Original Article

A sequential study of Chikungunya fever cases notified in the urban setup of India

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Abstract

Context: Chikungunya's resurgence highlights reporting and awareness challenges. **Aims:** To analyze trends in 170 laboratory-confirmed Chikungunya cases in Urban Surat's Central Sentinel Surveillance (2016-2020), supplemented by a subset (n = 30) examining perceptions, attitudes, and risk reduction practices based on notification level. **Results:** Notification rates peaked in 2017 (1.14 cases/100,000). A high House Index (>1) was observed in 59% (2018) and 58% (2019) of cases. Seasonal peaks occurred in November (31%) and December (24.7%), with no private sector notifications. Highest case rates were in South (9.2) and Southeast (8.1) zones. Over half of the cases in Central (69.2%), Southeast (67.2%), and South (52.8%) zones had a House Index >1 ($P = 0.001$), indicating significant indoor mosquito breeding. Median age was 37 years (30-43), with females comprising 65.3% of cases. Awareness of mosquitoes as vectors (40%) and their day-biting behavior (26.7%) was low, despite familiarity with Abate larvicide (60%). Prevention methods included mosquito coils (76%) and fumigation (73%), with less emphasis on water change (40%) and container maintenance (23%). Only 13% perceived Chikungunya as preventable, with low readiness for community engagement (13%). Misconceptions included considering chemical fogging sufficient (63%) and neglecting water-logging as a health concern (40%). Few implemented risk reduction measures (23% removing stagnant water, 20% weekly water change). **Conclusion:** Fluctuating notifications and unnoticed surges in 2019-2020 underscore the need for continuous, standardized surveillance. Higher case rates in southern and central regions were linked to high indoor breeding. The lack of private sector reporting and underreporting indicate a need for integrated surveillance. Awareness and adoption of *Aedes*-specific risk reduction practices remain low, with persistent misconceptions and poor attitudes.

Keywords: Chikungunya, entomological indices, epidemiology

Introduction

Chikungunya has re-emerged in India, exhibiting varying attack rates (4%–45%) since 2006, leading to substantial outbreaks.[1-3] Over 1.39 million individuals across 16 states have been affected, with cases steadily increasing since 2015.[1-4] Although the case fatality rate is low (~0.1%), about 30% of patients may suffer from persistent debilitating disabilities.[5] This resurgence presents challenges due to inadequate antivirals/vaccines, underreporting, and complex differential diagnosis with other viral diseases such as Dengue and Zika.[1,2]

Aedes aegypti, the primary vector, thrives in artificial water containers, with its resilient eggs enduring dry conditions. Its multiple biting behaviors, known as nervous feeding, limited flight range, and preference for indoor environments, contribute to resurgence and clustered infections. Active daytime biting highlights the necessity for personal protection and larval control. Entomological indicators, such as House Index, Container Index, Breteau Index, and Pupal Index, are utilized to assess outcomes by examining the presence of mosquito larval and pupal forms in household water storage containers, especially for container-breeding *Aedes* mosquitoes.[1,2]

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The tropical city of Surat is witnessing a rise in Chikungunya cases, attributed to conducive temperature and humidity, high rainfall, urbanization, high population density, migration, and ongoing construction activities.[6]

Aim and objectives

This study aims to integrate epidemiological (time, place, and person distribution) and entomological indices of all laboratory-confirmed chikungunya cases at the Central Sentinel Surveillance in Urban Surat from 2016 to 2020. Additionally, it investigates perceptions, attitudes, and risk-reduction practices. The epidemiological data gathered intend to provide evidence-based insights to identify and map the burden of Chikungunya in the study area over the years, while the qualitative exploration aims to identify the scope of interventions needed and effective control measures.

Subjects and Methods

Study design, area, and setting

This mixed-methods study was conducted in Surat, a tropical city located on India's western coast with a population of six million. Surat's climate is mild and favorable, characterized by temperatures ranging from 25° to 35°C, an average annual rainfall of 60 inches, and consistent humidity levels above 60%.[6] These conditions create an ideal environment for the development and spread of the *Aedes* mosquito. Since 2006, the Central Sentinel Surveillance site in Surat has integrated case, laboratory, and entomological data from both governmental and private sources for suspected and confirmed cases of Chikungunya through passive surveillance. Data on confirmed cases notified by both governmental and private entities were obtained from 2016 to 2020 for this study.

