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Impact of Climate Change on Vector Borne Diseases in Vellore Town, Tamilnadu, India

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ABSTRACT

Objective: The world is witnessing climate change. This change has already started affecting air quality, food production, water supply, coastal settlements and human health. Vector-borne diseases account for over 17% of all infectious diseases. There is increasing evidence about the impact of climate change on vector borne diseases. The present study was aimed to investigate any significant correlations between the vector borne diseases and climate change in Vellore town, Tamilnadu, India. **Methods:** We collected medical data from the standard government hospital located in Vellore town while the meteorological data was obtained from meteorological station situated in the study area under the state ministry of agriculture for the past three years (2015-2017). **Results:** There are 31 positive cases of Malaria was recorded in 2015 and 42 positive cases of Dengue in 2017 than in other periods of observation. Excessive monsoon rainfall and resultant high humidity were clearly identified as major factors for malaria and dengue in this region. **Conclusion:** The result shows that there is a significant correlation between the vector borne diseases and climate change in Vellore town.

Key words: Dengue, Malaria, Lymph edema, Meteorological data, Climate change

1. INTRODUCTION

Over the past decade our knowledge about many aspects of climate change effects and adaptation strategies has increased significantly, but a large knowledge gap still exists regarding how climate change effects on climate sensitive infections will affect humans and animals [1].

Developing countries like India are responsible only for a small percentage of greenhouse gases and global warming but this account for significant impact on health. Increase in global temperature affects water, food, air quality, infectious diseases, physical comforts and human health. Researchers have estimated that climate change have caused 1,50,000 deaths and 5 million illnesses each year [2]. Vulnerable population includes elderly, children, pregnant ladies, urban populations and slum [3]. The relationship between climate and health is evidenced by the increase in the visit of patients to clinics after severe heat, rain and cold. Variation in climate temperature over a period of 100 years in India has been reported as 0.5˚C [2].

The IPCC [4] (Intergovernmental Panel on Climate Change) has projected rise of about 4˚C in temperature, increase or decrease in rainfall patterns and a rise in sea level upto 0.59 meters by the year 2100. Therefore, there is a need to acquire more information about the spread of possibly climate sensitive infections in this region, and to clarify the impacts of climate change on humans and animals. An important goal is contributing to the development of an early warning system for increased risk of spread of climate sensitive infection at the local level, a so called, alarm system intervention. This paper will contribute to the work of identifying climate sensitive infections as well as helping in defining the meaning of an infection being climate sensitive. Objective of the present study is to investigate is any significant correlations may be demonstrated between the vector borne diseases and climate change in Vellore town, District of Vellore, Tamil Nadu, India.

2. METHODOLOGY

2.1. Study area

Two criteria were used to select the study site. First, was the presence of a government or a missionary hospital with well maintained and credible accessible vector borne diseases data while the second criterion is that, the site was required to have a meteorological station with long term data located nearby and the station must be within the same climatological zone as the study site.

Vellore town, the capital of District Vellore has been chosen for this study in order to analysis the meteorological data related to vector borne diseases like lymph edema, malaria and dengue. The Vellore town is situated on the west of the Palamathi Hill range. The river Palar flows on the north of the town. The town lies between 12º 15’ to 13º 15’ north latitudes and 78º 20’ to 79º 50’ east longitudes. The geographical area of this district is 6077 sq.km. Total population of Vellore district in 2011 census was 3,936,331. Of these male population is 1,961,688 and female population is 1,974,643. The area is characterized by a tropical climate. The area receives rainfall from South–West Monsoon. The average maximum temperature experienced is 39.5 ˚C and the average minimum temperature experienced is 15.6 ˚C. The region experiences an average annual rainfall of 795 mm, out of which North-East Monsoon contributes to 355 mm and the South-West Monsoon contributes to 440 mm.

2.2. Data collection

This work makes use of medical data and meteorological data spanning 3 years period (2015-2017). The medical data was obtained from the standard government hospital located in the study area under the state ministry of health while the meteorological data was obtained from meteorological station situated in the study area under the state ministry of agriculture. The medical data collected include monthly diagnosed cases of malaria, dengue and lymph edema. While meteorological data collected were monthly values of relative humidity (%), minimum and maximum temperature (°C) and rainfall (mm).

2.3. Statistical analysis

Simple and basic statistics like mean was employed to compute for both monthly trends of the medical and meteorological data.

3. RESULTS

Figure 1.1 shows the comparative analysis of number of positive cases of Lymph edema, Malaria and Dengue. 4 positive cases of lymph edema, 31 positive cases of malaria and 14 positive cases of dengue were found in the year 2015. 4 positive cases of lymph edema, 12 positive cases of malaria and 20 positive cases of dengue were found in the year 2016. 2 positive cases of lymph edema, 10 positive cases of malaria and 42 positive cases of dengue were found in the year 2017.

