

ORIGINAL ARTICLE - PUBLIC HEALTH

RETROSPECTIVE STUDY ON THE CYCLIC OCCURRENCE OF DENGUE FEVER CASES (2012 - 2023) IN MADURAI DISTRICT, AN ENDEMIC AREA IN TAMIL NADU, INDIA

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Abstract

INTRODUCTION : Dengue Fever (DF) has become a serious public health problem in India during the past few decades and several outbreaks have been reported in many parts of the country. The problem of dengue, once confined to urban areas only, has now penetrated in rural areas also due to rapid urbanisation, implementation of several development schemes. In Tamil Nadu, an effective surveillance system has been established in recent years to prevent outbreaks. However, there is a paucity of information on the cyclical occurrence of dengue fever in a geographical area which is essential for forecasting any possible outbreak. Further, Epidemiological findings such as Attack Rate of dengue cases will provide reliable estimate of disease burden of an area so as to evolve appropriate strategies spatially and temporally in a geographical area. Therefore, a retrospective study on cyclic occurrence of dengue in Tamil Nadu from 2012 – 2023 is documented in order to implement appropriate control measures to prevent any possible major outbreak in Madurai district, Tamil Nadu.

OBJECTIVES : It is aimed to find out the spatial and temporal distribution of dengue fever cases in Madurai District, Tamil Nadu from 2012-2013 (12 Years), to analyse the effectiveness of Fever surveillance system an unique system followed in Tamil Nadu, to find out the Attack Rate of dengue cases in rural and urban areas for 12 years and to study the cyclic occurrence of cases and to recommend appropriate control measures.

METHODOLOGY : The effectiveness of the Fever surveillance system in Madurai District is analysed and documented in this article. Dengue cases confirmed serologically were considered for case incidence and calculating Attack Rate per 1 Lakh population in both Rural and Urban areas of Madurai district from 2012-2023. Month wise and Year wise occurrence of dengue cases in relation to rainfall and age wise and sex wise analyses have been done. Mosquito vector surveillance and vector control strategies adopted in in Madurai district is documented.

RESULTS : Fever surveillance and dengue testing in Madurai district revealed that there is a definite cyclic pattern in dengue occurrence once in 5 6 years in both rural and urban areas in Madurai District. Further, the active transmission season of dengue is from June to December every year with a peak after Northeast Monsoon period in October confirming the positive correlation with rainfall. In all the 12 years, it is found that more number of males and adults have been affected with dengue than females and children (less than 12 years). Vector surveillance and control involving line departments like local bodies and creation of awareness on dengue control among people have provided good results.

CONCLUSION : It is evident from this study that the Fever surveillance system existing at present is very effective and it provides reliable estimate of disease burden. It is confirmed that Dengue epidemic cycle is established once in 5 years in Madurai district. Further, the active transmission season is from June to December following monsoon period which necessitates the Public Health system to be alert in case management and vector control in time to prevent any possible dengue outbreak in Madurai district.

KEYWORDS : Dengue Fever, Epidemic Cycle, Seasonal occurrence of Dengue, Aedes aegypti mosquitoes

INTRODUCTION

Dengue is a rapidly expanding mosquito-borne virus infection in tropical and subtropical climates. It is endemic in more than 100 countries, and about 400 million people are infected with dengue fever annually. In India, Dengue Fever has become a significant public health problem in many parts of the country in recent years. Dengue fever surveillance and mosquito control activities are implemented through various health programs in India to reduce the disease burden and dengue related deaths. Since the dengue vaccine has not yet

been developed, various vector control strategies are being implemented intensively. In recent decades, due to climate change and global warming, the density of mosquitoes, population dynamics, disease transmission potential,



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etc., have tremendously altered. Further, due to rapid urbanization, the implementation of various development schemes, industrial developments, and the construction of dams, the breeding grounds of mosquitoes have enormously increased in both rural and urban areas. The public health interventions now adopted for mosquito control involve anti-larval and anti-adult measures, which require high inputs of insecticides and manpower. Since the mosquitogenic conditions in and around human habitations are man-made problems, and because of the diverse breeding sites of *Aedes aegypti* mosquitoes, it is felt essential to evolve community-based strategies for mosquito control to reduce the disease burden.

