Social and Housing Determinants of Dengue and Chikungunya in Indian Adults Aged 45 and Above: Analysis of a Nationally Representative Survey (2017-18)

Winnie Paulson
Central University of Tamil Nadu

Karuppusamy Balasubramani
Central University of Tamil Nadu

Rashi Dixit
Central University of Tamil Nadu

Savitha Chellappan
National Institute of Traditional Medicine, Belgavi

Sujit Kumar Behera
Central University of Tamil Nadu

Praveen Balabaskaran Nina (praveen@cutn.ac.in)
Central University of Tamil Nadu https://orcid.org/0000-0003-4096-0738

Research

Keywords: LASI, Social determinants of dengue, Social determinants of chikungunya, Risk factors of dengue and chikungunya

Posted Date: November 10th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1046511/v1

Abstract

Background

Dengue and chikungunya (CHIKV) are the two major vector-borne diseases of serious public health concern in India. Studies on socio-economic and housing determinants of dengue and CHIKV at a pan-India level are lacking. Here, we took advantage of the recently carried out Longitudinal Ageing Study in India (LASI) carried across all the States and Union Territories of India to study the social determinants of dengue and CHIKV in India.

Methods

LASI-1 (2017-2018) data on the self-reported period prevalence of dengue and CHIKV from 70,865 respondents aged ≥45 years were used for this analysis. The State-wise distribution of dengue and CHIKV was mapped. Prevalence was estimated for each study variable, and the difference was compared using the $\chi 2$ test. The adjusted odds ratios (AOR) of the socio-economic and housing variables for dengue and CHIKV were calculated using a multiple logistic regression model.

Results

Urban residence is the major socio-economic determinant of dengue and CHIKV (dengue: AOR: 1.57, 95% CI: 1.17-2.10; CHIKV: AOR 1.56, 95% CI: 1.20-2.02). Wealth status (richest) and less than primary schooling are associated with dengue and CHIKV prevalence. In addition to these factors, social group (scheduled and forward castes) is also associated with CHIKV prevalence. Water-source outside the dwelling (AOR: 1.20, 95% CI: 0.96-1.50), pucca or semi- pucca house type are also associated with increased odds of CHIKV.

Conclusions

Despite the limitation that the data is only from adults ≥ 45, this analysis provides important insights into the socio-economic and housing variables that increase the odds of dengue and CHIKV in India. Understanding these determinants may assist in the national planning of prevention and control strategies for dengue and CHIKV.

Author Summary

Dengue and chikungunya are two of the major vector-borne viral diseases that cause significant morbidity in India. For effective prevention and control strategies of dengue and chikungunya, it is important to understand the various social, economic and demographic risk factors that increase the odds of these infections in the population. Our analysis here shows in Indian adults aged 45 and above, both dengue and chikungunya are predominantly associated with urban settings. Among the factors that increase the odds, improving education levels and better access to water supply are two determinants that could be the focus of targeted interventions to reduce the prevalence.

Background

The dengue virus primarily transmitted by *Aedes aegypti*, and to a lesser extent by *Ae. albopictus* consists of four serotypes (DENV1-4), which contribute to the distinct epidemiological spread [1]. In recent decades, global incidence of dengue has increased alarmingly, and about half the world's population are at risk [1]. Globally, there is an eightfold increase in dengue cases from 505,430 in 2000 to 5.2 million cases in 2019. Even though dengue risk is in 129 countries, the actual burden (70%) is in Asia, and India is one of the major contributors [2, 3].

In India, from 1990 onwards, there have been frequent dengue epidemics [4]. Compared to 1998-2009 (82,327 cases), dengue cases have increased by a factor of ~2.6 in 2010-14 (213,607 cases) [5]. In India, the actual numbers of dengue could be grossly underreported [6, 7], as the majority of the cases are mild/asymptomatic and/or misdiagnosed [8]. In 2017, a nation-wide dengue serosurvey carried out across 60 districts in 15 States of India, covering five geographical regions reveal a seroprevalence of 48·7% (95% CI: 43·5-54·0); the highest positivity (56.2%, 95% CI: 49.0-63.1) rate is seen in 18-45 years old [7]. This study, based on constant force of infection models, also estimates ~13 million dengue infections across the 30 Indian States [7]. Initially restricted to urban areas, dengue has spread to rural regions of India making the entire country susceptible [4, 9].

