an urban area is extremely affected. The area including blocks like Koduvally (0.73), Chelannur (0.85) and Balussery (0.2) are highly affected by dengue fever. The incident rate is moderately distributed in Kunnamangalam Block (-0.32). The incident rate is low in the northern blocks of the district such as Vadakara (-0.62), Thodannur (-0.62), Thuneri (-0.56), Kunnumal (-0.52), Perambra (-0.56), Meladi (0.62) and Panthalayani (-0.51)

The standard deviation value of this particular case is (17.0), the maximum value is recorded (58), the mean value is identified (12.6) and the minimum value of dengue cases in 2016 is (2.00), (Table 5). Mostly the cases are in the southern region and very rare incidence occurred in the northern part of the district.

The overall pattern of 'Z' scores analysis result in the increasing trend of Dengue fever during the year 2017. The maximum incident rate occurs in coastal and hilly areas of the district.

The spatial distribution pattern of dengue fever is clearly shown in map (Fig 8). Most of the dengue fever cases are found in the area including Kozhikode (2.27) and Chelannur (1.91). The area of Balussery block (0.13) is a hilly area and is highly affected. The moderate rate of incident is recorded in the areas of Kunnamangalam (-0.33), Koduvally (0.45), Panthalayani (-0.27), Meladi (-0.45) and Perambra (-0.44). The incident rate is low in the usual northern blocks of the district which include Vadakara (-0.6), Thodannur (-0.58), Thuneri (-0.59) and Kunnumal (-0.59).

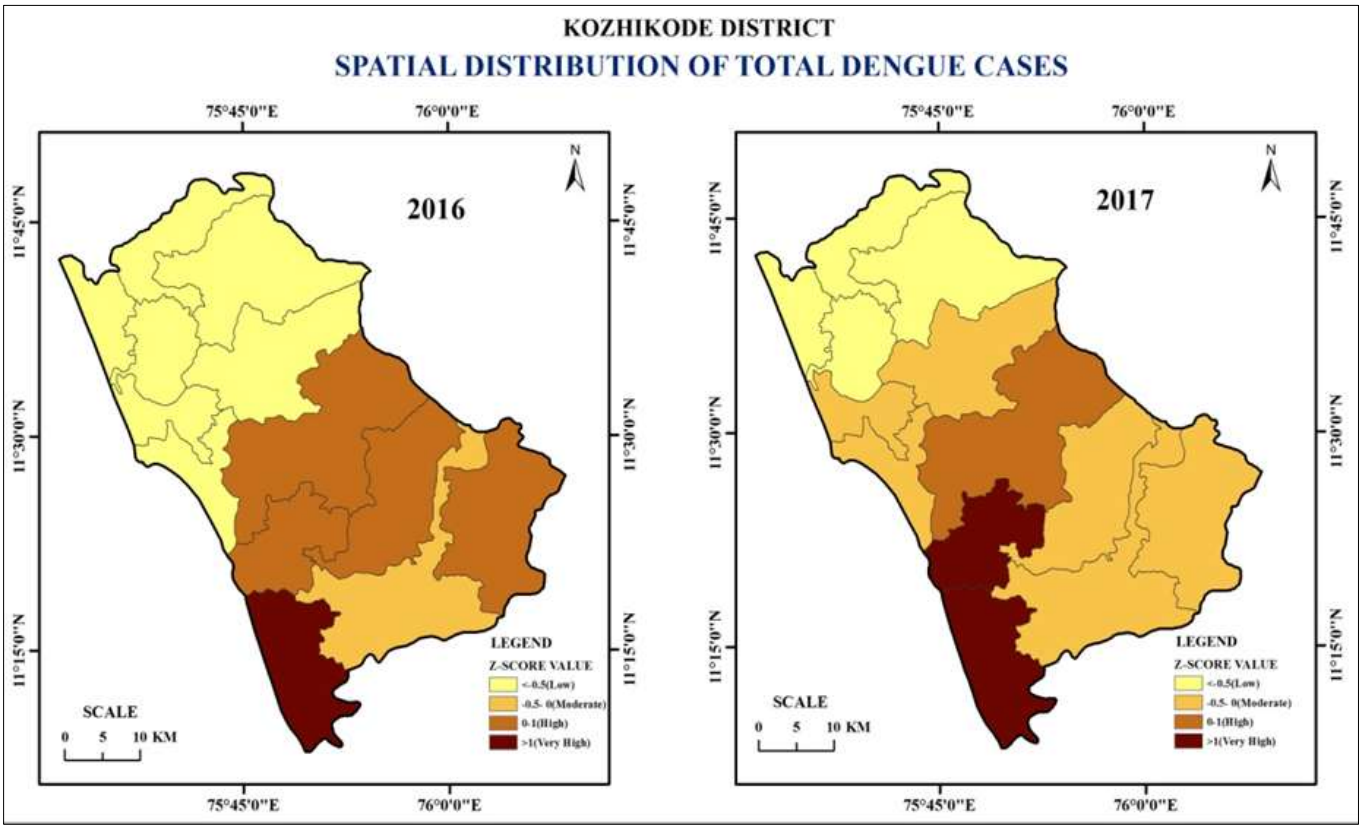

Fig 8: Total number of dengue cases in 2016 and 2017

Standard deviation value of this particular disease is (182.7). The minimum value is (3.00), maximum value is found to be (528.00), and the mean value of this disease is identified as (112.8), (Table No.5). The main reason for increasing rate of dengue fever cases in 2017 is due to the climate fluctuation mainly the early rainfall. Density of population in urban area leads to spread of the disease easily and the lack of awareness of breading sources of *Aedes aegypti* mosquitos are the other reasons.

