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A study of geospatial distribution and seasonal trend of dengue fever in a Ratnagiri District of Konkan Region of Maharashtra

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Abstract

Introduction: Dengue fever, a vector-borne disease primarily transmitted by Aedes aegypti and Aedes albopictus, poses a significant public health challenge in tropical and subtropical regions, including the Asia-Pacific. The Konkan region of Maharashtra, with heavy monsoon rainfall, an average temperature of 25ºC, and 73% humidity, provides an ideal environment for dengue transmission.

Methods: A record-based descriptive study was conducted in Ratnagiri district (August 2024–January 2025) using secondary data from the government health administration (January 2020–December 2023). Descriptive statistics determined epidemiological distribution, while Pearson's Chi-square test assessed associations. Geospatial mapping with QGIS 3.40.1 visualized disease patterns.

Results: Among 398 cases, males (64.57%) had a significantly higher burden than females (35.43%) ($p < 0.001$). The 16–30 age group was most affected (41.46%). Cases peaked in September–October. Ratnagiri and Chiplun subdivisions had the highest burden, with five prominent hotspots identified.

Conclusion: The monsoon and post-monsoon periods were high-risk transmission windows. Geospatial mapping can aid real-time monitoring, targeted vector control, and outbreak preparedness. Further research should explore the socio-environmental determinants of dengue transmission.

Keywords: Geospatial distribution; Dengue fever; Hotspots; Seasonal trend; Epidemiology; Vector control

1. Introduction

Dengue fever, a mosquito-borne viral infection, remains a major public health concern in tropical and subtropical regions, including Asia, the Pacific, the Americas, and Africa. It is primarily transmitted by *Aedes aegypti* and *Aedes albopictus*, with *DENV 1–4* of the *Flaviviridae* family as its causative agent. The disease manifests as an acute febrile illness, often progressing to severe complications such as haemorrhage, hepatomegaly, and multi-organ dysfunction (1). Over 2.5 billion people globally are at risk, with an estimated 100 million cases occurring annually (2). India has witnessed a growing burden of dengue since its first outbreak in Kolkata in 1963, with a progressive geographical expansion to rural areas due to unplanned urbanization, climate change, and inadequate vector control measures (3). Maharashtra is one of the worst-affected states, reporting 19,034 cases and 55 deaths in 2023. The extended monsoon, high humidity, and inadequate vector management have contributed to persistent disease transmission in urban and peri-urban areas such as Mumbai, Pune, Nagpur, and Kolhapur (4).

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Geospatial analysis has emerged as a crucial tool in dengue surveillance, enabling the identification of hotspots and high-risk zones for targeted interventions. Geographical Information Systems (GIS) allow the visualization of disease spread, optimizing vector control measures and outbreak preparedness (5). Ratnagiri district, located in the Konkan region of Maharashtra, is highly vulnerable to dengue transmission due to its tropical monsoon climate, heavy rainfall, and high humidity. Spanning 8,326 square kilometres with a projected population of 1.53 million in 2024, the district exhibits significant spatial variations in disease burden (6). This study aims to analyze the epidemiology, seasonal trends, and geospatial distribution of dengue cases in Ratnagiri district using GIS-based mapping. The findings will aid in designing evidence-based vector control strategies and improving public health responses to dengue outbreaks.

2. Methodology

A record-based descriptive study was conducted in Ratnagiri district, Konkan region of Maharashtra, over six months (August 2024–January 2025). As dengue is a notifiable disease, all laboratory-confirmed cases (*IgM +ve* or *NS1 Antigen +ve* ELISA) reported to the government health administration were included. Data recorded included age, sex, location (colony/street, subdivision, and district), and date of notification.

A universal sampling technique was applied, encompassing all computerized dengue case data from January 2020 to December 2023 as recorded by the government health administration of Ratnagiri district.

Descriptive analysis was performed to determine the epidemiological distribution by age, sex, seasonal trends, and subdivision-wise case distribution. Pearson's Chi-square test assessed associations between demographic variables, seasonality, and geographical spread. Geospatial analysis was conducted using QGIS 3.40.1, generating geocoded maps to visualize disease patterns. Results were presented in tabular, graphical, and GIS-based formats to enhance interpretation and guide public health interventions.