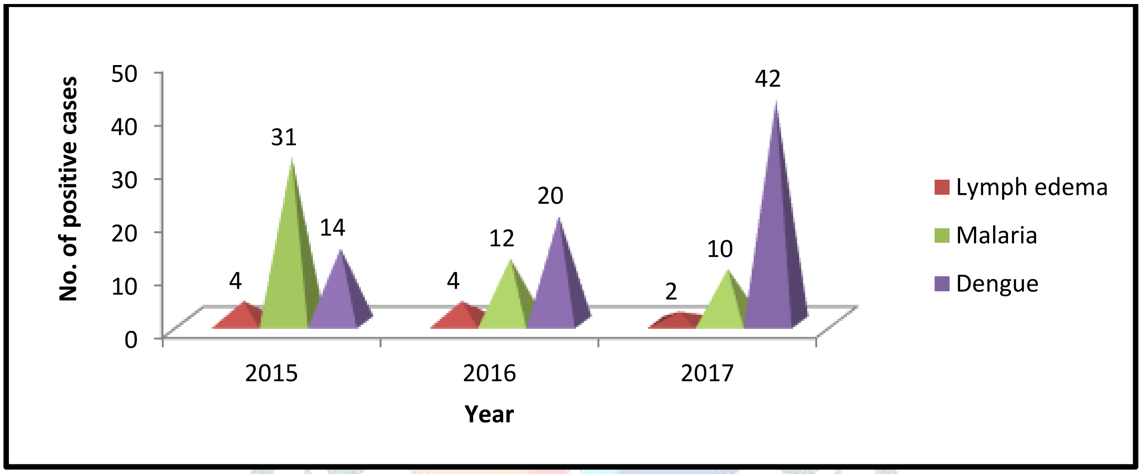

Fig.1.1: Comparative analysis of number of positive cases of lymph edema, malaria and dengue

Figure 1.2 shows the sex – wise positive cases of Lymph edema. Out of 4 positive cases, 3 of them were found to be male and one was found to be female in the year 2015 and 2016. 2 positive cases were found to be female in the year 2017.

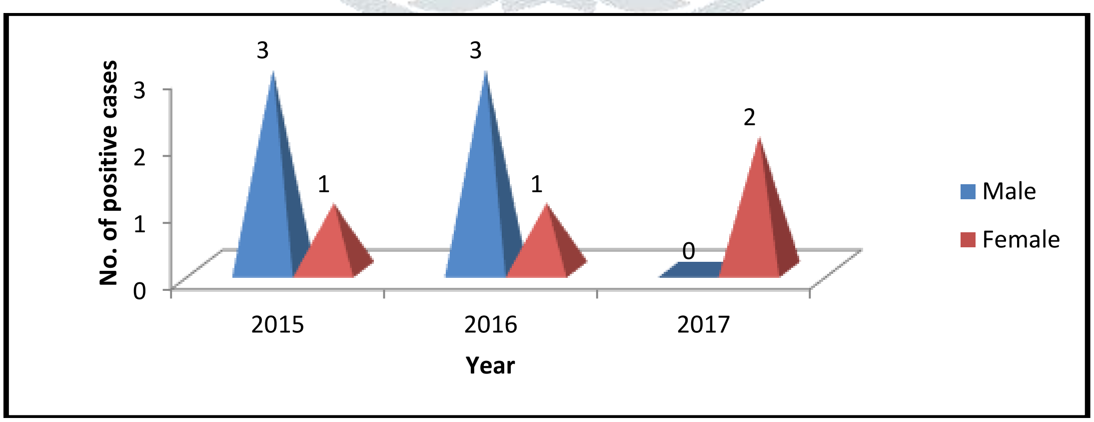

Fig.1.2: Sex – wise positive cases of lymph edema

Figure 1.3 shows the sex – wise positive cases of Malaria. Out of 31 positive cases, 21 of them were found to be male and 10 of them were found to be female in the year 2015. Out of 12 positive cases, 8 of them were found to be male and 4 of them were found to be female in the year 2016. Out of 10 positive cases, 9 of them were found to be male and one of them was found to be female in the year 2017.

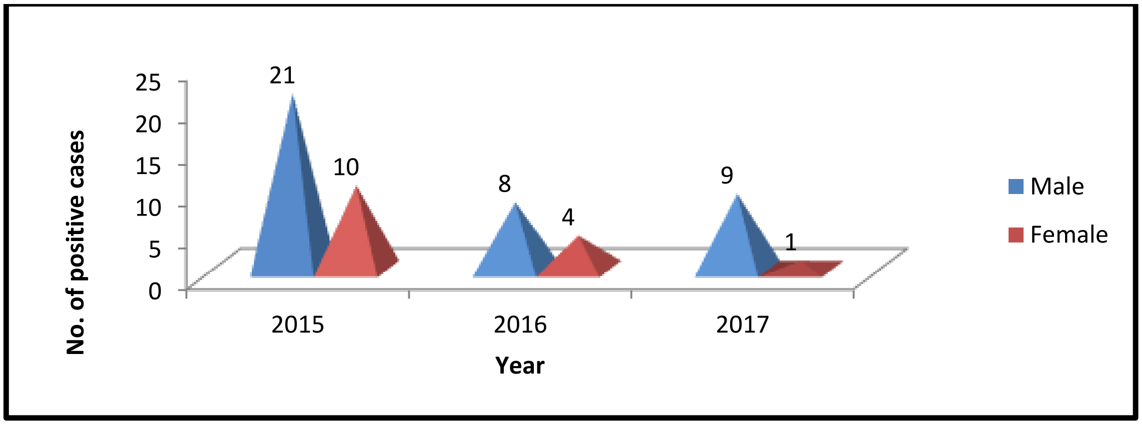

Fig.1.3: Sex – wise positive cases of malaria

Figure 1.4 shows the sex – wise positive cases of Dengue. Out of 14 positive cases, 8 of them were found to be male and 6 of them were found to be female in the year 2015. Out of 20 positive cases, 14 of them were found to be male and 6 of them were found to be female in the year 2016. Out of 42 positive cases, 23 of them were found to be male and 19 of them were found to be female in the year 2017.