In India, Chikungunya (CHIKV) is the second major vector-borne viral disease transmitted by *Ae. aegypti* and *Ae. albopictus*. India has witnessed CHIKV outbreaks from 1963-74 [10]. This was followed by three decades of quiescence, and CHIKV re-emerged in 2005 with 1.39 million suspected cases in 2006, and after a gradual decline till 2014, the cases started rising in 2015, with 67,769 cases reported in 2017 [11]. A nation-wide CHIKV serosurvey (2017-18) of 15 States showed a seroprevalence of 18.1% (95% CI: 14·2–22·6), and southern region was highest (43.1%; 95% CI: 34.3-52.3) [12]. Furthermore, seroprevalence was much higher in urban areas (40.2%; 95% CI: 31.7-49.3) compared to rural (11.5%; 95% CI: 8.8-15) [12]. An estimated 56.3-98% of the population in India are still susceptible to CHIKV, and this could explain the continuous transmission of CHIKV after re-emerging in 2005 [12].

Indian Council of Medical Research (ICMR) and Department of Health Research (DHR) have set up Viral Research Diagnostic Laboratories throughout India to diagnose viral diseases [13]. The major vector control intervention for dengue and CHIKV in India are source reduction, larviciding the positive containers (Temephos 50% EC), indoor space spray (Pyrethrum, Cyphenothrin 5% EC) and outdoor fogging (Technical Malathion, Cyphenothrin 5% EC) [11].

In India, dengue and CHIKV pose a serious public health risk, and for effective control strategies, in addition to environmental risk factors, it is important to understand the socio-economic determinants of health (SDH) influencing transmission. Income, education, employment-status, housing and access to affordable health care services are some of the important SDH that affect health equity [14]. Studies detailing the socio-economic and housing risk factors of viral vector-borne diseases are sparse in India, and are largely focused on selected districts [15–18]. A pan-India study on the socio-economic and housing determinants of vector borne diseases may provide important insights to their prevention and

control. A nation-wide Longitudinal Ageing Study in India (LASI) wave 1 was carried out for the first time in India (2017-18) to collect important information on health, health care, socio-economic status (SES) and self-reported prevalence of vector borne diseases including dengue and CHIKV among adults aged 45 and above [19]. Here, we have analyzed the LASI data, and detailed the SES and housing risk factors of dengue and CHIKV.

Methods

Data and participants

Data from the recent LASI wave 1 (2017-2018) carried out by the International Institute for Population Sciences (IIPS), Mumbai, India, was used for the analysis. The LASI wave 1 is a nationally representative study of adults aged ≥45 from all States and Union Territories (UT) except Sikkim. LASI has gathered important information on health, infectious diseases, socio-economic determinants, and consequences of population ageing in India. LASI utilized a multistage clustering sampling design to obtain the data from Indian residents aged ≥45 years and their spouses (regardless of age). Participants provided written consent to participate in the survey. There were total of 70,865 individuals, out of which 28,952 (40.7%) were between 45-54 years, 28,765 (40.4%) were in the age group of 55-69 years, and 13,417 (18.9%) were ≥70 years, and 58% were females. LASI data were obtained after written request to IIPS [19].

Study variables

Outcome variable

The outcomes of interest are dengue and CHIKV, and were based on the following questions: 1. In the past two years, have you had dengue? 2. Were you treated by health professionals for dengue? 3. In the past two years, have you had CHIKV? 4. Were you treated by health professionals for CHIKV? The options were ‘Yes’ and ‘No’. Only those responses were considered ‘Yes’, wherein the respondent reported to have dengue/CHIKV and got treated by a health professional for the same. The untreated respondents were excluded from the analyses. The responses were coded as a binary variable (‘0’ for absence and ‘1’ for presence- Dengue:620; CHIKV:1628).

Household variables

The household variables utilized are household size (1-5 or ≥6 members), type of house i.e. permanent (pucca) or temporary (kutcha), location of water source (own dwelling, yard/plot or outside dwelling), toilet-type (improved sanitation: flushed to piped sewer system/septic tank/pit latrine, pit latrine, twin pit, composting toilet; unimproved sanitation: open defecation), cooking fuel (clean fuel: LPG, biogas and electricity; unclean fuel: kerosene, charcoal, coal, crop residue, wood/shrub and dung cake) and having a damp wall or ceiling (yes/no).

