Kavya Setu
A Multidisciplinary Open Access, Peer-Reviewed Refereed Journal
Impact Factor: 7.2 ISSN No: 3049-4176

Study Of Environmental And Socioeconomic Factors Contributing To Dengue Outbreak In Maharashtra

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Abstract
Dengue fever is a rapidly expanding Aedes-borne viral infection and a continuing public health challenge in India. The disease is strongly influenced by climatic, environmental, demographic and socioeconomic conditions that promote mosquito breeding and human-vector contact. Maharashtra has repeatedly reported dengue cases and deaths in the national surveillance system, with marked year-to-year variation and urban clustering. The present study was undertaken to assess environmental and socioeconomic factors contributing to dengue outbreak in Maharashtra, with special attention to household water storage, drainage, sanitation, waste disposal, housing, population density and dengue prevention awareness. An analytical community-based cross-sectional study approach was used. The study population comprised households from selected outbreak-affected urban and peri-urban areas of Maharashtra. Data collection included a structured questionnaire, socioeconomic assessment and environmental observation checklist. Data were tabulated by dengue case-household status and analysed using descriptive statistics, chi-square test and odds ratio. A p value less than 0.05 was considered statistically significant. The analysis showed that uncovered or irregularly cleaned water storage containers, stagnant water near households, blocked/open drainage, poor waste disposal and visible mosquito breeding sites were more frequent among dengue case households. Low education, lower income, larger family size, semi-pucca housing, overcrowding and inadequate awareness were associated with increased dengue risk. High environmental risk score showed the strongest association with dengue occurrence.

Keywords: Dengue, Maharashtra, Environmental factors, Socioeconomic factors

I. INTRODUCTION

Dengue fever is among the most important mosquito-borne viral infections affecting tropical and subtropical regions. It is caused by dengue virus, transmitted primarily through infected female Aedes aegypti and, to a lesser extent, Aedes albopictus mosquitoes. The World Health Organization has described dengue as a disease whose global incidence has increased substantially in recent decades, with nearly half of the world population living in areas at risk. The public health importance of dengue lies not only in the number of cases but also in its capacity to produce seasonal outbreaks, overwhelm urban health services and cause severe disease and death when diagnosis and supportive care are delayed. In India, dengue has changed from an episodic urban disease to an endemic and recurrent public health problem. Maharashtra represents a useful setting for studying dengue because the state includes large metropolitan corporations, industrial towns, peri-urban settlements, rural areas with rapid urban transition and climate zones ranging from coastal humidity to inland dry heat. These features create diverse environmental niches for Aedes mosquitoes. The relationship between dengue and environmental conditions is therefore complex; rainfall may create containers and puddles, but heavy flushing rains may reduce larvae, while temperature and humidity influence mosquito survival, virus development and biting behaviour.

Overview of Maternal Health Services under NHM

Dengue fever is an acute febrile illness caused by four antigenically distinct dengue virus serotypes. Infection with one serotype produces long-term immunity to that serotype but not necessarily to the others. The clinical presentation ranges from asymptomatic infection to undifferentiated fever, classical dengue fever, dengue with warning signs and severe dengue. Common symptoms include sudden fever, headache, retro-orbital pain, myalgia, arthralgia, rash, nausea and leucopenia. Severe dengue may involve plasma leakage, haemorrhage, severe organ involvement and shock. There is no specific antiviral treatment for dengue; early recognition, fluid management and referral are central to reducing mortality.1 The vector biology of dengue is closely linked with the domestic environment. Aedes mosquitoes often breed in clean water accumulated in artificial containers such as drums, buckets, overhead tanks, discarded tyres, flowerpots, coolers, construction materials and solid waste. Aedes aegypti is a day-biting mosquito and prefers human dwellings, making household and community behaviour highly relevant to transmission. Therefore, dengue prevention cannot be limited to hospital care. It must include source reduction, environmental management, household water protection, community education and local government sanitation measures.

II. LITERATURE REVIEW

Global Burden of Dengue

Bhatt et al. (2013) estimated the global distribution and burden of dengue and highlighted that many infections remain unreported because of asymptomatic infection and weak surveillance systems.The work shifted global understanding from dengue as a disease of selected tropical cities to a widely distributed infection with substantial hidden burden.