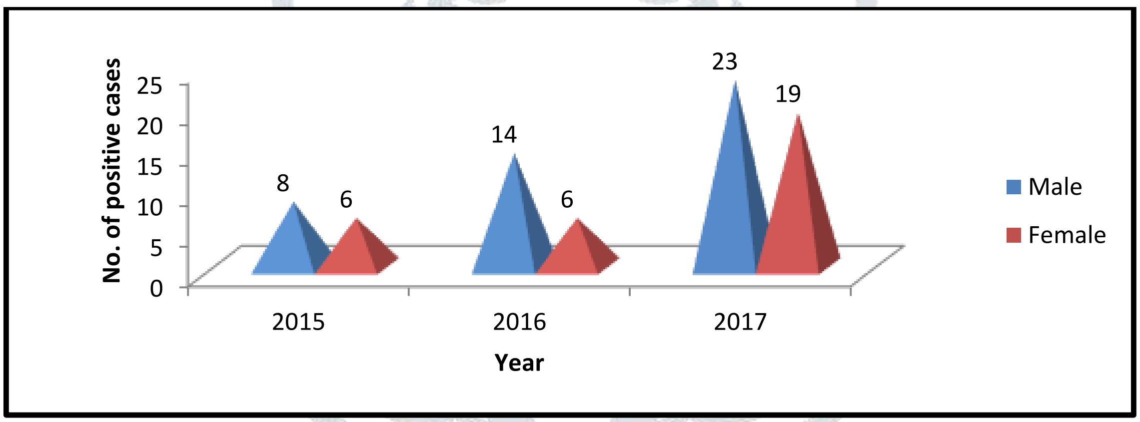

Fig.1.4: Sex – wise positive cases of dengue

Figure 1.5 shows the age – wise positive cases of Lymph edema. Below the age of 40, one positive case was found in the year 2015. Between the ages of 41-50, two positive cases were found in the year 2017. Between the ages of 61- 70, one positive case was found in the year 2015 and three positive cases were found in the year 2016. Above the age of 70, two positive cases were found in the year 2015 and one positive case was found in the year 2016.

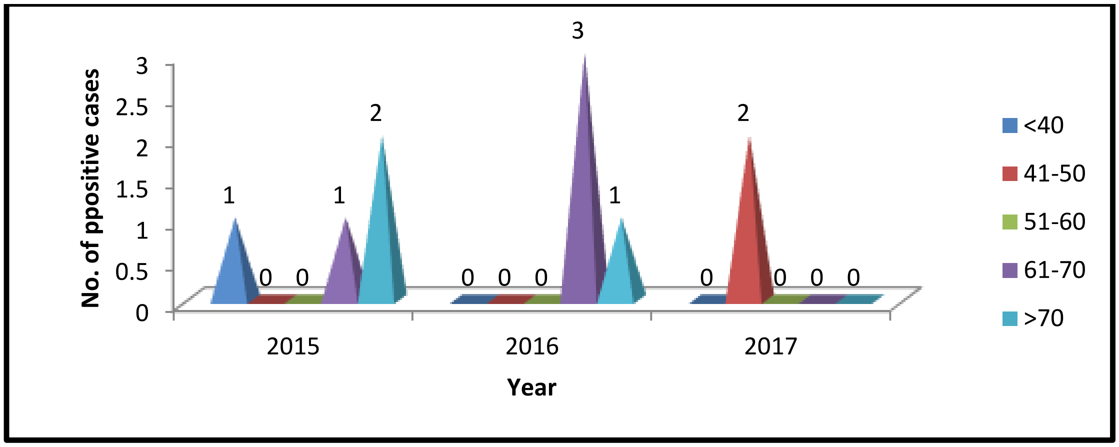

Fig.1.5: Age – wise positive cases of lymph edema

Figure 1.6 shows the age – wise positive cases of Malaria. Below the age of 10, five positive cases were found in the year 2015 and one positive case was found in the year 2016. Between the ages of 11-20, four positive cases were found in the year 2015 and one positive case was found in the year 2017. Between the ages of 21-30, five positive cases were found in the year 2015 and also in 2016 and one positive case was found in the year 2017. Between the ages of 31-40, ten positive cases were found in the year 2015 and three positive cases were found in the year 2017. Between the ages of 41-50, three positive cases were found in the year 2015 and also in 2016 and one positive case was found in the year 2017. Between the ages of 51- 60, four positive cases were found in the year 2015, two positive cases were found in the year 2016 and one positive case was found in the year 2017. Between the ages of 61-70, one positive case was found in the year 2016 and three positive cases were found in the year 2017.