Case definition

All laboratory-confirmed chikungunya cases reported by both governmental and private sectors at the Central Sentinel Surveillance laboratory were verified using Chikungunya IgM antibody capture enzyme-linked immunosorbent assay (MAC-ELISA) test kits. The uniformity of tests and guidelines was maintained by procuring kits from the National Institute of Virology (NIV) Pune.

Sampling, recruitment, and data collection [Figure 1]

Quantitative Study

A descriptive trend analysis was undertaken to document the epidemiological characteristics, encompassing time, place, and person distribution, of all laboratory-confirmed chikungunya cases (n = 170) reported to the Central Sentinel Surveillance site between 2016 and 2020. Entomological indicators, including the House Index (HI), denoting the percentage of houses infested with mosquito larvae and/or pupae, the Container Index (CI), indicating the percentage of water-holding containers infested with mosquito larvae and/or pupae, and the Breteau Index (BI), representing the number of positive containers per 100 houses inspected, were analyzed as part of this investigation.[1]

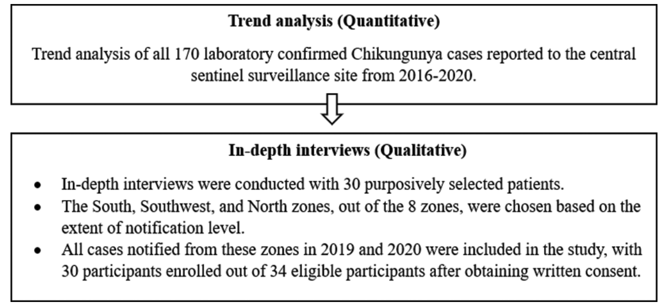

Figure 1: Flowchart of study design, sampling, and recruitment of laboratory-confirmed Chikungunya cases in Urban Surat

Qualitative study

The interview guide was developed to explore individual and community-level perceptions, attitudes, and risk reduction practices related to mosquito transmission dynamics, breeding, and personal protection. Coding and thematic analysis were conducted using a deductive approach, and codes were quantified through directed content analysis.

Cases from 2019 and 2020 were selected from the South (22 cases), Southwest (4 cases), and East (4 cases) zones to represent three out of the eight zones, based on notification levels to maximize variability and ensure a longer saturation window. The southern zone exhibited the highest incidence of Chikungunya notifications, the eastern zone demonstrated an average level, and the southwestern zone displayed the lowest number of notifications for Chikungunya.

Thirty-four eligible participants were provided with study information, a participant information sheet, and an informed consent form. From these, 30 participants who provided written consent were included in the study, excluding those requiring hospitalization for unmanaged comorbidities.

Declaration of ethical issues

This study was critically appraised and approved by the Institutional Review Board and Human Research Ethics Committee of Government Medical College, Surat. Written informed consent was obtained from all participants, and patient confidentiality was ensured by de-identification.

Data management and statistical analysis

Data management procedures involved initial entry into Microsoft Excel, followed by validation for consistency and completeness. Analysis was then conducted using Microsoft Excel and SPSS version 21.

House index, Container index, and Breteau index were dichotomized to delineate risk levels. Low-risk areas were determined as having House index and Container index below 1, and Breteau index below 5. Moderate to heavy-risk areas were identified when House index and Container index exceeded 1, and Breteau index surpassed 5.

Categorical data were summarized by percentages, and comparisons were made using Chi-square tests with a significance level set at $P < 0.05$. Continuous data were summarized using mean and standard deviation. Comparisons of means utilized independent t-tests for two means and ANOVA for more than two means, with Tukey's *post hoc* analysis. Normality was assessed visually through Q-Q plots, and homogeneity of variance was evaluated using Fisher's exact test ($P > 0.05$). The significance level for all analyses was set at $P < 0.05$ with a 95% confidence interval.