In India, several outbreaks of dengue fever have been reported since 1912, when an outbreak of dengue fever was reported in Kolkata.¹ In south India, all four serotypes of dengue virus were first isolated from febrile patients in Vellore, Tamil Nadu, between 1956 and 1966.³ During the same period, dengue virus isolations were made in wild caught *Aedes aegypti* mosquitoes^{4,5} confirming the activity of different serotypes in Tamil Nadu as early as the 1960s. However, until 1990, no major outbreak of dengue/dengue haemorrhagic fever (DF/DHF) was reported in Tamil Nadu. Epidemics of DF/DHF that were reported after 1990 were confined to some regions of Tamil Nadu.⁶⁻⁹

In Tamil Nadu, several dengue fever outbreaks have been reported during the last two decades, and a detailed study on the spatial and temporal incidence of dengue cases has already been documented from 1998 to 2006.¹⁰ However, the dengue fever outbreaks that occurred in Madurai district during 2012 necessitated the Tamil Nadu Public Health Department for the establishment of a daily fever surveillance system, the networking of laboratories, the involvement of various line departments in dengue control activities, and community – based vector control strategies. It is imperative to analyze the data on the dengue fever incidence during the last 12 years in Madurai district to understand the distribution of cases in various geographical areas during different seasons of the year in order to implement appropriate vector control activities in time, thereby preventing significant outbreaks of dengue.

Therefore, this article aims to find out the temporal and spatial occurrence of dengue fever cases in Madurai district, Tamil Nadu, during the last 12 years (from 2012 to 2023), to analyse the establishment of a Fever surveillance system in Madurai district and its effectiveness in disease monitoring and control activities, to find out the Attack Rate of dengue cases in rural and urban areas for the last 12 years

in Madurai district to assess the burden of the disease, to determine the impact of vector control activities on dengue case incidence in rural and urban areas and to identify the significant factors responsible for the occurrence of dengue cases in Madurai district during the study period.

METHODOLOGY

Study Area : Dengue fever surveillance and vector control activities are carried out routinely in both rural and urban areas of Madurai district, Tamil Nadu. Madurai district is one of the central districts in south Tamil Nadu, and there is a frequent migration of people from neighboring districts for various purposes, including attending to health care facilities for various illnesses. Madurai district (3741.73 km² area) is located in North Latitude between 9°30' 00" and 10°30'00" and East Longitude between 77°00'00" and 78°30'00" with a population of 30,38,252 (Rural 1191451 and Urban 1846801). Madurai district includes one corporation with 100 wards, 3 municipalities, and 13 blocks with 9 town panchayats and 420 village panchayats.

A retrospective study on dengue incidence in Madurai district was carried out, and secondary data was collected from the District Health Office at Madurai. The networking of the fever surveillance system and vector control activities followed in Madurai district are documented in this article.

Fever/Dengue Surveillance system in Madurai District :

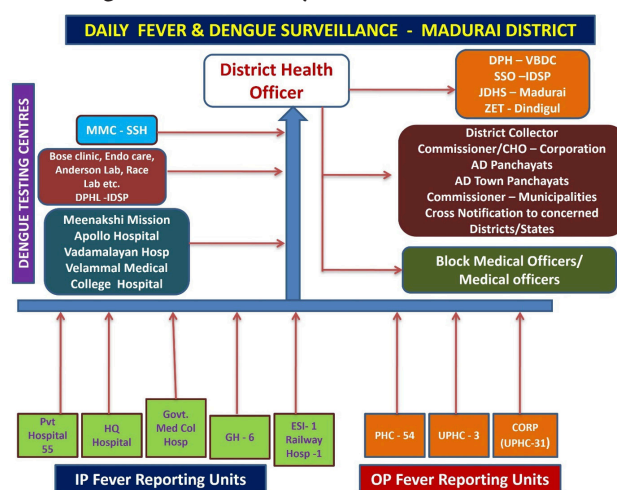


Figure 1: Fever/Dengue Surveillance system in Madurai

Prior to 2012, there was no networking of hospitals for daily fever surveillance, and the experience learned from the 2012 outbreak necessitated establishing a well-organized fever surveillance system in Tamil Nadu. Dedicated health inspectors have been deployed to all surveillance hospitals,

and data from 8.00 a.m. to 8.00 a.m. (24 hours) on a daily basis regarding the admission and discharge of fever cases and dengue cases within the last 24 hours has been collected. Thus, a total of 53 private hospitals and 10 government hospitals, including Madurai Medical College hospital, are included in the daily surveillance network in Madurai district (Figure 1). Similarly, major dengue testing laboratories in Madurai district are also included in the reporting system, and a line list of dengue positive cases is received on a daily basis. The data thus collected from surveillance hospitals and dengue testing centers are communicated to the respective peripheral health facilities and the stakeholders to take appropriate control measures immediately in the field. The District Health Officer, Madurai District, acts as a nodal officer who communicates information on dengue incidence and monitors control activities in the district.