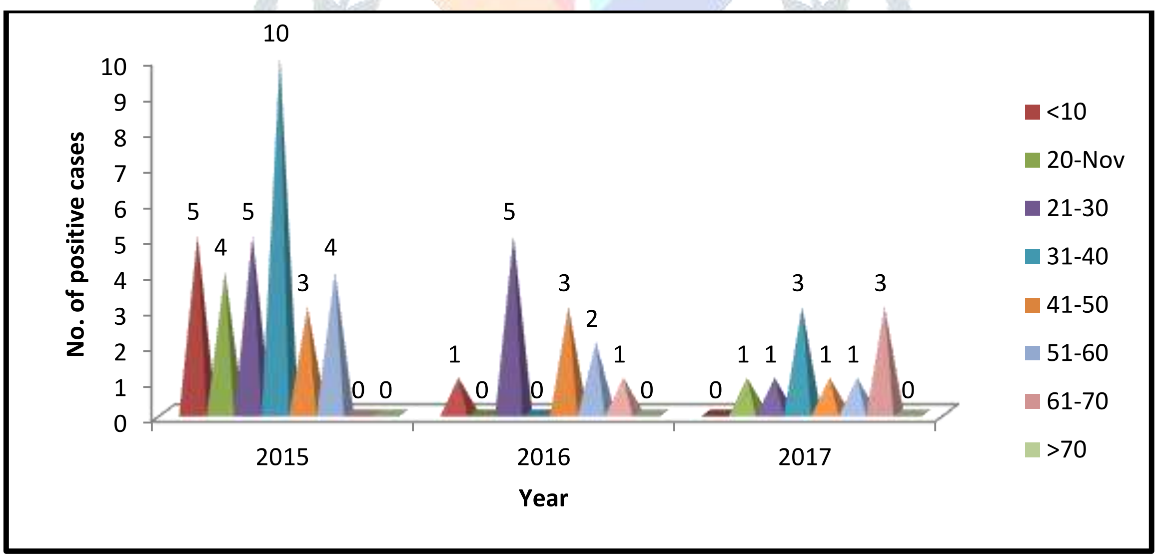

Fig.1.6: Age – wise positive cases of malaria

Figure 1.7 shows the age – wise positive cases of Dengue. Below the age of 10, two positive cases were found in the year 2015 and also in 2016 and six positive cases were found in the year 2017. Between the ages of 11-20, five positive cases were found in the year 2015 and also in 2016 and fifteen positive cases were found in the year 2017. Between the ages of 21-30, four positive cases were found in the year 2015 and seven positive cases were found in the year 2016 and also in 2017. Between the ages of 31-40, one positive case was found in the year 2015, two positive cases were found in the year 2016 and four positive cases were found in the year 2017. Between the ages of 41-50, one positive case was found in the year 2015 and also in 2016 and seven positive cases were found in the year 2017. Between the ages of 51- 60, two positive cases were found in the year 2016 and one positive case was found in the year 2017. Between the ages of 61-70, one positive case was found in the year 2016 and also in 2017. Above the age of 70, one positive case was found in the year 2015 and also in 2017.

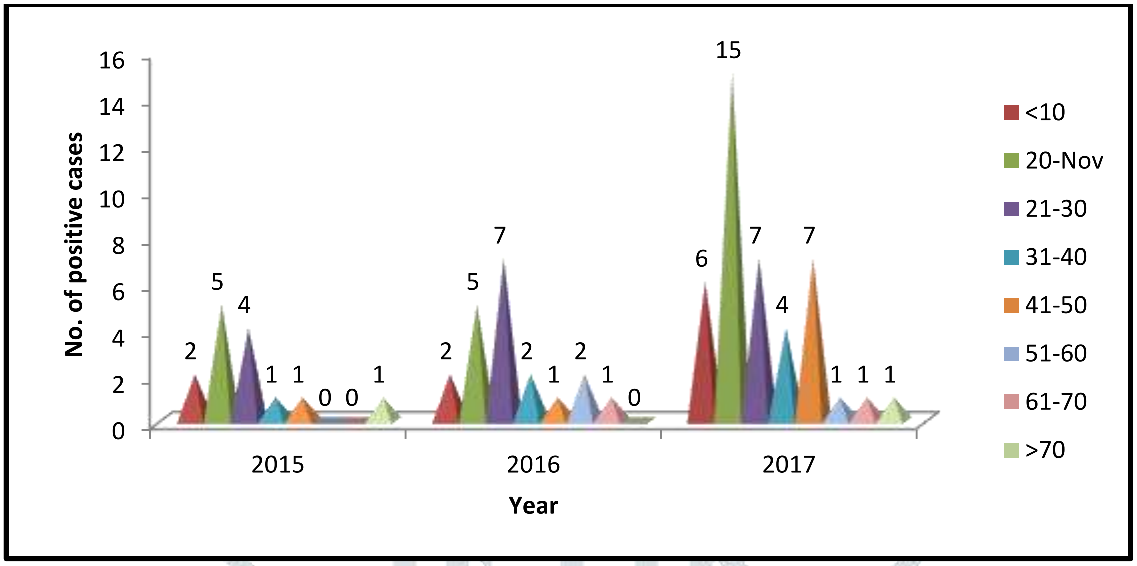

Fig.1.7: Age – wise positive cases of dengue

Figure 1.8 shows the monthly – wise positive cases of Lymph edema. In the year 2015, one positive case was found in the month of February and also in September and two positive cases were found in the month of August. In the year 2016, one positive case was found in the month of May and also in August and two positive cases were found in the month of June. In the year 2017, one positive case was found in the month of June and also in November.