2.1. Ethical Considerations

This study was conducted after obtaining approval from the Institutional Ethics Committee (IEC) of Grant Government Medical College and Sir J.J. Group of Hospitals, Mumbai (Approval No: IEC/Pharm/RP/29/JAN/2025). The research adhered to the Good Clinical Practice (GCP) and ICMR guidelines, ensuring compliance with ethical standards. As the study used secondary data from government health records, no direct patient interaction was involved, and all data were anonymized to maintain confidentiality.

3. Results

A total of 398 confirmed dengue cases were recorded between 2020 and 2023, with a gradual increase over the years and a sharp rise in 2023. The highest number of cases (239; 60.05%) was reported in 2023, followed by 106 cases (26.63%) in 2022, 32 cases (8.04%) in 2021, and 21 cases (5.28%) in 2020 (Table 1).

Among all cases, males (64.57%) were significantly more affected than females (35.43%), with a statistically significant difference ($\chi^2 = 25.79$, $p < 0.001$) (Table 1). Dengue affected all age groups, with the highest proportion in the 16–30 years age group (41.46%), followed by 31–45 years (25.62%). The 0–15 years age group accounted for 15.07%, while 46–60 years and above 60 years had 13.32% and 4.53%, respectively ($\chi^2 = 22.48$, $p < 0.05$) (Table 1).

Dengue cases began increasing in June–July, peaked in September–October, and declined from November onwards. The monsoon period (June–September) contributed 47.73% of cases, followed by the post-monsoon period (October–December) (37.94%), and the pre-monsoon period (January–May) accounted for 14.33% ($\chi^2 = 91.19$, $p < 0.001$) (Table 1, Figure 1).

The geographical distribution of cases showed spatial heterogeneity, with Ratnagiri (52.26%) and Chiplun (21.36%) reporting the highest burden. Other subdivisions, including Sangmeshwar (6.78%), Khed (6.03%), Dapoli (6.03%), and other areas (7.54%), had fewer cases. The association between subdivision and year of occurrence was statistically significant ($\chi^2 = 101.99$, $p < 0.001$) (Table 1, Figure 2).

Table 1 Annual Distribution of Dengue Cases by Age, Sex, Season, and Subdivision in Ratnagiri District (2020–2023)

Variables	**Dengue cases reported %**				**Total (N=398)**	**Chi-square Value**	**p-Value**
	2020	**2021**	**2022**	**2023**			
	(N= 21)	**(N=32)**	**(N=106)**	**(N=239)**			
Gender							
Male	6(28.57)	28(87.50)	79(74.53)	144(60.25)	257(64.57)	25.79	<0.001
Female	15(71.43)	4(12.50)	27(25.47)	95(39.75)	141(35.43)		
Age Groups							
0-15	1(4.76)	4(12.50)	8(7.55)	47(19.66)	60(15.07)	22.48	<0.05
16-30	9(42.86)	15(46.88)	40(37.73)	101(42.26)	165(41.46)		
31-45	6(28.57)	10(31.25)	33(31.13)	53(22.18)	102(25.62)		
46-60	5(23.81)	1(3.12)	21(19.82)	26(10.88)	53(13.32)		
> 60	0(0)	2(6.25)	4(3.77)	12(5.02)	18(4.53)		
Seasons							
Pre-monsoon (January - May)	17(85.95)	1(3.12)	9(8.49)	30(12.55)	57(14.33)	91.19	<0.001
Monsoon (June- September)	4(19.05)	24(75)	51(48.11)	111(46.44)	190(47.73)		
Post monsoon (October - December)	0(0)	7(21.88)	46(43.40)	98 (41.01)	151(37.94)		
Subdivision							
Ratnagiri	7(33.33)	8(25)	40(37.73)	153((64.01)	208(52.26)	101.99	<0.001
chiplun	0(0)	12(37.5)	34(32.07)	39(16.33)	85(21.36)		
Sangmeshwar	2(9.52)	3(9.37)	12(11.33)	10(4.18)	27(6.78)		
Khed	0(0)	6(18.75)	9(8.49)	9(3.76)	24(6.03)		
Dapoli	8(38.10)	1(3.13)	1((0.94)	14(5.87)	24(6.03)		
Others	4(19.05)	2(6.25)	10(9.44)	14(5.85)	30(7.54)		