Results

Time

The case notification rate was calculated as the number of new cases during a particular year per 100,000 mid-year population estimates. A cyclic trend in notification rates was observed, characterized by an upward peak reaching 1.14 cases per 100,000 population in 2017, followed by a subsequent decline to 0.44 cases per 100,000 population by 2020 [Figure 2]. All reported cases of Chikungunya were notified exclusively from the government sector, with no cases reported from the private sector.

In the years 2017 and 2018, coinciding with increased case notifications, the highest proportions of cases with House Index values exceeding 1 were observed: 39 (59.1%) and 24 (57.1%) respectively, and Container Index values surpassing 1: 15 (22.7%) and 7 (16.7%), respectively. However, subsequent statistical analysis via Chi-square revealed nonsignificant disparities in the House Index ($P = 0.435$), Container Index ($P = 0.503$), and Breteau Index ($P = 0.857$) across these years [see Figure 3].

A seasonal distribution was observed, with peaks in November (53 cases, 31.20%) and December (42 cases, 24.70%), followed by a decline in February (4 cases, 2.3%).

Place

Zone-wise case notification rates were determined by dividing the number of laboratory-confirmed Chikungunya cases notified from each zone by the midyear population per 100,000 based on the 2011 census. The highest rates were observed in the South zone (9.2) and South East zone (8.1), with the lowest rates in the East zone (0.3) and South West zone (0.6) [Table 1]. Consistent reporting of cases was noted in the South and Southeast zones throughout the study period [Figure 4]. In densely populated areas, Navagam in the South East zone (30 cases, 17.64%) and Pandesara in the South zone (28 cases, 16.47%) accounted for 35% of Chikungunya cases.

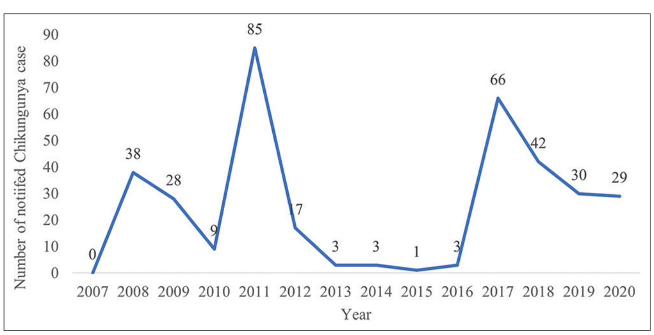

Figure 2: Time trend of laboratory-confirmed Chikungunya cases at the central sentinel surveillance in Urban Surat (2007-2020). Source: https://www.suratmunicipal.gov.in/Departments/VectorBorneDiseasesControlHome

More than half of the notified cases from the Central (69.2%), Southeast (67.2%), and South (52.8%) zones exhibited a House Index exceeding 1, with statistically significant variation observed across zones (χ^2 (6) =26.9, $P = 0.001$). A limited number of cases from the Central (23%) and Southeast (21%) zones exhibited a Container Index surpassing 1, with only 2 patients from these zones reporting Breteau indices above 5. Statistical analysis by Chi-square indicated no significant difference in the Container Index ($P = 0.412$) and Breteau index ($P = 0.423$) across the various zones [Table 1].

Person

The median age was 37 (30-43) years, with females comprising 65.3% of cases. Increasing or decreasing age showed no significant correlation with a higher risk of high House Index ($P = 0.309$), Container Index ($P = 0.0.299$), and Breteau index ($P = 0.616$) by Pearson's correlation. No difference was noted between House ($P = 0.906$), Container ($P = 0.806$), and Breteau ($P = 0.793$) indices across genders by independent sample *t*-test.

Qualitative

The findings of the qualitative directed content analysis are organized into three primary categories and 10 codes [Figure 5].