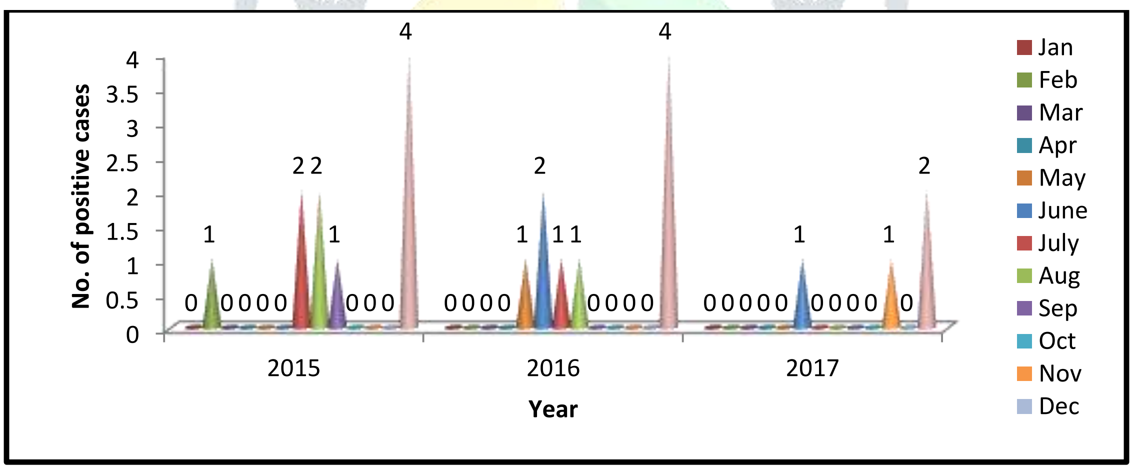

Fig.1.8: Monthly – wise positive cases of lymph edema

Figure 1.9 shows the monthly – wise positive cases of Malaria. In the year 2015, 4 positive cases were found in the month of June, 2 positive cases were found in the month of September, 5 positive cases were found in the month of October and 20 positive cases were found in the month of November. In the year 2016, 2 positive cases were found in the month of January and also in August, 3 positive cases were found in the month of April, one positive case was found in the month of May and also in July, October, November and December. In the year 2017, one positive case was found in the month of February and also in July, August, October, November and December, two positive cases were found in the month of June and also in September.

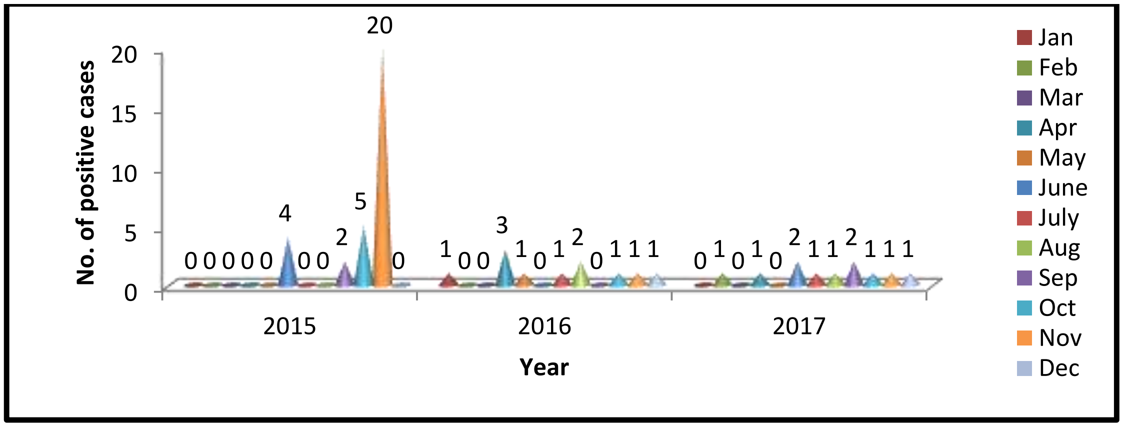

Fig.1.9: Monthly – wise positive cases of malaria

Figure 1.10 shows the monthly – wise positive cases of Dengue. In the year 2015, 2 positive cases were found in the month of January and also in August, 4 positive cases were found in the month of July and 3 positive cases were found in the month of September and also in October. In the year 2016, 3 positive cases were found in the month of January and also in March, 2 positive cases were found in the month of February and also in July, August, September, one positive case was found in the month of April and also in May, June, October, November and December. In the year 2017, one positive case was found in the month of February, 2 positive cases were found in the month of March and also in April, 3 positive cases were found in the month of August, 4 positive cases were found in the month of September, 11 positive cases were found in the month of October, 13 positive cases were found in the month of November and 6 positive cases were found in the month of December.

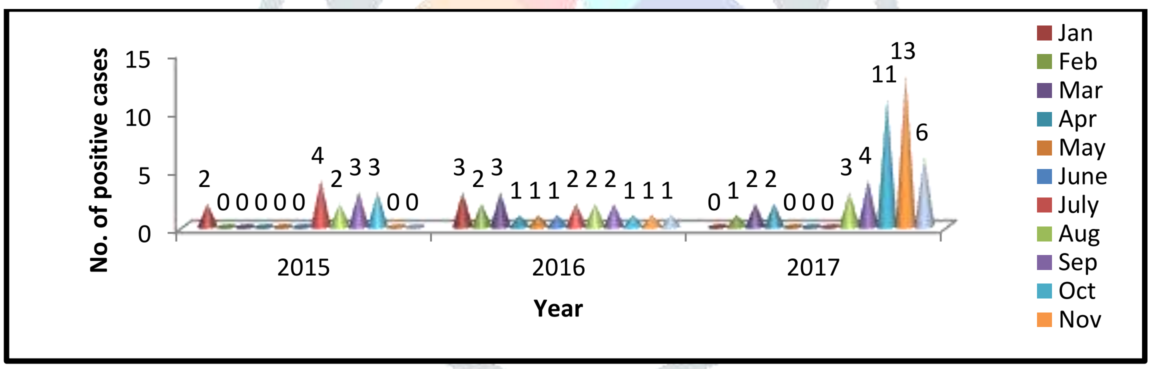

Fig.1.10: Monthly – wise positive cases of dengue

Figure 1.11 shows the monthly – wise total rainfall (mm). In the year 2015, the highest total rainfall was recorded in the month of November (447.2 mm), followed by August (202.2 mm) and September (178.9 mm) and the lowest total rainfall was recorded in the month of January (0.1 mm) and no rainfall was recorded in the month of February and March. In the year 2016, the highest total rainfall was recorded in the month of July (279.6 mm), followed by June (198.4 mm) and December (189.5 mm) and the lowest total rainfall was recorded in the month of November (21.3 mm) and no rainfall was recorded in the month of February, March and April. In the year 2017, the highest total rainfall was recorded in the month of September (268.1 mm), followed by August (267.8 mm) and October (252.6 mm) and the lowest total rainfall was recorded in the month of March (1.7 mm) and no rainfall was recorded in the month of February.