Wilder-Smith et al. (2019) reviewed dengue as a major global infection and discussed the complexity of prevention because vector control, vaccines, clinical management and surveillance all have limitations. The review emphasized that dengue is expanding geographically and that urbanization and mobility are important contributors.

The World Health Organization (2025) described dengue as a rapidly increasing global public health challenge and noted that prevention and control rely primarily on vector control, while early diagnosis and proper clinical care reduce fatality.1 This is directly relevant to public health planning in India and Maharashtra.

Dengue Burden in India

Gupta et al. (2012) reviewed dengue in India and described its expansion, changing epidemiology and recurring outbreaks across several states. Their review showed that dengue had become a major public health concern with urban and semi-urban transmission.

Murhekar et al. (2019) conducted a cross-sectional population-based serosurvey in India and demonstrated substantial dengue seroprevalence with geographic heterogeneity. This indicates that surveillance data underestimate true infection exposure and that prevention must be informed by local risk.

Mutheneni et al. (2017) analysed dengue trends in India and emphasized the role of climatic parameters in dengue transmission. Their findings support the use of climatesensitive surveillance and early warning in state programmes.

Dengue Situation in Maharashtra

NCVBDC surveillance data show that Maharashtra reported 19034 dengue cases and 55 deaths in 2023, 19385 cases and 40 deaths in 2024 and 14168 cases and 24 deaths in 2025.5 The state therefore remains a high-priority area for dengue prevention, especially during monsoon and post-monsoon months.

Sophia et al. (2025) examined dengue dynamics in Pune and found that temperature, rainfall and relative humidity influenced dengue mortality at lag periods of two to five months. This study is highly relevant because Pune is an important urban centre in Maharashtra and demonstrates how climate variables can provide lead time for outbreak preparedness.

Studies Related to Climatic Factors and Dengue

Kakarla et al. (2019) studied lag effects of climatic variables on dengue burden in India and reported that rainfall, temperature and humidity can influence transmission with time lags. Such lag effects are important for forecasting because vector breeding and virus amplification do not occur immediately after weather changes.

Nasirian (2025) discussed factors influencing establishment of dengue vectors in urban areas and described how temperature, rainfall and humidity affect vector breeding, survival and spread.9 The review supports the inclusion of climatic and micro-environmental variables in dengue outbreak studies.

Studies Related to Rainfall, Temperature and Humidity

Rainfall can increase Aedes breeding by filling artificial containers, while excessive rain may flush larvae from some sites. Temperature affects mosquito development, survival and extrinsic incubation of the virus. Relative humidity supports adult mosquito longevity. The Pune climate-dengue study provides a Maharashtrabased example showing that dengue mortality may respond to rainfall, temperature and humidity at different lag periods.

These findings imply that dengue surveillance should be linked with meteorological monitoring. For Maharashtra, pre-monsoon inspections, monsoon source reduction and post-monsoon fever surveillance are all important.

Studies Related to Water Stagnation and Mosquito Breeding

Aedes mosquitoes breed in domestic and peri-domestic water collections. NCVBDC guidelines for prevention and control of Aedes breeding emphasize environmental manipulation, personal protection, IEC/BCC and institutional responsibility in preventing breeding sources.

Buhler et al. (2019) reviewed environmental methods for dengue vector control and described interventions such as emptying containers, cleaning potential breeding sites, using covers, waste management, clean-up campaigns and improved piped water supply. These interventions are practical and directly relevant to household and community settings. '

Studies Related to Waste Disposal and Drainage Conditions

Poor waste disposal contributes to dengue by increasing water-holding discarded materials such as cups, bottles, tyres and plastic containers. Blocked drains and open plots can retain water after rainfall. Studies of socio-ecological predictors in Indian urban areas have identified garbage collection and drainage conditions as relevant to dengue risk. The literature suggests that waste disposal and drainage must be measured not merely as municipal indicators but as household-perceived and directly observed environmental conditions.

III. MATERIALS AND METHODOLOGY

Study Design

The study design was community-based analytical cross-sectional. This design was selected because it allows assessment of exposure variables and dengue case-household status during a defined outbreak period. It is suitable for identifying associations between environmental and socioeconomic conditions and dengue occurrence at household level.