Perception

The analysis revealed varying levels of awareness and misconceptions regarding mosquito vectors and prevention methods among respondents. Less than half (12, 40%) correctly identified mosquitoes as disease vectors, and only a minority (8, 26.7%) recognized the day-biting behavior of *Aedes* species. Despite 60% being aware of Abate larvicide, a substantial portion (18, 60%) mistakenly believed that *Aedes* mosquitoes breed in clean stagnant water. Additionally, 18 (60%) incorrectly perceived that cleaning garbage alone would reduce mosquito breeding sites. Commonly cited prevention methods included mosquito coils (23, 76%), fumigation (22, 73%), maintaining a clean household environment (19, 63%), and applying repellents (18, 60%). However, specific practices such as regularly changing water in storage jars (12, 40%) and maintaining containers (7, 23%) were less frequently mentioned.

Attitude

The analysis highlighted mixed attitudes towards Chikungunya prevention. Only a minority (4, 13%) believed the disease is preventable. While a majority (18, 60%) acknowledged the

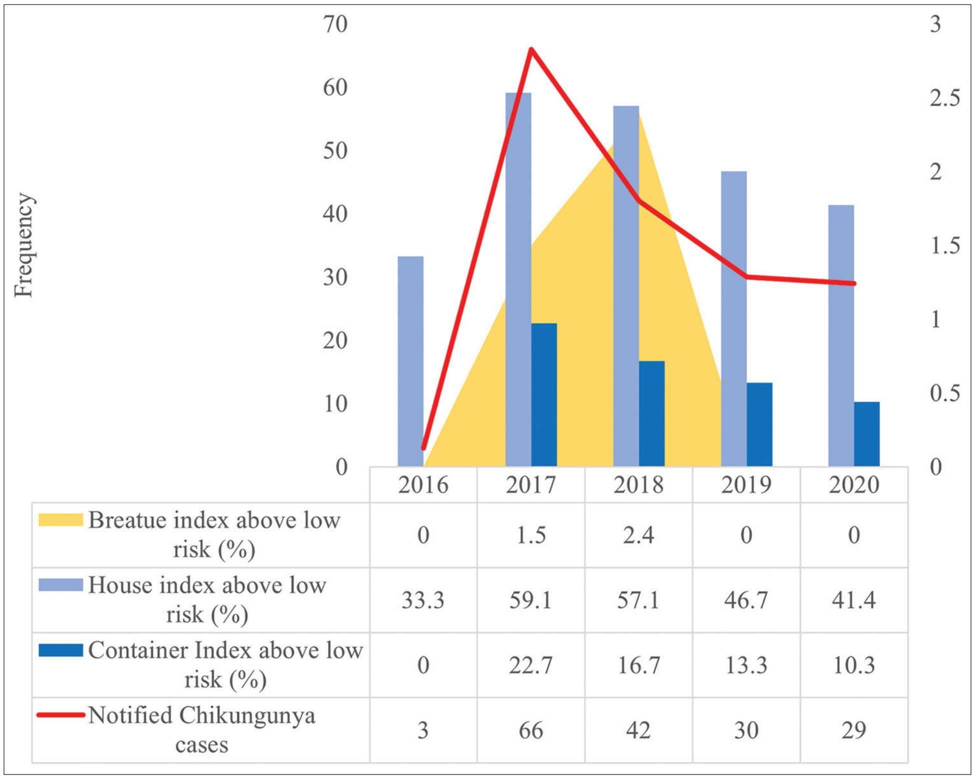

Figure 3: Summary of entomological indicators for laboratory-confirmed Chikungunya cases at the central sentinel surveillance in Urban Surat (2016-2020) (n = 170)

Table 1: Zone-wise summary of entomological indicators for laboratory-confirmed Chikungunya cases at the central sentinel surveillance in Urban Surat (2016–2020) (*n*=170)

Zones	Notified cases of Chikungunya (%)	Case notification rate of Chikungunya	Density per Sq.km	HI above low risk (%)	CI above low risk (%)	BI above low risk (%)
Central	13 (7.6)	3.2	49,971	9 (69.2)	3 (23.1)	1 (7.7)
South west	2 (1.2)	0.6	3,105	0	0	0
South	72 (42.4)	9.2	11,253	38 (52.8)	13 (18.1)	0
South east	61 (35.9)	8.1	38,390	41 (67.2)	13 (21.3)	1 (1.6)
East	3 (1.8)	0.3	30,303	1 (33.3)	0	0
North	13 (7.6)	1.8	19,392	0	0	0
West	6 (3.5)	1.3	8,288	1 (16.7)	0	0