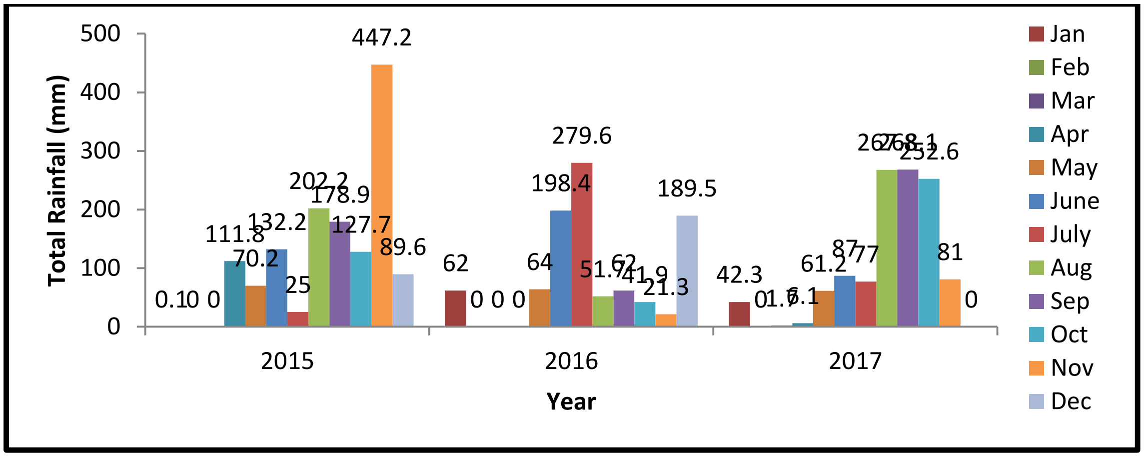

Fig.1.11: Monthly – wise total rainfall (mm)

Figure 1.12 shows the monthly – wise highest rainfall in 24 hrs (mm). The highest rainfall in 24 hr was recorded in the month of November (136.2 mm) in the year 2015, followed by December (108.3 mm) in the year 2016 and August (74.4 mm) in the year 2017.

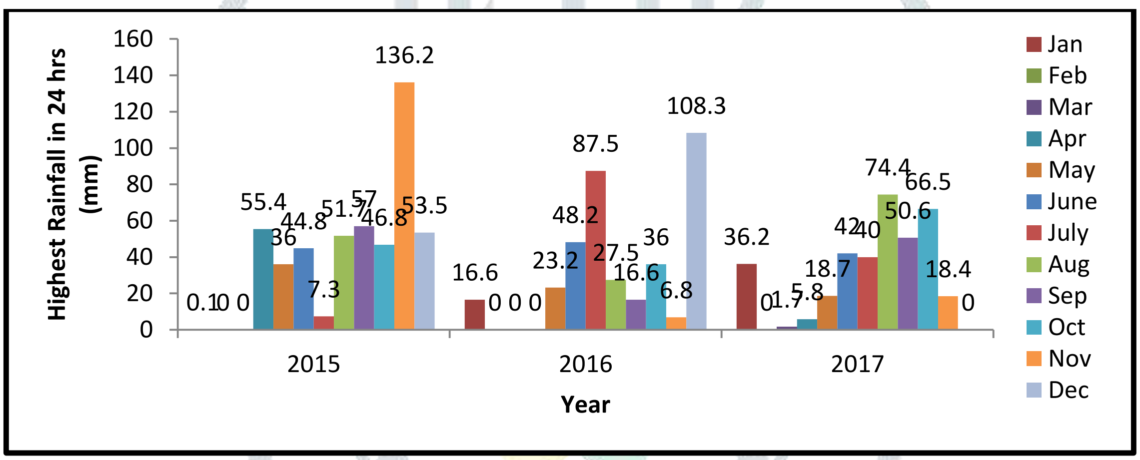

Fig.1.12: Monthly – wise highest rainfall in 24 hrs (mm)

Figure 1.13 shows the monthly – wise number of rainy days (2.5mm & above). The highest number of rainy days was recorded in the month of November (17 days) in the year 2015, followed by July (10 days) in the year 2016 and August (14 days) in the year 2017.