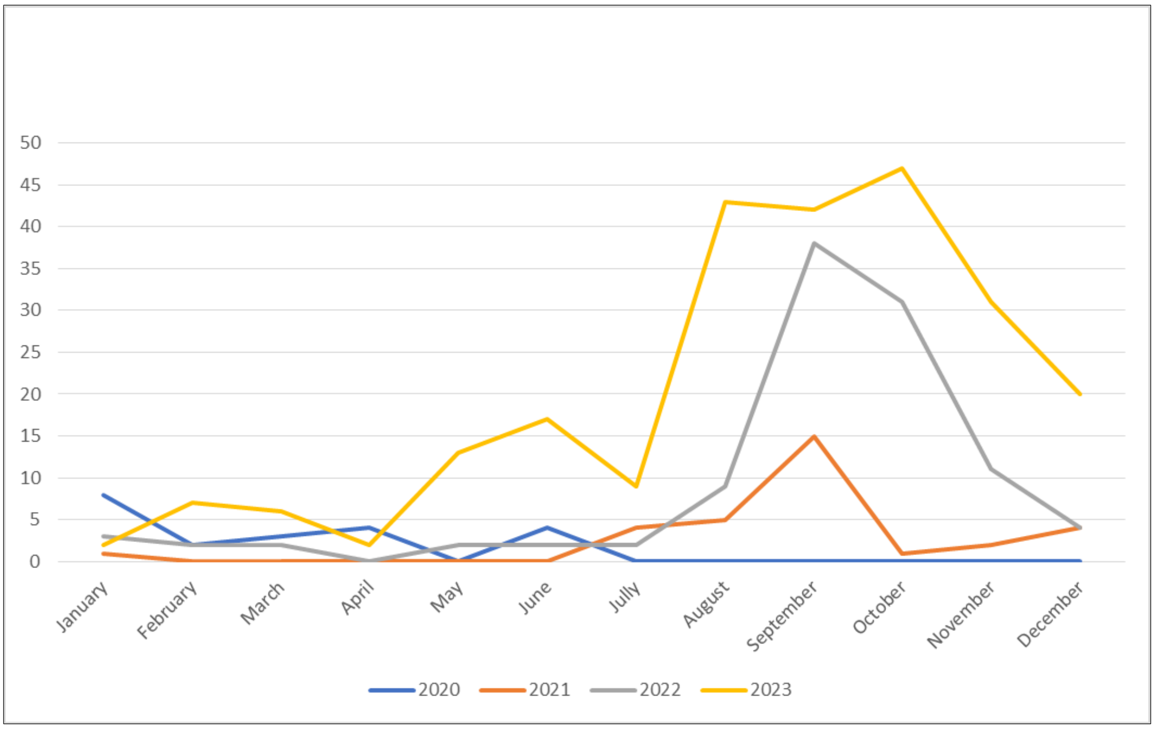

Figure 1 Month-wise number of laboratory-confirmed Dengue cases reported in the district Ratnagiri- 2020- - 2023