Further, the data on the dengue cases in other districts was communicated to the districts concerned and the Directorate on a daily basis. This system has paved the way to work in coordination with all line departments, such as municipal corporation, municipalities, rural development department, town panchayats, all block level health facilities, education, ICDS, etc., Further, daily OP fever surveillance system has been established in all primary health centres in Rural Areas and Urban Primary Health Centres in corporation and municipalities and this enables the health authorities at the PHC level to take immediate intervention measures in the village/ward/street reporting fever cases continuously and to attend any area with an unusual occurrence of fever cases immediately. The flow of information at various levels is shown in Figure 1.

Dengue testing and Laboratory Network : The serological diagnosis of dengue viral infections in the Institute of Microbiology, Government Medical College Hospital (Govt Rajaji Hospital), Madurai, was carried out using the NIV IgM ELISA kit and designated as Sentinel Surveillance Hospital for dengue diagnosis. Further, in the private hospitals, dengue testing laboratories, and District Public Health Laboratory under IDSP, dengue diagnosis was done using either IgM ELISA, NS1 antigen detection ELISA, or Rapid Diagnostic Test kits that are commercially available. However, the data on the results of laboratory testing centers were collected on daily basis (8.00 a.m. to 8.00 a.m.) and communicated to the various levels online for taking the necessary interventions to interrupt dengue transmission. Thus, ten dengue testing laboratories were included in the dengue surveillance network in Madurai district.

For vector control activities, dedicated, well trained manpower designated as Domestic Breeding Checkers (DBC's) are involved in fever/dengue case reported areas. For engaging DBC's and supervising their activities related to dengue control, the intersectoral coordination with line departments such as Rural Development, Town Panchayats, Urban Local Bodies etc., is well established with a network of various staff in each department.

Data analysis : Data on the dengue case incidence for 12 years (from 2012 to 2023) were analyzed year-wise by calculating the Attack Rate / 1 Lakh population for rural areas, municipalities, and corporation and the month-wise incidence of dengue cases was also analyzed to find out the seasonal occurrence of dengue cases. Further, age-wise and sex-wise analyses of dengue cases have been done to find out the male-to-female ratio in dengue incidence and to find out whether children or adults were affected more in numbers during the study period.

RESULTS

It is obviously known that disease surveillance plays a vital role in the Public Health Care system to identify the geographical area where the disease occurrence is high, which age group is affected, and during which season the disease occurs, which enables the program implementors to act rapidly to prevent any major outbreaks. In Tamil Nadu, dengue fever outbreaks were reported in various districts, resulting in a sizeable number of dengue-related deaths during 2012. Madurai is one of the various districts where 2364 cases were reported during this period.

Dengue incidence in Madurai District from 2012 to 2023 :

Laboratory-confirmed dengue-positive cases (either by Dengue IgM ELISA, NS1 antigen ELISA, or Rapid Diagnostic Test kit) are included in the study from 2012 to 2023. Attack Rate (AR) per 1 lakh population was calculated for laboratory confirmed cases year-wise and area-wise and it was found that dengue case incidence was high during 2012 (Attack Rate 77.14), 2017 (Attack Rate 125.69), and 2023 (Attack Rate 63.0), as shown in Figure 2. Further, the analysis of the geographical distribution of cases in Madurai district revealed that dengue case incidence in rural and urban areas (Municipalities & Corporation) also showed a similar trend with high incidence during 2012, 2017, and 2023, as shown in Figure 3. Data analyzed for all blocks which included Town Panchayats and Village Panchayats separately year-wise, it was found that all blocks, showed the same trend in dengue

case incidence from 2012 to 2023, with peaks in 2012, 2017, and 2023. Similarly, the data for all 3 municipalities and Madurai Corporation, when analyzed separately, showed a similar trend in dengue case incidence in Madurai district.