Socio-economic status variables

The SES variables used for this analysis are age-group (45-54 years, 55-69 years and ≥70 years), sex (male/female), residence (rural/urban), Monthly Per Capita Consumption Expenditure (MPCE) quintiles (poorest, poorer, middle, richer and richest), education (0 school years, 1-5 school years, 6-12 school years and college), Caste (Scheduled Castes [SC], Scheduled Tribes [ST], Other Backward Classes [OBC] and unreserved (forward) category), and employment status (not working, agricultural and allied, self-employed and wage/salary worker).

Both the household and socio-economic variables were selected after prior literature search [20-23]

Statistical analysis

Frequency and percentage distribution tables were prepared for all the variables used in this study. Dengue and CHIKV prevalence with each of the housing conditions and SES variables were reported. The variables for multiple logistic regression analyses were chosen based on purposeful selection of variables [24]. Univariable analyses were conducted and predictors with <0.25 significance level were selected for the next-level analyses. From the model containing these variables, variables not significant at 0.10 level were removed one at a time, so that their effects on the odds ratios of other variables (15% change) could be assessed. Following this, variables eliminated (did not meet the criterion of 0.25 significant level) during the univariable analyses were added to the model and were retained if the predictors are significant at 0.1 level and their addition caused a change of 15% or more in the odds ratios for at least one of the categories of these variables. Hence, 'location of water source' (not significant in univariable analyses) remained in the analyses for both dengue and CHIKV as it changed the odds ratio of wealth quintiles by more than 15%. Collinearity was checked for the selected variables and vif (variance inflation factor) values were found to be <5. We have applied sampling weights computed by LASI during the data analysis to obtain accurate estimates. LASI individual and household datasets were merged to realize the study's objectives, and due to the merging of the datasets, few missing values were generated. However, missing values were less than 2%. The final sample size considered for the analysis was 70,865. STATA MP statistical software version 16 was used for data analysis. The STATA Do file in txt format has been given as **Additional file 1.**

Spatial analysis

The State-wise prevalence (%) was used to visualize the spatial distribution of dengue and CHIKV using the ArcGIS software. The averaged prevalence of State and UT was analysed and grouped into four classes, two above and two below the national average. The choropleth technique was used for visualization where the darker hue was used to denote higher prevalence.

Results

Prevalence of dengue and CHIKV in adults ≥45 years

The distribution of all the study variables is shown in **Table 1**. The period prevalence of dengue and CHIKV is 0.87% (95% CI 0.81-0.95%), and 2.3% (95% CI 2.19-2.41%) respectively. **Figures 1-2** show the distribution of dengue and CHIKV across India's States and UT. Dengue is highly prevalent in the northern states of India, and the highest prevalence is observed in Delhi (5.6%), followed by, Chandigarh (3.1%), and Dadra & Nagar Haveli (3.1%), while Delhi (14%) and Haryana (7%) show the highest prevalence of CHIKV cases.

The prevalence of dengue and CHIKV associated with SES and housing factors in adults ≥45 years is shown in **Table 2**. Dengue and CHIKV are less in males (0.74% and 2.05%, respectively) compared to females (0.97% and 2.48%, respectively). Dengue and CHIKV are higher in the urban (1.12% and 2.92%, respectively) than in the rural areas (0.76% and 2.02%, respectively). ST had the lowest prevalence of dengue (0.55%) and CHIKV (1.18%), while the highest is seen in SC (1.12%) and the forward caste (2.95%) respectively. In the income category, a slightly higher prevalence is seen in the richest for both the diseases. College-educated respondents have the lowest prevalence of dengue (0.48%). The prevalence of both diseases is higher in pucca/semi-pucca houses. The prevalence of CHIKV is slightly high in households with no toilet facility, while it is the opposite in dengue. For both dengue and CHIKV, prevalence marginally increased in households using clean fuel. Damp walls or ceilings in households decreased the prevalence of CHIKV (2.07% *vs* 3.10%).