Source: https://www.suratmunicipal.gov.in/Departments/VectorBorneDiseasesControlHome

importance of community involvement in vector control, only 4 (13%) were willing to participate in public efforts. A significant proportion (19, 63.3%) incorrectly considered chemical fogging by health authorities sufficient for disease prevention. Additionally, less than half (12, 40%) perceived water-logging as a significant health risk.

Risk reduction practices

Only a minority engaged in effective risk reduction practices, such as removing clean stagnant water around their homes (7, 23%), changing stored water weekly (6, 20%), and modifying containers to prevent water accumulation (2, 6.7%). Notably, none reported using protective measures like wearing full sleeves or pants during the daytime, using mosquito nets, or actively eliminating potential mosquito breeding sites.

Discussion

Time

We observed fluctuating disease notification patterns, peaking in 2017 and subsequently declining in 2019 and 2020 at the Central Sentinel Surveillance site in Urban Surat. A cyclical case trend, with the latest peak, noted in 2011 (85 cases), has been consistent in previous years.[6] A rising trend of chikungunya was also noted in Delhi and Maharashtra from 2016 onwards.[7,8] Reduced notifications in 2019 and 2020 may be attributed to increased focus on reporting COVID-19 cases and control measures.[9] The World Health Organization (WHO) acknowledges Chikungunya as a re-emerging disease, displaying cyclical patterns with a 4–8-year interepidemic period.[1] This study reaffirms Chikungunya's re-emergence and sustained transmission in western India,