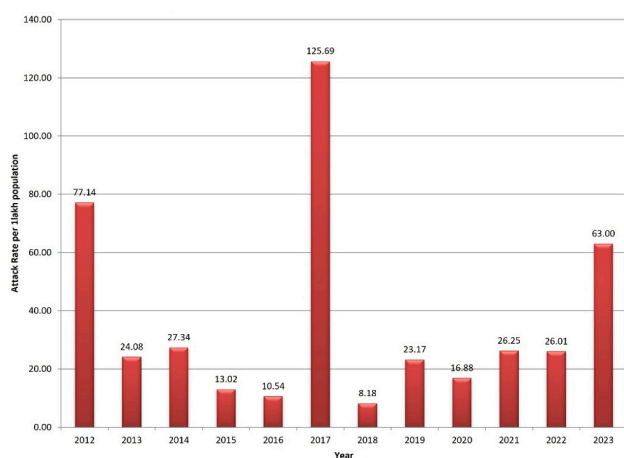


Figure 2: Attack Rate of Dengue Cases - 2012 - 2023 - Madurai District

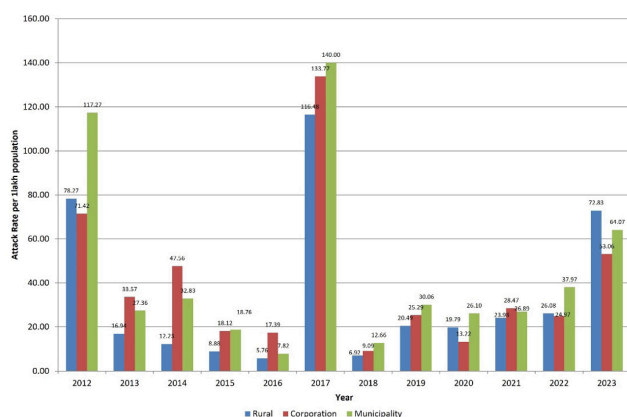


Figure 3: Area wise - Attack Rate of Dengue Cases - 2021 to 2023 Madurai District

Age wise analysis of dengue cases in Madurai district was done from 2013 to 2023, which showed that more dengue cases were reported in adults (above 12 years) than children (less than 12 years) in all years (Table 1 and Figure 4). Similarly, gender-wise analysis revealed that more males were infected with dengue infections than females (Table 1 and Figure 5) in all years. Thus, the male-female ratio for the study period with regard to dengue case incidence was found to be 1.15:1 in Madurai district.

Table 1: Age wise and Sex wise Percentage of Dengue in Madurai District (2013 to 2023)

Year	Male	Female	<=12 (Children)	>12 (Adults)
2013	54.2	45.8	43.9	56.1
2014	54.9	45.1	45.1	54.9
2015	56.4	43.6	44.6	55.4
2016	47.2	52.8	36.2	63.8
2017	51.4	48.6	30.8	69.2
2018	52.6	47.4	28.0	72.0
2019	55.1	44.9	34.7	65.3
2020	56.8	43.2	40.7	59.3
2021	56.0	44.0	34.9	65.1
2022	53.5	46.5	33.0	67.0
2023	55.8	44.2	33.3	66.7
TOTAL	53.7	46.3	34.8	65.2

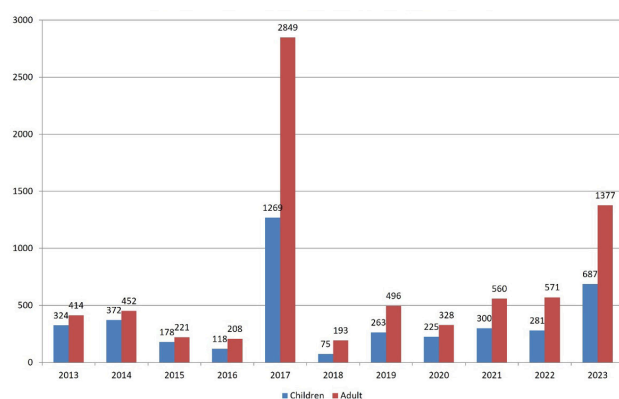


Figure 4: Age wise Dengue Cases in Madurai District (2013 to 2023)

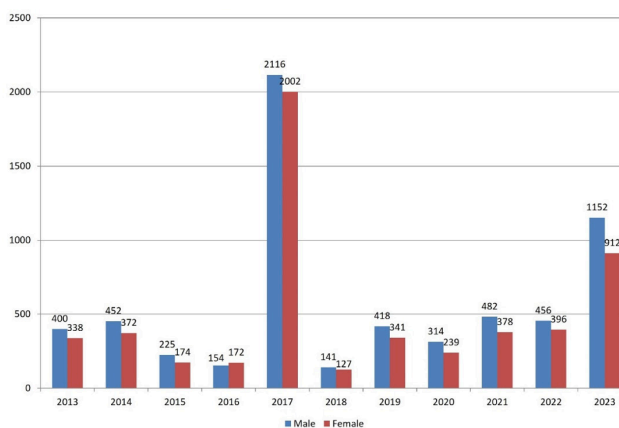


Figure 5: Sex wise Dengue Cases in Madurai District (2013 to 2023)

Seasonal occurrences of dengue cases were analyzed month-wise and year-wise from 2013 to 2023 (month-wise data is unavailable for 2012). Rainfall data collected from the District Statistical Office in Madurai showed that Madurai district receives more rainfall during the northeast monsoon period (October to December) than the southwest monsoon

period (June to July), as shown in Figure 6. It was observed that month-wise and year-wise dengue case incidence increased from June to December every year (Figure 7).

Further, when data on dengue cases were analyzed separately for urban (Figure 8) and rural (Figure 9) areas for the study period, the same trend was observed.