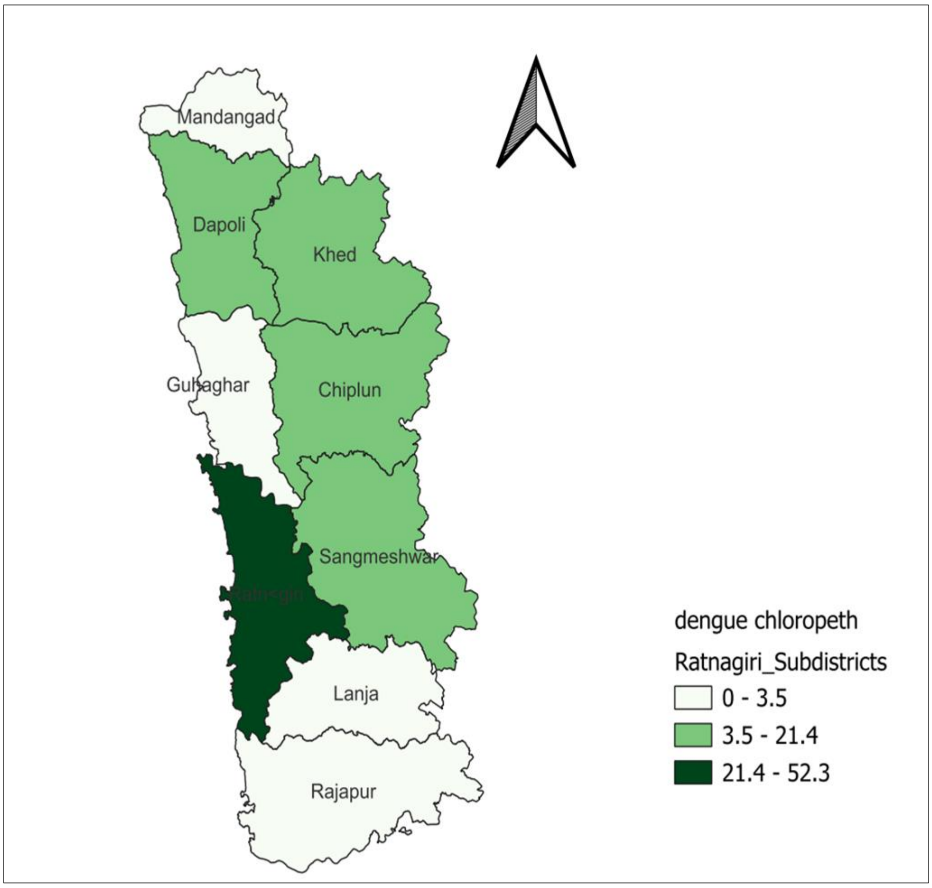

Figure 2 Choropleth map of Dengue Cases distribution in Ratnagiri District of Maharashtra (2020–2023)

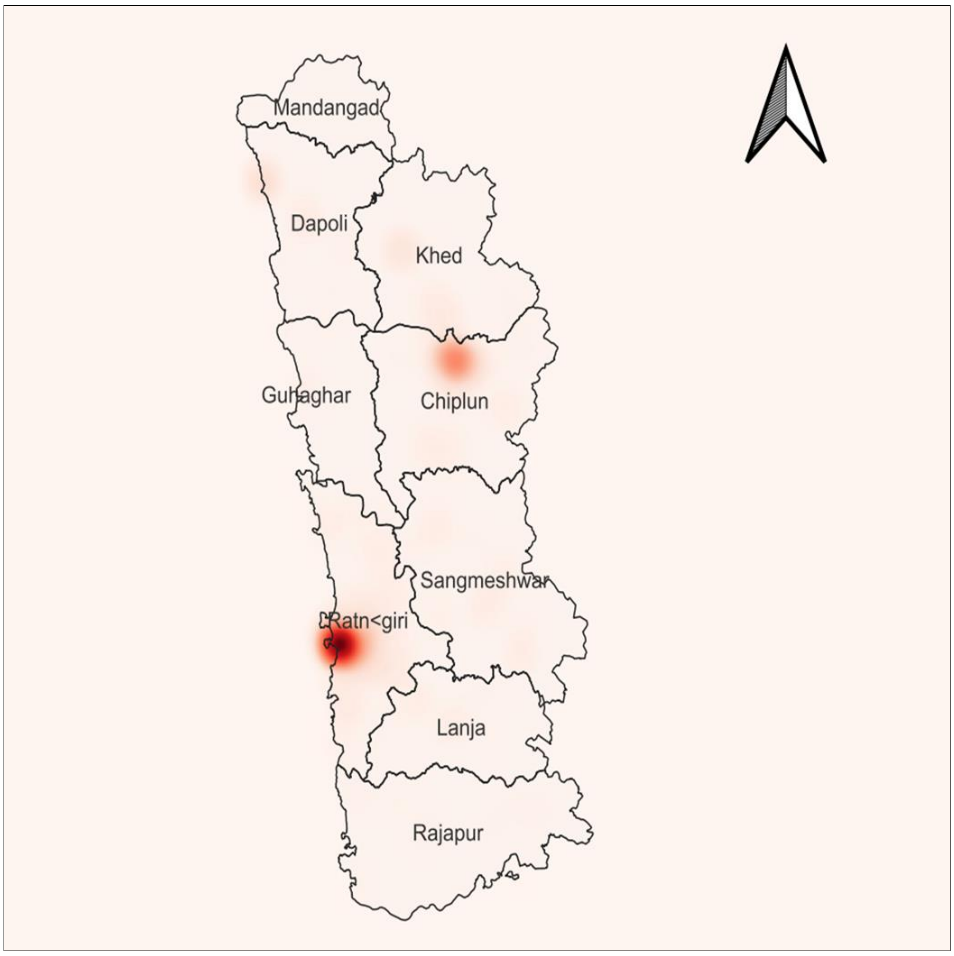

Figure 3 Heatmap Showing Hotspots of Dengue Cases in Ratnagiri District of Maharashtra (2020–2023)

The spatial distribution revealed clustering, with the highest concentrations in Ratnagiri and Chiplun, while Mandangad, Guhagar, Lanja, and Rajapur had lower case densities (Figure 2). Heatmap analysis identified major dengue hotspots in Ratnagiri and Chiplun, with smaller hotspots in Khed and Dapoli (Figure 3). The hotspots were concentrated in urban wards, slum areas, and densely populated villages. These findings highlight seasonal peaks, demographic susceptibility, and spatial clustering.