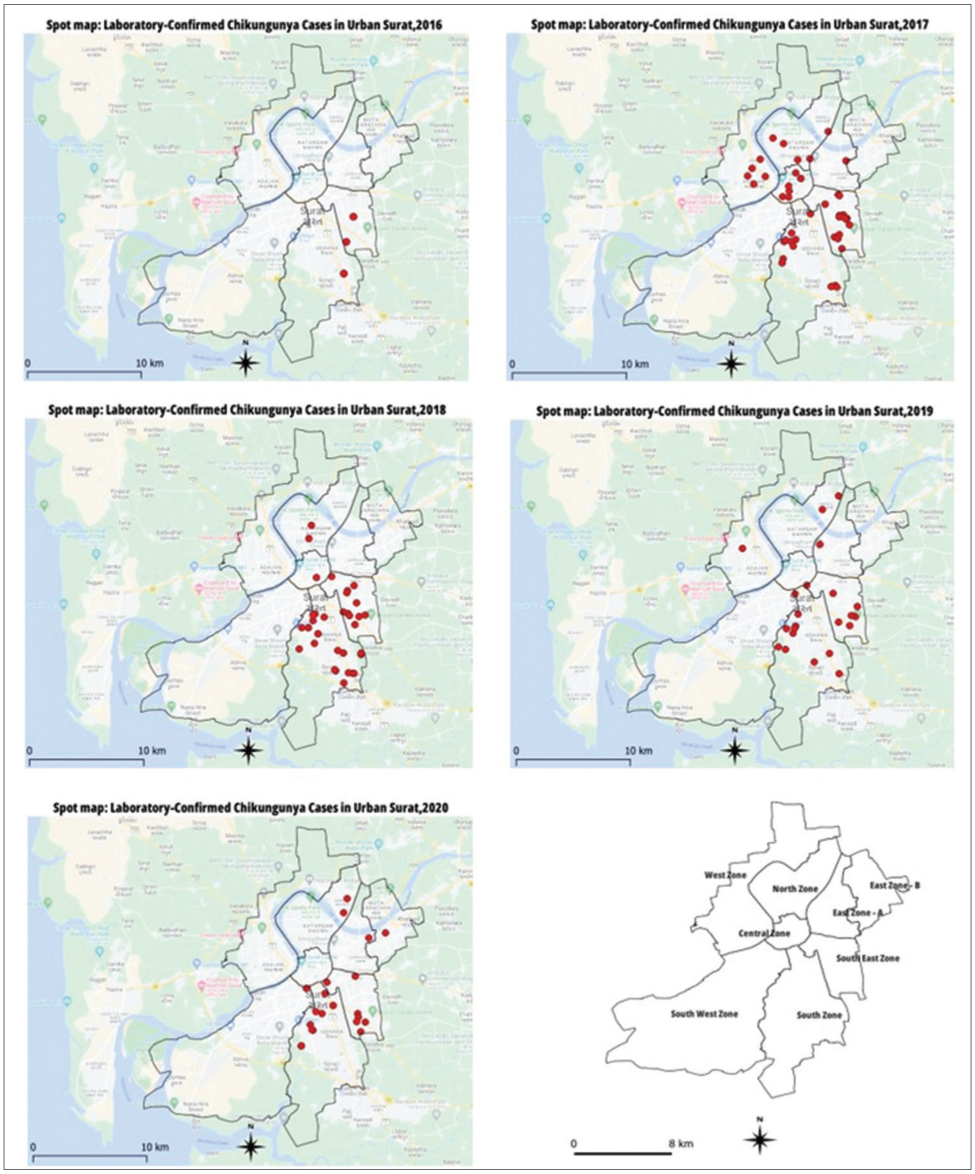

Figure 4: Place distribution of laboratory-confirmed Chikungunya cases at the central sentinel surveillance in Urban Surat (2016-2020) ($n = 170$)

emphasizing the importance of continuous reporting and surveillance to prevent epidemic establishment [Figure 2].

The House Index measures indoor *Aedes* mosquito breeding, while the Container Index tracks outdoor breeding, mainly in water-holding containers in urban areas and periurban areas. The Breteau Index assesses overall *Aedes* breeding sites in an area, regardless of container types, and helps gauge vector control effectiveness and disease transmission risk. High-risk areas have House Index and Container Index above 10% and Breteau Index over 50%. Moderate-risk areas have House Index and Container Index between 5 and 10%, and Breteau Index between 5 and 50%. Low-risk areas have House Index and Container Index below 1%, and Breteau Index under 5%.[1]

In 2017 and 2018, alongside an increased notification rate of Chikungunya cases, a substantial proportion of reported cases demonstrated a House Index exceeding the threshold for low-risk classification, indicative of notable larval breeding within residential or indoor environments. Concurrently, a minority of cases reported during these years exhibited Container and Breteau indices above the low-risk threshold, suggesting a reduced degree of *Aedes* mosquito breeding in outdoor settings and potential effectiveness of vector control measures. However, the observed difference in indices did not achieve statistical significance. The co-occurrence of elevated Chikungunya case notifications and high larval indices suggests a strong correlation between mosquito activity and disease transmission in these years. Understanding these disparities in indices assists in targeting interventions to effectively reduce dengue transmission, with a focus on indoor mosquito breeding sites to reduce the risk of Chikungunya outbreaks [Figure 3].

Seasonal peaks in Chikungunya cases were observed during post-monsoon months, particularly in November and December, followed by declines during dry months, consistent with patterns observed in other Indian studies. Wet seasons extend mosquito lifespan and breeding, increasing transmission risk. Dry periods lead to water storage, creating *Aedes* breeding sites, and shifting transmission from seasonal to perennial. *Aedes* eggs' resistance to drying aids virus persistence, with sporadic cases during arid periods perpetuating the disease cycle.[1,2]

Chikungunya cases are not reported by the private sector, leading to underreporting due to its non-notifiable status. To address this, integrated passive surveillance involving both public and private sectors, alongside standardized testing guidelines and case definitions, is crucial for accurate measurement of the disease burden, especially considering its re-emerging potential.