Relationship between the study variables (SES and housing) and dengue/CHIKV in adults ≥ 45 years

The odds ratios of dengue and CHIKV for the SES and housing variables are shown in **Table 3**. Residence in an urban area, adults in the age group of 45-54 years, wealth, education less than six school years, not working individuals increase the odds for dengue. Urban residents have 1.6 times (AOR :1.57; 95% CI: 1.17-2.10) higher odds for dengue than rural. The odds for dengue are highest in richest (AOR: 2.10; 95% CI: 1.33-3.31). Compared to illiterates (0 school years), the lowest risk (AOR: 0.24; 95% CI: 0.12-0.49) for dengue is seen in the college-educated. Households with water-source in the yard/plot have lesser odds (AOR: 0.55; 95% CI: 0.37–0.80, p value=0.02) for dengue.

Residence in an urban area, increasing MPCE quintiles, education with less than six school years, SC and forward castes, people in the pucca/semi pucca house, no water source within a dwelling, increase the odds for CHIKV. Urban residents have 1.6 times more odds (AOR: 1.56; 95% CI: 1.20-2.02) for CHIKV than rural residents. CHIKV odds are higher by 1.7 times in richest (AOR: 1.73; 95% CI: 1.30-2.28) when compared to the poorest. Respondents with high school (6-12 grade) (AOR: 0.65; 95% CI: 0.52-0.81) and college education (AOR: 0.51; 95% CI: 0.34-0.77) have lower odds of CHIKV. All the other caste groups have higher odds for CHIKV compared to ST. Households with water-source not in the dwelling have 1.2 times (AOR: 1.20; 95% CI: 0.96-1.50) more likelihood for CHIKV. The odds are lower (AOR: 0.62; 95% CI: 0.50-0.77) for CHIKV in households with damp wall/ceiling.

Discussion

Dengue and CHIKV infections are often mild, and may be undiagnosed or misdiagnosed. Hence, we have only considered those who self-reported that they were treated for dengue or CHIKV. Dengue is the dominant vector-borne viral disease in India; population level serosurvey carried out in 2017-2018 (5-45 years) showed 48.7% seropositivity for dengue [7] vs. 18.1% for CHIKV [12]. Analysis of LASI data shows dengue and CHIKV prevalence to be 0.87% and 2.3%, respectively. Dengue is endemic in most States of India [5], and population level serosurvey carried out in 2017-2018 in the age group of 5-45 years has reported a seropositivity of 60.3%, 5%, 18.3%, 62.3% and 76.9% in the Northern, North-Eastern, Eastern, Western and Southern regions respectively, with an overall 48.7% seropositivity for India [7]. The low self-reported prevalence could be due to the high seropositivity across India, except for the North-Eastern and Eastern regions. The North Indian States of Delhi, Uttar Pradesh, Punjab and Haryana are the only ones to report ≥2% prevalence. Delhi is highly endemic for dengue, and multiple serotypes co-circulate [6]. Secondary infections resulting in severe dengue illness are known to occur due to the circulation of numerous serotypes [25], and may explain the highest self-reported prevalence (5.6%) in Delhi.

The high prevalence of CHIKV could be explained by the study period of the LASI survey. Even though, the LASI survey was carried out in 2017-18, the respondents were asked to self-report if they had the disease in the preceding two years. In 2016, there was a massive outbreak of CHIKV in North India [26, 27]. The highest prevalence (>4%) of the self-reported CHIKV cases were in the northern States of Delhi, Uttar Pradesh, Haryana and Rajasthan. Even though, the population level serosurvey shows South India to have the highest seropositivity (43.1%) [12], the self-reported cases in the LASI survey are lower. The Southern States were the most affected in the CHIKV outbreak in 2005-06 [28–30]. A multicentric hospital-based study carried out in 2008-2009 to detect CHIKV cases by RT-PCR and/ or IgM-ELISA reported highest positive cases in South India (49.36%), followed by West (16.28%), and the lowest was in North (0.56%) [31]. Prior exposure to CHIKV could explain the low self-reported prevalence rates in the South when compared to North India. The eastern States of Odisha and West Bengal, and the adjacent States of Bihar, Jharkhand and Chhattisgarh have <1% prevalence, and this overlaps well with the 4.4% seropositivity in the East [12]. Similarly, the prevalence was 0% in the North-East, and is in line with the 0.3% seropositivity in this region [12]. In line with the population level serosurvey data [12], LASI survey shows the Eastern and the North-Eastern region of India to have low prevalence of CHIKV, and are susceptible to future outbreaks.