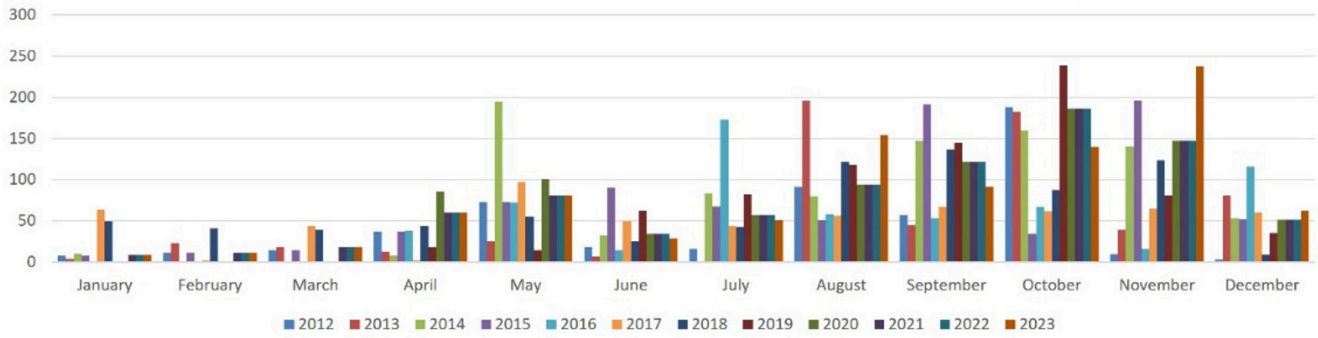


Figure 6: Month wise rainfall Recorded in Madurai District (2012 - 2023)

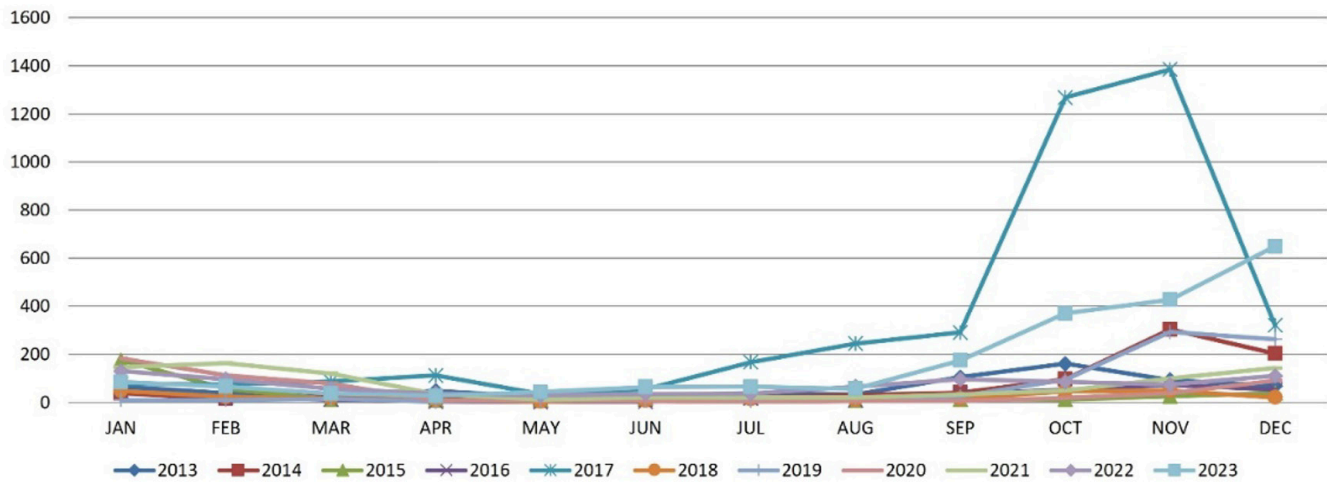


Figure 7: Month and Year wise incidence of Dengue Cases - 2013 to 2023 - Madurai District