Place

The study identified a consistent reporting pattern of Chikungunya cases in the southern zone throughout the study period. Notified cases in both the southern and central zones exhibited a statistically significant proportion with a House Index exceeding the threshold for low risk. This indicates a notable prevalence of *Aedes* mosquito breeding within residential or indoor environments in these regions. Conversely, a smaller subset of cases from the southern and central zones showed Container Index and Breteau Index values surpassing the low-risk threshold, suggesting minimal *Aedes* mosquito breeding in outdoor settings and effective vector control measures [Table 1, Figure 4].

The observed difference between House Index and Container Index values underscores a potential variation in the distribution and intensity of breeding sites between indoor and outdoor environments. Moreover, higher notifications of dengue and malaria in previous years from the same area indicate clustering and endemicity in the southern region,[10] attributed to significant larval breeding activity influenced by factors such as multiple biting habits, limited flight range of *Aedes* mosquitoes, high population density [Table 1] and socioeconomic challenges in slum population (147,050 in Southeast, 76,025 in South, 49,323 in Central).[6] These findings facilitate the mapping of foci to stratify areas based on endemicity for the prioritization of resources.

Person

The involvement of middle-aged individuals and the predominance of females in the study align with findings from other studies.[7] Increased Chikungunya notifications among females may stem from their higher presence at home compared to males, as well as the endophilic behavior of *Aedes* mosquitoes. Despite higher larval indices among females compared to males, statistical significance was not achieved.

Perception, attitude, and risk reduction practices [Figure 5]

Our study underscores the critical importance of understanding mosquito vectors' behavioral patterns and local breeding ecology among individuals with a history of Chikungunya.[1,2] However, significant knowledge gaps and misconceptions were evident among participants. Only 40% recognized mosquitoes as vectors, and a mere 26.7% were aware of their day-biting habits. Misconceptions about *Aedes* breeding sites were prevalent, with 60% erroneously believing clean stagnant water or garbage to be breeding sites. Given that *Aedes* species predominantly bite during the daytime, these findings emphasize the urgent need for comprehensive interventions focusing on personal protection, larval control, and environmental modifications.

Interestingly, our study contrasts with the findings of Kumaran *et al.*,[11] who reported high levels of knowledge among participants regarding dengue transmission, *Aedes* breeding, and biting prevention methods in a rural area in their quantitative study. This disparity suggests potential variations in knowledge levels across different populations and underscores the importance of tailoring interventions to address specific community needs.

Control strategies for Chikungunya primarily rely on vector control and social mobilization in the absence of specific drugs and vaccines. However, our study revealed that a significant proportion (63.3%) of participants believed Chikungunya control to be solely the responsibility of health authorities, indicating a need for greater community engagement and awareness. Additionally, only 40% of participants considered water-logging as a serious concern, highlighting the importance of addressing environmental factors in disease prevention efforts.

These findings align with the results of studies by Debayan Podder *et al.*,[12] which demonstrated unsatisfactory levels of knowledge, attitudes, and practices regarding malaria and dengue prevention/control among participants in a mixed-method study. This underscores the importance of participatory community-based approaches in promoting healthy behaviors and empowering communities to take ownership of vector control efforts at both intra- and peridomiciliary levels.

Limitations

The study was constrained by limitations including the inclusion of patients from standard surveillance sites only, restricted coverage of interview zones due to time and manpower constraints, and the necessity for repeated measures to accurately monitor entomological indices. Single visits were insufficient for precise measurement of mosquito preventive practices.

Conclusion

Chikungunya persisted from 2016 to 2020 with variable notification rates and sporadic cases during dry periods. The surge in cases during the 2019 to 2020 pandemic went unnoticed despite previous high levels of indoor larval breeding, emphasizing the necessity for continuous vigilant reporting through Standardized Surveillance sites. While