Study Area

The study area included selected outbreak-affected urban and peri-urban localities of Maharashtra. Wards were selected to represent variation in municipal services, housing density, water storage patterns and sanitation conditions. The state context included high-burden urban centres and peri-urban settlements where dengue risk is influenced by monsoon rainfall, water storage, construction activity and population movement.

Study Population

The study population consisted of households residing in selected localities during the study period. A household was considered the unit of study because dengue prevention practices, water storage, sanitation and socioeconomic characteristics are mainly organized at household level. Adult respondents aged 18 years and above who were responsible for household management or able to provide information were interviewed.

Study Period

The study period was planned for one year, covering pre-monsoon, monsoon and post-monsoon phases. This time frame was appropriate because dengue transmission in Maharashtra is often seasonal and associated with rainfall and vector breeding patterns.

Sample Size

A sample size of 300 households was considered adequate for descriptive and analytical assessment of selected determinants. The sample included 120 dengue case households and 180 non-case households from the same or comparable localities. The sample size allowed comparison of environmental and socioeconomic exposures between groups and enabled chi-square testing for major variables.

Sampling Technique

A multistage sampling technique was used. First, outbreak-affected districts and urban/peri-urban localities were identified from health records. Second, wards with reported dengue clustering were selected. Third, case households were identified with the help of health workers and local records, and non-case households were selected from neighbouring areas to represent comparable environmental exposure.

Inclusion Criteria

Households residing in the selected area for at least six months; households with an adult respondent aged 18 years or above; households willing to participate; dengue case households with reported dengue during the reference outbreak period; and non-case households without reported dengue during the same period were included.

Exclusion Criteria

Households locked during repeated visits; households not willing to participate; respondents unable to provide consent; households with incomplete information; and households that had migrated into the area after the reference outbreak period were excluded.

Study Variables

The dependent variable was dengue case-household status. Independent variables included environmental factors, socioeconomic factors, awareness level and preventive practices. Environmental factors included rainfall context, temperature and humidity perception, stagnant water, drainage, waste disposal, mosquito breeding sites and household surroundings. Socioeconomic variables included income, education, occupation, housing type, family size, population density and water storage practices.

Table 1: Study variables and measurement approach

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Impact Factor: 7.2 ISSN No: 3049-4176

Variable group	Variables	Measurement
Dependent variable	Dengue case-household status	Case household / non-case household
Environmental variables	Water stagnation, drainage, waste disposal, breeding sites, housing surroundings	Observation checklist and respondent report
Socioeconomic variables	Income, education, occupation, housing type, family size	Questionnaire and socioeconomic tool
Behavioural variables	Water storage, container cleaning, use of preventive measures	Questionnaire
Awareness variables	Knowledge of transmission, symptoms and prevention	Knowledge score

IV. DATA ANALYSIS AND INTERPRETATION

The analysis compares 120 dengue case households and 180 non-case households. Frequencies, percentages, chi-square values and p values are used to identify statistically significant associations. Interpretation is provided after each table to link numerical findings with public health meaning.

Table 2: Sociodemographic profile by dengue case-household status

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Variable	Category	Case households n=120	Non-case households n=180	Total n=300
Age group	15-24 years	22 (18.3%)	35 (19.4%)	57 (19.0%)
Age group	25-34 years	36 (30.0%)	48 (26.7%)	84 (28.0%)
Age group	35-44 years	30 (25.0%)	42 (23.3%)	72 (24.0%)
Age group	45-54 years	20 (16.7%)	34 (18.9%)	54 (18.0%)
Age group	55 years and above	12 (10.0%)	21 (11.7%)	33 (11.0%)
Gender	Male	68 (56.7%)	94 (52.2%)	162 (54.0%)
Gender	Female	52 (43.3%)	86 (47.8%)	138 (46.0%)
Education	No formal/Primary	38 (31.7%)	38 (21.1%)	76 (25.3%)
Education	Secondary	42 (35.0%)	68 (37.8%)	110 (36.7%)
Education	Higher secondary	25 (20.8%)	46 (25.6%)	71 (23.7%)
Education	Graduate and above	15 (12.5%)	28 (15.6%)	43 (14.3%)
Occupation	Daily wage/labour	36 (30.0%)	36 (20.0%)	72 (24.0%)
Occupation	Service/business	39 (32.5%)	62 (34.4%)	101 (33.7%)
Occupation	Homemaker	24 (20.0%)	44 (24.4%)	68 (22.7%)
Occupation	Student/other	21 (17.5%)	38 (21.1%)	59 (19.7%)
Income group	Low	58 (48.3%)	47 (26.1%)	105 (35.0%)
Income group	Middle	47 (39.2%)	86 (47.8%)	133 (44.3%)
Income group	High	15 (12.5%)	47 (26.1%)	62 (20.7%)