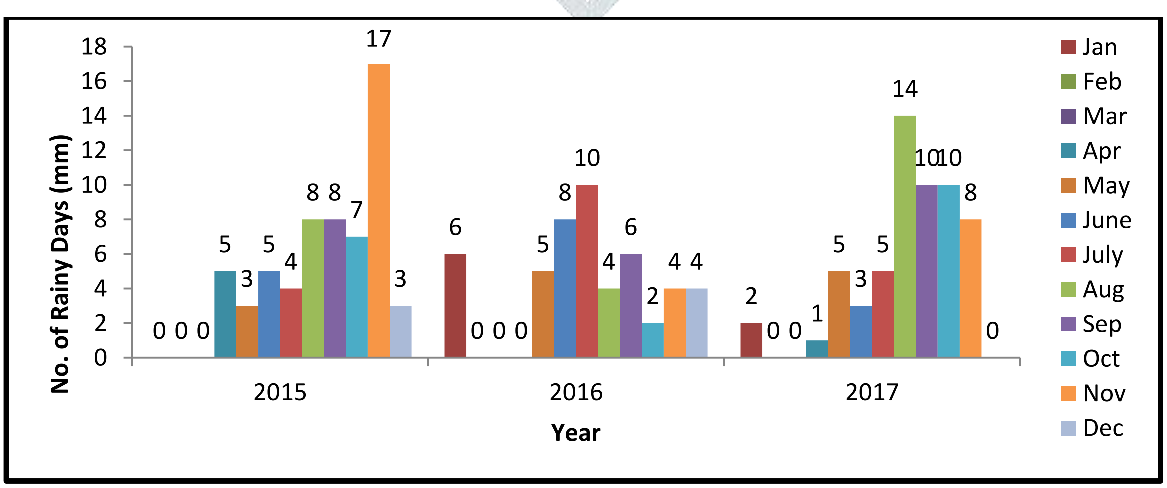

Fig.1.13: Monthly – wise number of rainy days (2.5mm & above)

Table 1.1 shows the monthly – wise mean of Maximum – Minimum temperature (˚C). In the year 2015, the highest mean of maximum and minimum temperature was recorded in the month of July (37.1-27˚C), followed by May (37-24˚C) and April (36.4-25.3˚C) and the lowest mean of maximum and minimum temperature was recorded in the month of November (28-22.8˚C). In the year 2016, the highest mean of maximum and minimum temperature was recorded in the month of April (39.6-27˚C), followed by May (38.3-27.3˚C) and March (36.4-24.2˚C) and the lowest mean of maximum and minimum temperature was recorded in the month of December (29.5-19.6˚C). In the year 2017, the highest mean of maximum and minimum temperature was recorded in the month of April (40.9-26.3˚C), followed by May (40.4-26.9˚C) and June (37.3-27.1˚C) and the lowest mean of maximum and minimum temperature was recorded in the month of December (28.9-20˚C).

Table – 1.1: Monthly – wise mean of maximum – minimum temperature (˚C)

Month	2015 (˚C)	2016 (˚C)	2017 (˚C)
January	29.5-19.5	30.4-19.3	30.1-18.9
February	32.6-19	33.2-20.9	32.5-18
March	35.7-23	36.4-24.2	36.5-23.5
April	36.4-25.3	39.6-27	40.9-26.3
May	37-24	38.3-27.3	40.4-26.9
June	35.2-26.1	35.1-25.9	37.3-27.1
July	37.1-27	34.3-25.3	36.9-26.7
August	34.5-25.4	35.9-26	33.9-24.7
September	33.5-25.3	34.6-25.4	32.8-24.4
October	32.3-23.5	35.6-23.8	31.6-23.9
November	28-22.8	32.7-20.8	29.1-22.7
December	29.1-21.4	29.5-19.6	28.9-20

Table 1.2 shows the monthly – wise mean of relative humidity (%) at 0830-1730 HRS. In the year 2015, the highest mean of relative humidity was recorded in the month of November (93-86 %), followed by December (90-71 %) and January (87-54 %) and the lowest mean of relative humidity was recorded in the month of July (61-41 %). In the year 2016, the highest mean of relative humidity was recorded in the month of January (89-61 %), followed by February (85-56 %) and March (84-56 %) and the lowest mean of relative humidity was recorded in the month of August (66-58 %). In the year 2017, the highest mean of relative humidity was recorded in the month of November (87-78 %), followed by October (86-74 %) and December (85-65 %) and the lowest mean of relative humidity was recorded in the month of June (63-47 %).

Table – 1.2: Monthly – wise mean of relative humidity (%) at 0830-1730 HRS

Month	2015 (%)	2016 (%)	2017 (%)
January	87-54	89-61	84-59
February	81-38	85-56	77-43
March	78-37	84-56	75-41
April	76-45	77-49	70-38
May	73-57	69-52	65-48
June	70-54	70-60	63-47

July	61-41	76-60	64-51
August	73-57	66-58	77-67
September	78-64	69-58	83-71
October	86-65	70-53	86-74
November	93-86	77-55	87-78
December	90-71	83-67	85-65

4. DISCUSSION

Emerging infectious diseases is believed to be an increasing global health burden due to climate change. More knowledge regarding the effects of climate change on the emergence of infectious diseases is needed since only a few diseases are being recognized as sensitive to climate. Knowledge regarding the effects of climate on the spread of infectious diseases will most likely become more important due to global warming and weather hazards like flooding. To find out if these diseases are sensitive to changes in climate is important to try and predict where outbreaks or epidemics can occur in the future. This is of value for preparing health care institutions as well as the public and to know which areas are in need for interventions.

Some vector-borne diseases (e.g. malaria and dengue fever) show significant seasonal patterns whereby transmission is highest in the months of heavy rainfall and humidity. The most influential climatic factors for vector borne diseases include temperature and precipitation but sea level elevation, wind, and daylight duration are additional important considerations. Temperature may modify the growth of disease carrying vectors by altering their biting rates, as well as affect vector population dynamics and alter the rate at which they come into contact with humans. Humidity can greatly influence transmission of vector-borne diseases, particularly for insect vectors. Mosquitoes and ticks can desiccate easily and survival decreases under dry conditions. Rainfall patterns can influence the transport and dissemination of infectious agents while temperature can affect their growth and survival.