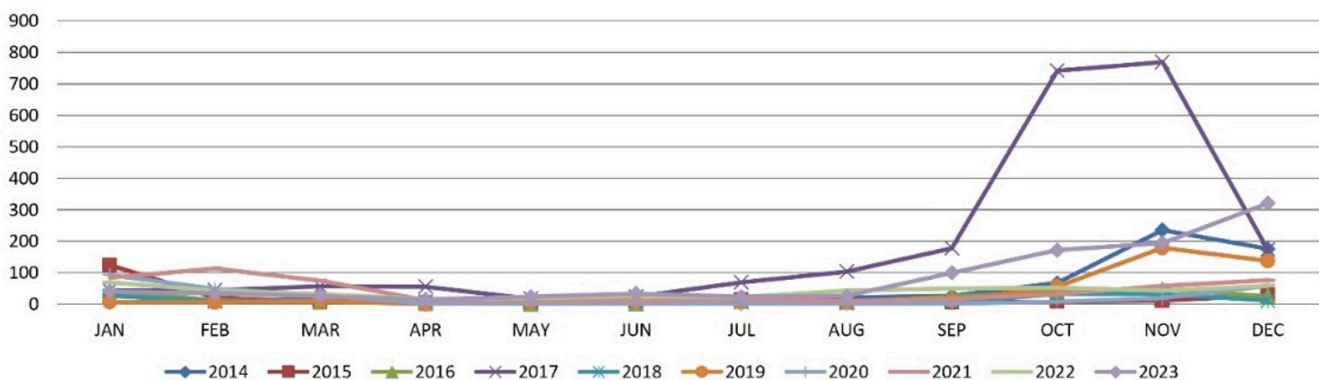


Figure 8: Month and Year wise incidence of Dengue Cases - 2014 to 2023 - Madurai District (Urban Area)

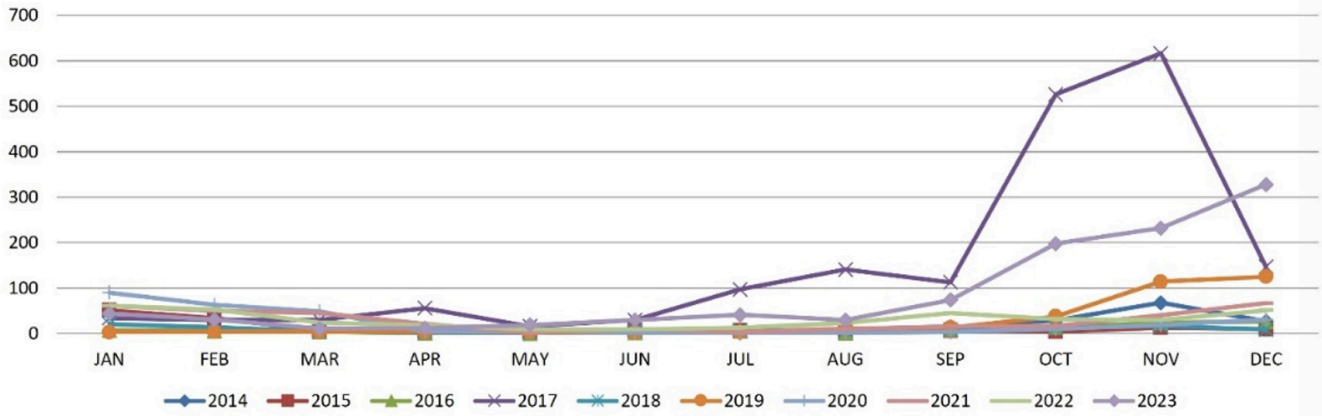


Figure 9: Month and Year wise incidence of Dengue Cases - 2014 to 2023 - Madurai District (Urban Area)

Dengue Vector Surveillance and Control :

It is well known that *Aedes aegypti* mosquitoes transmit dengue virus, and this mosquito breeds in clean water storage containers, drums, barrels, discarded containers, refrigerators, air coolers, etc. Prior to 2012, an adequate number of dengue control workers (DBC's) were not engaged in dengue control activities. However, after the 2012 dengue outbreak, due to inter departmental coordination in dengue control activities and understanding the need for increasing the work force in dengue control, 20 DBC's in each block, 10 DBC's in each Town Panchayat and the number of DBC's as per Plan 300 in Municipalities and Corporations were engaged in Madurai district. The network of Dengue Vector Surveillance and Control and the various departments and staff involved are shown in Figure 10. The areas with dengue case incidence and high *Aedes* larval density were prioritized for dengue control activities.

study period, Standard *Aedes* larval indices were calculated to assess the intensity of breeding in an area and the type of larval breeding sites found to vary from area to area. Based on the available major breeding sources in an area, appropriate control measures were taken. However, source reduction was given priority in dengue vector control activities, and the elimination of breeding sites by DBC's under the supervision of the health inspectors was carried out intensively. Indoor thermal fogging was carried out in the areas using Pyrethrum 2% extract in hand-operated fogging machines. Fogging was preferred in the areas where dengue positive cases were reported and the areas found to have a high density of *Aedes* mosquitoes. In Madurai district, all three commonly prevalent aedine species, viz., *Aedes aegypti*, *Ae. albopictus*, and *Ae. vittatus* were collected. However, *Ae.aegypti*, the principal vector of dengue, was found to be the most prevalent species in Madurai district in both rural and urban areas.