The sociodemographic profile shows that dengue case households were distributed across all age, gender, education, occupation and income categories. A higher proportion of cases was observed among low-income households, daily wage or labour households and respondents with lower educational status. This pattern suggests that dengue risk may be concentrated in groups with greater environmental exposure and fewer resources for prevention. However, dengue was not restricted to low-income households, indicating that Aedes breeding can occur across socioeconomic settings where water storage and sanitation practices are inadequate.

Table 3: Distribution of dengue cases by age group

Category	Case households n=120	Non-case households n=180	Total n=300
15-24 years	22 (18.3%)	35 (19.4%)	57 (19.0%)
25-34 years	36 (30.0%)	48 (26.7%)	84 (28.0%)
35-44 years	30 (25.0%)	42 (23.3%)	72 (24.0%)
45-54 years	20 (16.7%)	34 (18.9%)	54 (18.0%)
55 years and above	12 (10.0%)	21 (11.7%)	33 (11.0%)

Chi-square value for age group was 0.80 with 4 degree(s) of freedom and p value 0.939. Age distribution indicates that adults aged 25-44 years contributed a major share of dengue case households. This may reflect greater population mobility, occupational exposure and household representation by adult respondents. The association between age group and dengue case-household status was not statistically strong, suggesting that environmental exposure may be more important than age alone.

Table 4: Distribution of dengue cases by gender

Category	Case households n=120	Non-case households n=180	Total n=300
Male	68 (56.7%)	94 (52.2%)	162 (54.0%)
Female	52 (43.3%)	86 (47.8%)	138 (46.0%)

Chi-square value for gender was 0.41 with 1 degree(s) of freedom and p value 0.523. Male respondents were slightly more represented among dengue case households, but the difference was not statistically decisive. Gender may influence exposure through work and outdoor movement, but household-level breeding affects all members irrespective of gender.

V. RESULTS

Major Findings Related to Environmental Factors

The study found that environmental risk factors were strongly associated with dengue case-household status. Uncovered or irregularly cleaned water storage containers were more common among case households than non-case households. Stagnant water near the household was present among a large proportion of case households. Blocked or open drainage and irregular waste disposal were also associated with dengue occurrence. Visible mosquito breeding sites represented the strongest environmental indicator. These findings demonstrate that the domestic and peri-domestic environment is central to dengue prevention. Environmental risk factors were not isolated; many households had multiple risk conditions.

For example, poor drainage often coexisted with water stagnation and waste accumulation. Such clustering of environmental risks increases the likelihood of sustained Aedes breeding.

Major Findings Related to Socioeconomic Factors

Low income, lower educational status, daily wage or labour occupation, semipucca housing and larger family size were more frequent among dengue case households. These factors may not directly cause dengue, but they influence exposure and ability to prevent breeding. Low-income households may store water because of irregular supply, have limited space for safe storage, and live in areas with weaker municipal services. Socioeconomic vulnerability was therefore found to modify dengue risk. The relationship between dengue and socioeconomic status was not absolute, since dengue also occurred in middle and higher income households where water containers or coolers were not maintained. However, lower socioeconomic groups appeared to face a higher cumulative risk because several determinants overlapped.

Findings Related to Knowledge and Preventive Practices

Awareness level was associated with dengue prevention practices. Households with higher awareness were more likely to cover containers, clean water storage vessels, remove stagnant water and seek early treatment for fever. Low awareness was more common among case households. However, some respondents with moderate awareness did not practice regular source reduction, indicating a gap between knowledge and behaviour. The study found that public health education must be practical and repeated. Messages should focus on weekly container cleaning, dry-day practice, identification of breeding sites, symptoms and warning signs. IEC should be adapted for low-literacy communities and delivered through ASHA workers, schools, resident groups and municipal campaigns.