6. Age Structure and Dengue

In Kozhikode district the percentage of dengue cases is very high in the age group 15-30 that is adult age and low in both old (>60) and child population(<15) (Table 6).

Table 6: Age Structure and Dengue in 2016-17

Age Group	Total Dengue Cases 2016 in percentage	"Z" Score Value	Total Dengue Cases 2017 in percentage	"Z" Score Value
<15	13	-.61394	7	-1.14905
15-30	35	1.31559	35	1.32583
31-45	27	0 .61394	26	.53033
46-60	19	-.08771	21	.08839
>60	6	-1.22788	11	-.79550
Mini.Value	6	-	7	
Maxi.Value	35	-	35	-
Mean Value	20	-	20	-
Std. Deviation	11.40175	-	11.31371	-

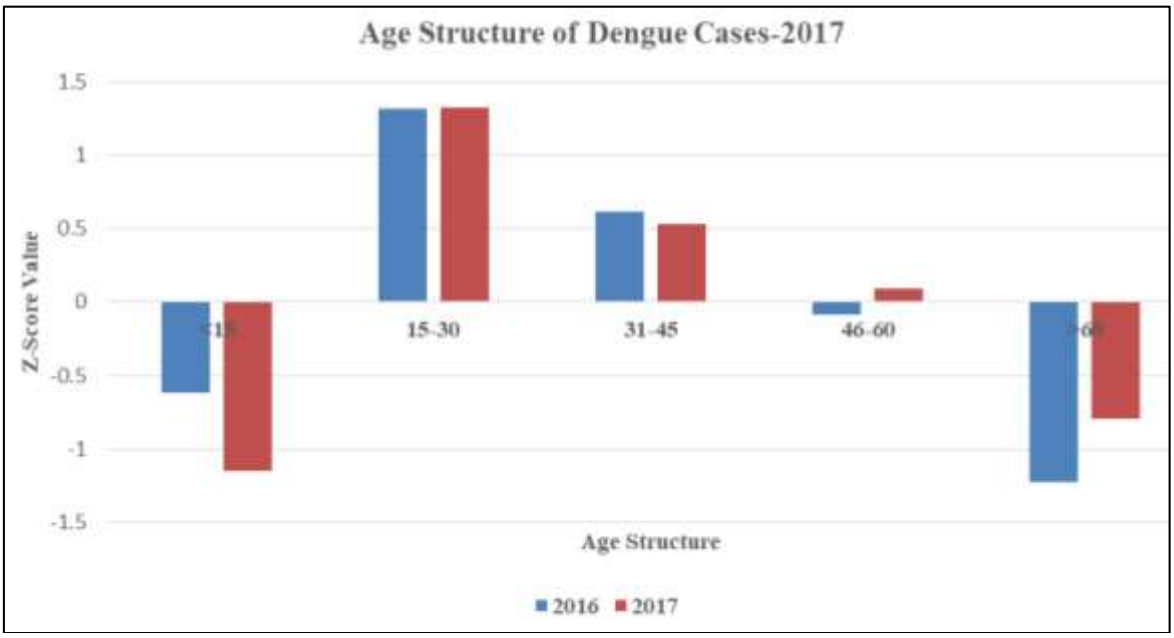

Fig 9: Age wise Dengue Cases

Dengue fever mostly affected people in 15-30 years, which includes both adult age and working population.(Fig 9). Majority of working population is engaged in secondary and tertiary fields.[47,48,49] It is noted that most of the cases occur in urban areas.[50] The frequent movement of adult and working population leads to higher infection of the disease than the old age (>60) and child population (<15) because mostly these age group do not move from their home area, so chances of infection of dengue fever is low.

7. Conclusion

The study of environmental relationship of these factors according to its nature reveals alternative points of relation for managing health problems and also to find out where future problem might emerge.

The 'Z' score analysis technique is an important measure whereby it identified the casual links in the distribution pattern of Dengue fever incidents which in turn must react to responses of related environmental factors like social, physical and economic. The urban area of the district registered a high incident rate of dengue fever. In Northern part and rural areas the influence dengue fever is very low. Dengue fever mostly affected people of the age between 15-30. Male cases are reported more and most of the cases are reported in the months of June- September.

Understanding the environmental conditions of patients is essential to focus on the socio-economic condition of the patients, cleanliness of the surrounding, waste disposal etc.

The strategy of dengue control measures is called source reduction. The Primary preventative measure to reduce dengue infections is the control of mosquito populations. Since the transmission of dengue requires mosquitoes as vectors, the spread of dengue can be limited by reducing mosquito population.

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Ethical approval

Ethical approval not required. This article does not contain any studies with human participants or animals performed by any of the authors. Since only the Secondary data collected at various centres are used in the study

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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