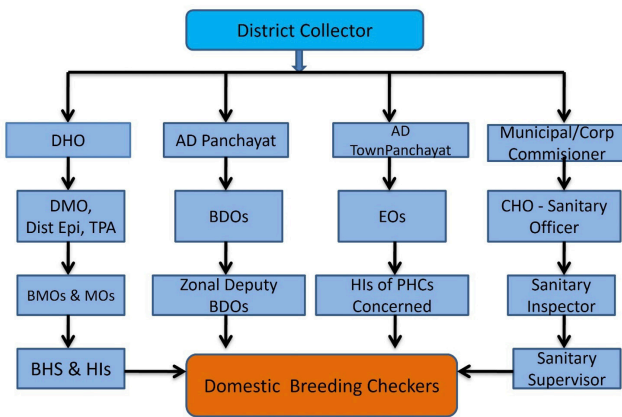


Figure 10: Dengue Vector Surveillance & Control - Madurasi District

DISCUSSION

Madurai district is one of the major cities in southern Tamil Nadu, where people from other districts visit the city for various purposes like occupation, pilgrimage, and accessing health care facilities. It has been observed for a long time that outbreaks of communicable diseases such as Hepatitis, Leptospirosis, and water-borne and vector-borne infections have occurred on several occasions in both rural and urban areas. Prior to 2012, there were sporadic occurrences of dengue cases in Madurai district, and after the development of diagnostic facilities in Madurai district, few outbreaks of dengue fever have been reported. However, the outbreak occurred during the year 2012 in urban and rural areas in Madurai district, necessitating the development of an organized and systematic surveillance system involving

all government and private hospitals where the fever cases are admitted. Subsequently, the diagnostic facilities were made available in Government Medical College Hospital and Private Hospitals paving the way for identifying the geographical areas with the highest prevalence of dengue cases and the timely management of severe dengue cases in hospitals following standard treatment protocols.

The IP Fever/Dengue surveillance system on a daily basis in all health care facilities has helped in the timely implementation of intervention measures like fever control activities and vector control strategies through Primary Health Care network involving the line departments. Hence, the number of outbreaks reported in Madurai district in recent years has drastically reduced, and at the same time, the surveillance system and vector control have also been strengthened in Madurai district.

It is obviously known that the circulation of multiple serotypes and genotypes of dengue viruses in the community favors the occurrence of Dengue Haemorrhagic Fever (DHF), a severe form of dengue fever that requires immediate medical attention. A study on molecular analysis of dengue virus serotypes circulating in Chennai, Tamil Nadu, revealed that the samples tested were positive for dengue 2 virus and dengue 3 virus during 2013 – 2015¹¹ and it was found that the Dengue virus-3 serotype belonged to genotype III and clustered with Delhi and Gwalior sequences. Similarly, another study conducted in O. Alangulam village in a rural area of Madurai district, Tamil Nadu, also showed that the sample tested was positive for Dengue 3 serotype, and phylogenetic analysis revealed that it was closely related to the Delhi-12 and Gwalior-25 isolates¹². The authors have concluded that the Dengue 3 virus might have invaded this area through a North Indian traveler infected with this dengue virus to the airport which is geographically closer to the village. These findings made during dengue outbreaks may be useful in the documentation of the prevalence of different serotypes and genotypes that are circulating in the community. However, the detection of dengue virus infections in mosquitoes will be very helpful in forecasting possible outbreaks and can be considered an essential tool for epidemiological surveillance.

The Cyclical occurrence of dengue has been established in the present study. Further studies are needed to analyze various factors, including the invasion of new serotypes and Genotypes in the community as reported in other areas, so as to develop newer strategies for dengue control.

Several studies in Tamil Nadu have documented the

presence of all four serotypes of dengue viruses in *Ae. aegypti* mosquitoes since 1960s^{4,5,8,13} and vertical transmission of dengue virus in *Ae. aegypti* mosquitoes has been confirmed in wild caught mosquitoes in Tamil Nadu, confirming that the dengue virus is maintained in nature during the inter-epidemic period.¹⁴ Therefore, it is understood that there is a need for an effective surveillance system to find out dengue virus infections in mosquitoes to forecast outbreaks in Tamil Nadu. However, the epidemiological significance of the vertical transmission of dengue virus in *Aedes* mosquitoes in the occurrence of clinical cases of dengue fever needs to be studied in detail.