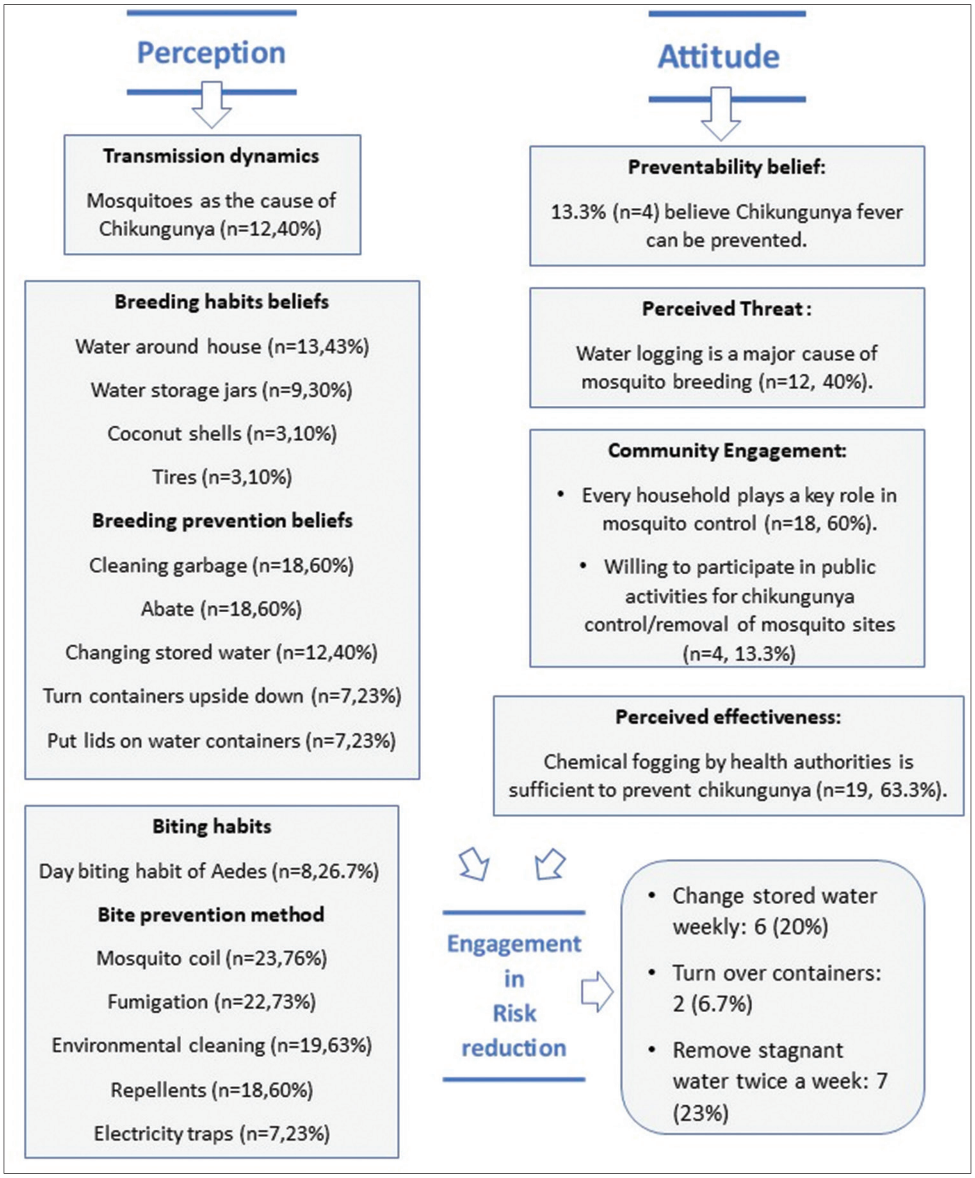

Figure 5: Perception, attitude, and risk reduction practices of laboratory-confirmed Chikungunya cases in Urban Surat (2019-2020) (n = 30)

citywide reporting occurred, consistent clusters and endemicity primarily existed in the southern and central regions, indicating significant indoor breeding. Improved reporting in certain areas may signify disproportionate cases from similar nearby environments, aiding in disease transmission understanding and resource allocation. The absence of private sector notifications and underreporting from specific areas highlight the need for integrated surveillance. Chikungunya predominantly affects working-age individuals, with greater female involvement due to increased daytime availability at home. Despite prior exposure, persistent low awareness, misconceptions, negative attitudes, and limited adoption of *Aedes*-specific risk reduction practices underscore the importance of comprehensive health education campaigns.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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