In the present study the data has been collected from Vellore town during the year Jan 2015 to Dec 2017. No previous studies have confirmed associations between these diseases and climate in this study area. In this study, there are 4 positive cases of lymph edema and 31 positive cases of malaria were found in the year 2015 and 42 positive cases of dengue were found in the year 2017. A study by Lal *et al*. [5] who demonstrated dengue is occurring in tropical and subtropical regions, particularly in urban settings. Since 1960, more than 50 outbreaks have been reported to or investigated by the National Institute of Communicable Diseases in India. The 1996 epidemic in New Delhi was the worst of its kind, which affected 16,517 persons and killed 545.

Sex-wise distribution of positive cases indicates males were highly affected by the lymph edema, malaria and dengue when compared to females during the study periods. Majority of the positive cases were found between the ages of 60-70 in lymph edema, 5-60 in both malaria and dengue. Children's were highly affected by malaria and dengue. Similar result was also obtained by Dhingra *et al*. [6] who discussed malaria mortality in India is difficult and found that approximately 2,00,000 deaths per year before 70 years of age and 55,000 in early childhood.

The high prevalence of malaria (20) and dengue (13) were found in the month of November during the year 2015 and 2017. The high degree Celsius of maximum and minimum temperature was recorded in the month of July (37.1-27.3$^{\circ C}$) in the year 2015 followed by April (39.6-27$^{\circ C}$) in the year 2016 and also April (40.9-26.3$^{\circ C}$) in the year 2017. The high relative humidity (%) at 0830-1730 HRS was recorded in the month of November (93-86%), January (89-61%) and November (87-78%) in the year 2015, 2016 and 2017 respectively. The highest total rainfall (mm) was recorded in the month of November (667.2 mm), July (279.6 mm) and September (286.1 mm) in the year 2015, 2016 and 2017 respectively. The high number of rainy days (2.5 mm & above) was recorded in the month of November (17 days), July (10 days) and August (14 days) in the year

2015, 2016 and 2017 respectively. This study was correlated with a study of Vaghela and Mangal [7]; Bouma and van der Kaay [8] who discussed higher temperature and humidity will shorten the development period of the vectors leading to larger production of vector population as well as there are changes in feeding rate and host contact. Increased relative humidity increases vector activity and increases transmission rates whereas heavy rainfall decreases vector activity. Similar results were also obtained by Victor *et al*. [9]; Yang *et al*. [10]; Watts *et al*. [11] and Chakravarti and Kumaria [12] who discussed excess rain can eliminate vector habitat by flooding. Low rainfall can create habitat.

A study that analysed 23 years of Mexico's weather data shows that the risk of dengue is almost zero at temperatures below 5°C and modest between 5°C and 18°C. The risk increases as temperature rises above 20°C; and declines beyond 32°C as adult mosquitoes gradually die above 36°C. The researchers also found a link between dengue and rainfall pattern. Risk of dengue increases as precipitation rises to about 550 mm, beyond which the risk declines. This is due to the creation of rain-filled breeding sites, the researchers noted in journal plos Neglected Tropical Diseases in 2013. The risk declined at high levels of rainfall, which may be due to washing out of such breeding sites, conclude the authors. Another study in 2013 led by Baruah *et al*. [13] of Christian Medical College, Vellore, however, shows that in states like Tamil Nadu where temperatures are conducive for vector proliferation throughout the year, high incidences of dengue are reported in years that receive poor rainfall as well as in years of excess rainfall. Chennai experienced high incidences of dengue during the monsoons of 2001 and 2005 when it received excess rainfall. In 2003, it experienced poor rainfall, yet reported high incidence of dengue.

In this study, the data suggested that malaria and dengue varies seasonally in highly endemic areas. Malaria and dengue are probably the vector-borne diseases most sensitive to long-term climate change. The link between malaria, dengue and extreme climatic events has long been the subject of study in the Indian subcontinent. Excessive monsoon rainfall and resultant high humidity were clearly identified as major factors in the occurrence of epidemics through enhancement of both the breeding and life- span of mosquitoes. Further, the risk of an epidemic is greater in a year in which excess rain occurs in critical months. A strong correlation is found between both monthly rainfall and the number of rainy days and the incidence of malaria and dengue in Vellore town. Urbanization is also associated with a range of health problems, including vector-borne diseases such as dengue and malaria. This study confirmed that meteorological variables had a strong relationship with the prevalence of this disease with children less than five years having the highest risk.

One of the critical factors influencing the vulnerability of human health to climate change is the extent to which the health and socio-economic systems are robust enough to cope with demand. Some Communities have added risks of malaria and dengue diseases due to climate variability and change, lack of immunity, and poverty. The changing weather/climate observed in this study indicates that the station has a higher disposition to malaria and dengue epidemics. Additionally, the poor are further disadvantaged by their inability to access medical treatment and the lack of health care facilities during such epidemics. Therefore, the local capacity to develop adaptive strategies to cope with climate variations and extremes is still very low, at all levels, and remains a big challenge.

5. CONCLUSION

Malaria and Dengue incidence varies according to gender and age. Malaria incidence was higher in 2015 than in other periods of observation. Dengue incidence was higher in 2017 than in other periods of observation. This study has shown that changing weather/climate has altered the climates of the area. The maximum and minimum temperatures have changed, with significant increases generally recorded. The major outbreaks are associated with the unusually wet and warm climate events. Excessive monsoon rainfall and resultant high humidity were clearly identified as major factors for malaria and dengue in this region.

Author's Contribution

The first author carried out the experiment. The second author verified the analytical methods. Both the authors discussed the results and contributed to the final manuscript. First author wrote the manuscript with support from second author.

Competing Interests

The authors declare that they have no competing interests.

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