In the present study, it was observed that the dengue cases increased from June onwards, and the cases peaked during October and November following the monsoon period. Similar trend in Tamil Nadu has already been documented from 1998 to 2006, where dengue cases increased from June to December, confirming the active transmission period was during the monsoon and post monsoon period.¹⁰

Entomological surveillance carried out in the study area during 2012 -2023 has revealed that *Aedes aegypti* is the most prevalent dengue vector in Madurai district. The *Aedes* larval survey carried out in both rural and urban areas showed that peri-domestic water holding containers provided major breeding sites for *Aedes* mosquitoes during monsoon and postmonsoon periods. But during the summer season, water storage practices of people due to scarcity of water, resulted in high breeding of *Aedes* mosquitoes. However, the type of breeding habitat varies from one area to another. For instance, during 2012, a higher number of cases were reported in rural and urban areas of Melur block. In this area, the Ground Level Reservoir (GLR) and the pit taps acted as potential breeding sites for dengue vectors. Similarly, in the Corporation area, the water storage containers provided breeding grounds for *Aedes* mosquitoes. Hence, it is suggested that the anti-larval activities be formulated as per the types of breeding sites available in an area.

The results of the present study show that there is a definite pattern of epidemic cycle in the occurrence of dengue cases, and it is found that once every 5 to 6 years, there is an epidemic form of dengue in Madurai district. A study conducted in Singapore from 2004 to 2016 revealed that the dengue epidemic pattern followed once every three years, and in each epidemic cycle, dengue cases peaked during the traditional dengue transmission season from June to September.¹⁵ However, there are reports that emphasize that the changing pattern of circulating serotypes and genotypes during epidemics needs to be known to understand the

severity of the cases occurring in an area.¹¹

Dengue cases were reported in greater numbers in males than females from 2013 to 2023 in Madurai district, and the male: female ratio was found to be 1.5:1. Similar observations were made in several studies conducted in Tamil Nadu¹² and in Kolkatta¹⁶ India, in Saudi Arabia¹⁷ and in Singapore¹⁵ where more number of dengue cases were reported in males than females, whereas male:female ratio was 1:1 in Argentina¹⁸ and it was observed 1:4 in Karachi, Pakistan, in 2006.¹⁹ In the present study it was observed that dengue virus infections occurred more numbers in adults than Children in all the years under study. This is in conformity with the results observed in Malaysia²⁰, Argentina¹⁸, Singapore¹⁵ and in Kolkatta, India.¹⁶

CONCLUSION

Prior to 2012, dengue cases were reported sporadically in Madurai district, and the outbreak that occurred during 2012 necessitated the establishment of a routine surveillance system in the district. An unique Daily Fever surveillance system followed in Tamil Nadu involving sentinel centers involving Government and Private Hospitals has paved the way for identifying the areas with clustering of cases and is also useful in the implementation of appropriate control measures in coordination with the line departments in Madurai district. It is evident from the present study that there is a definite pattern of epidemic cycle in the occurrence of dengue fever once every 5 years in Madurai district, Tamil Nadu, which emphasizes the need for preparedness to implement appropriate control measures in the vulnerable areas in both urban and rural areas.

It is also observed that dengue cases occur in greater numbers from June to December, indicating that monsoon and postmonsoon periods are the active transmission periods because of the increased breeding sources available for *Aedes aegypti* mosquitoes in peri-domestic areas. However, it is noticed that the larval density is high indoors during the summer season since people tend to store water for more than a week. These results are in conformity with the results of the studies conducted in Tamil Nadu from 1998 to 2006¹⁰. Therefore, it is concluded that the transmission of dengue occurred in large numbers from June to December as evidenced from the data available from 1998 to 2023 (26 years of data). Further, the dengue Attack Rate in all 12 years under study revealed that both rural and urban areas followed a similar trend in all these years. The spatial distribution of cases shows that all rural and urban areas are affected with dengue cases sporadically. Systematic planning

and execution control activities utilizing available Domestic Breeding Checkers throughout the year have resulted in preventing many outbreaks in Madurai District.

Earlier investigations conducted during an outbreak in Madurai district revealed that the Dengue -3 serotype is circulating in certain rural areas of the district¹². It indicates the circulation of multiple serotypes and genotypes in the community. Further longitudinal studies are to be carried out to explore the occurrence or invasion of new serotypes or genotypes in the community in various seasons to map out the areas with a prevalence of various serotypes in Madurai district. Since, no vaccine is available for dengue control, the only possible way is vector control. *Aedes aegypti*, the principal vector of dengue fever, is the most abundant species in all areas, and the breeding sites vary from area to area. Therefore, appropriate control measures, such as source reduction and the application of larvicides, should be selected based on the availability of potential breeding sites. Vertical transmission of dengue virus has already been established in Tamil Nadu, and the virus is maintained in inter-epidemic periods, which favors the silent transmission of dengue virus in the community¹³. Dengue viral infection in vector mosquitoes, an essential tool for epidemiological surveillance, should be further strengthened with standard protocols so as to forecast any possible DF/DHF outbreaks in Tamil Nadu.

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