4. Discussion

Dengue cases recorded from the year 2020 to 2023 indicate an increasing trend, which may be due to societal changes such as urban population growth, rapid unplanned urbanization with unchecked construction activities, and poor sanitation facilities contributing to fertile breeding grounds for mosquitoes (7). The low number of reported dengue cases in 2020 and 2021 may be attributed to the COVID-19 pandemic. The analysis revealed a gender association with the occurrence of dengue cases. The male-to-female ratio of dengue cases was reported as 1.9:1 and 1.4:1 in different studies, which was comparable to our findings (1.8:1) (8). The high proportion of cases recorded among males was possibly due to greater exposure to outdoor work, increasing the risk of mosquito bites (9).

The association between age and the occurrence of dengue cases was significant, with more cases recorded in the 16–30 and 31–45 age groups. A study in Udupi district, Karnataka, also reported a higher number of cases in the 15–44 age group. The high incidence in younger individuals was possibly due to the co-circulation of multiple serotypes of dengue, increasing disease susceptibility. However, the higher number of cases among adults may be due to greater exposure to infection during outdoor working activities (10).

The occurrence of dengue cases was significantly associated with seasons. The trend of dengue cases increased during the monsoon season, peaked in September–October, and then gradually declined, which was also reported by other studies (11). This was mainly due to an increase in breeding sites in stagnant water after the monsoon, leading to a rise in the number of mosquitoes hatching. However, heavy rainfall during the monsoon in July can have a decreasing effect on mosquito density due to the washout of breeding sites (12).

The spatial analysis of dengue cases in Ratnagiri district shows spatial diffusion patterns and significant variation in the spatial distribution, enabling the identification of dengue hotspots. The presence of dengue cases was mainly confined to two subdivisions, Ratnagiri and Chiplun, across all four years, possibly due to the high urban population and industrialization in these areas (13). The geospatial analysis identified four hotspots, which are useful for targeting interventions to control vector-borne diseases such as dengue by focusing on mosquito vector control. Such identification has operational implications for detecting and responding effectively with a proper surveillance system for better dengue control (14).

Limitation

The findings of this study have certain limitations, as they are based on the analysis of reported dengue cases provided by the government health authorities. Although dengue is a notifiable disease, and it is mandatory to record all cases reported to hospitals, the possibility of under-reporting cannot be ruled out.

5. Conclusion and Recommendation

The occurrence of dengue showed a significant association with age, sex, and seasonal variation across the study years. The majority of dengue cases were reported in the Ratnagiri and Chiplun subdivisions, likely due to high urbanization and industrialization in these areas. Geospatial analysis identified four hotspot areas, which can assist health administrators in implementing targeted prevention strategies and improving disease management. Strengthening community awareness, early diagnosis, and prompt management, along with rigorous vector control measures, is essential, particularly during the peri-monsoon period, to mitigate the increasing burden of dengue cases. The findings of the spatial analysis are instrumental in guiding targeted interventions for dengue control in hotspot areas and curbing its spread using QGIS-based geospatial techniques. Identifying spatial clusters of dengue cases serves as a critical tool for policy planning, optimizing resource allocation, and establishing achievable timelines for public health interventions.

5.1. Relevance to Preventive Medicine

This study highlights the seasonal surges in dengue fever cases, reinforcing the necessity for proactive vector control strategies and public health interventions. The monsoon and post-monsoon peaks emphasize the need for pre-monsoon preparedness, intensified larval source reduction, and targeted insecticide application to mitigate outbreaks. Additionally, geospatial mapping of hotspots provides a crucial tool for localized intervention planning, allowing health authorities to prioritize high-risk areas and allocate resources efficiently.

5.2. Implications for Clinical Practice

Incorporating geospatial analysis and predictive modelling can significantly enhance dengue surveillance, outbreak forecasting, and clinical preparedness. Identifying high-burden subdivisions enables healthcare providers to anticipate case surges, optimize bed capacity, and ensure timely access to diagnostic and therapeutic services. Real-time disease monitoring through GIS-based tools can facilitate early case detection, rapid response, and improved patient management, ultimately reducing morbidity and mortality during peak transmission seasons.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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