Findings Related to Household and Community Conditions

Household conditions such as water storage, containers, coolers, tanks and immediate surroundings were important. Community-level conditions such as open drains, waste disposal, construction activity and open plots were also important. This means dengue control cannot depend only on individual households. Even if one household removes breeding sites, nearby unmanaged spaces can continue to support mosquitoes. The findings support a dual approach: household inspection and community environmental management. Municipal and health departments should map high-risk lanes, drains, construction sites and open plots before monsoon and monitor them through the transmission season.

VI. DISCUSSION

Discussion of Sociodemographic Findings

The study found that dengue case households were present across age and gender groups, indicating that dengue risk is shared within the household environment. This is consistent with the biology of Aedes aegypti, which bites during daytime and lives close to human dwellings. Although male respondents were slightly more common among case households, gender was not the main determinant. Environmental exposure at household and locality level was more

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Impact Factor: 7.2 ISSN No: 3049-4176

important. Education and occupation showed clearer public health relevance. Lower education may reduce ability to identify breeding sites and warning signs, while daily wage occupations may be associated with residence in crowded or poorly serviced localities. These findings support targeted communication for vulnerable groups rather than uniform messaging alone.

Discussion of Environmental Factors Contributing to Dengue

Environmental factors were strongly associated with dengue case-household status. The findings are consistent with WHO and NCVBDC guidance that dengue prevention relies on vector control and elimination of breeding sources.13 Presence of stagnant water, poor drainage and visible breeding sites directly supports Aedes life cycle. The strong association with environmental risk score shows that combined environmental assessment is useful in outbreak prevention. Climate-related findings in the literature indicate that temperature, rainfall and humidity affect dengue transmission in India.715 Maharashtra-based evidence from Pune further suggests that these climatic factors may influence dengue mortality at lag periods of two to five months.8 The present study complements climate research by showing how household and neighbourhood environments translate climate conditions into breeding risk.

Discussion of Socioeconomic Factors Contributing to Dengue

The study found that lower socioeconomic status, lower income, semi-pucca housing and larger family size were associated with dengue case-household status. This supports the idea that dengue is socially patterned. Socioeconomic vulnerability may increase exposure through inadequate housing, water insecurity, overcrowding and poor sanitation. It may also reduce capacity to act on prevention messages. However, dengue should not be stereotyped as a disease of poverty alone. Aedes breeding can occur in any household with uncovered containers or poorly maintained coolers and tanks. The socioeconomic dimension is best understood as a modifier of risk and resilience, not as the sole cause.

Discussion of Water Storage and Sanitation Practices

Water storage was one of the most important modifiable factors. Households with uncovered or irregularly cleaned containers had higher dengue risk. This finding is consistent with environmental control literature showing that container management, covers and regular cleaning reduce breeding opportunities.11 In Maharashtra, intermittent water supply and seasonal water demand can make storage unavoidable. Therefore, health education should not simply advise against storage but should promote safe storage. Sanitation practices such as waste disposal and drain cleaning were also important. Discarded plastic, tyres and containers accumulate rainwater and become breeding sites. Municipal waste management and household clean-up campaigns must be synchronized with monsoon preparedness.

VII.CONCLUSION

The study concludes that dengue outbreak in Maharashtra is associated with a combination of environmental and socioeconomic factors. The most important environmental determinants were uncovered or irregularly cleaned water storage containers, stagnant water, blocked/open drainage, poor waste disposal and visible mosquito breeding sites. The most important socioeconomic determinants were lower income, lower socioeconomic status, larger family size, semi-pucca housing and inadequate awareness. Dengue risk was highest where multiple environmental hazards and social vulnerability overlapped. The findings show that dengue control cannot depend only on clinical management or emergency fogging. It requires integrated vector management, safe water storage, regular source reduction, sanitation improvement, climate-informed surveillance and community participation. The study supports early pre-monsoon action and ward-level risk mapping in Maharashtra.

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