Analysis of LASI data indicates urban residence, wealth, education and location of water-source to be the common risk factors for dengue and CHIKV in India. In addition, adults (45-54 years) are also at more risk for dengue, while for CHIKV, caste (SC and forward), pucca/semi-pucca house type are additional risk factors. Among the various factors of dengue transmission, urbanization, globalization and lack of effective vector control are considered to be the three major drivers [32]. *Ae. aegypti*, the primary driver of dengue and CHIKV lives in urban and peri-urban human habitation. In urban tropics, large swathes of human and *Ae. aegypti* population live in intimate association, and provide the perfect setting for the maintenance and generation of epidemic strains of vector-borne viruses [32, 33]. In this analysis, urban residence increases the odds for both dengue and CHIKV. Positive association has been reported with dengue and CHIKV prevalence, and population density [34–38]. Even though dengue is present both in

rural and urban India, incidence in urban areas are much higher; a nation-wide dengue serosurvey has recorded 70.9% (64·3–76·6) seropositivity in urban compared to 42.3% (36·0–48·9) in rural districts [7]. The urban incidence of CHIKV is even higher; 40·2% (31·7–49·3) in urban *vs.* 11·5% (8·8–15·0) in rural [12]. *Ae. aegypti*'s breeding preferences coupled with population density makes urban areas a significant risk factor for vector-borne viral diseases in India. Among all the States and UT of India, the National Capital Territory of Delhi and the Union Territory of Chandigarh are most urbanized with 97.5% and 97.25% urban population respectively, followed by Daman and Diu at 75.2% [39]. Delhi shares borders with Haryana and Uttar Pradesh, and the urban expansion has accelerated in the border regions of these States [40]. Thus, this region has emerged as hot spot of dengue and CHIKV prevalence in the country. Even though Himachal Pradesh is bordering this hot spotregion, the level of urbanization in Himachal Pradesh is least (10%) in the country, and this could explain the low period prevalence of dengue and CHIKV. Overall, urbanization appears to be a major driver of dengue and CHIKV.

Population based national serosurveys show that the incidence of dengue and CHIKV increases with age; compared to 5-8 (Dengue: 28.3%; CHIKV: 9.2%) and 9-17 (Dengue: 41.0%; CHIKV: 14%), seropositivity is high in the 18-45 age group (Dengue: 56.2%; CHIKV: 21.6%) [7, 12]. The age group more susceptible to clinical dengue infection varies among different geographical regions, and is influenced by host immunity and the circulating viral genotypes. Epidemiology of the 2017 dengue outbreak in Sri Lanka show adults ≥ 50 years are least affected [41]. In Taiwan, dengue prevalence from 2010-2015 show significantly higher prevalence rates in adults ≥ 60 years [42]. Cyclical pattern of dengue epidemics driven by DENV-1 and DENV-2 serotypes have been observed in Singapore from 2004-2016; in DENV-2 predominant years (2007-12 and 2016), the incidence rate of dengue in 55+ age group is almost equal to the 15-24 years age group, while in DENV-1 predominant years (2004-2006 and 2013-2015), the incidence rate in 55+ years is about half [43]. In the 2007 epidemic in Brazil, there was a shift in the age pattern, with dengue hemorrhagic fever affecting predominantly children<15 (>53%), compared to 22.6% in 2001 [44]. For pan-India, reliable estimates of age-stratified dengue caseloads are not available in the public domain. A nine year (2007-2015) dengue trend in Mumbai, western India shows dengue morbidity to be highest in young adults aged 21-40 years [45]. Analysis of the LASI data among the three age groups (45-54, 55-69 and ≥70) shows adults in the 45-54 years age group to have higher odds for dengue. One possible reason for the higher likelihood in this group could be their active life style related to employment, which would also make them travel frequently. A case-control study in Odisha, India shows the odds of dengue are three times higher in individuals whose work requires long travel [17].

Location of water source outside the house was found to increase the odds of both dengue and CHIKV. An individual-level cohort study carried out in Vietnam shows households that do not have access to tap water close to their dwelling have increased risk of dengue fever [46]. Lack of access to piped water supply will lead to households resorting to using containers for water-storage; these storage containers will provide the ideal breeding sites for mosquitoes resulting in increased dengue risk for the household [46]. A retrospective study carried out in Delhi has identified lack of access to tap water to be a key factor in dengue IgG seropositivity [15]. Lack of proper toilet facility in the household also increases the likelihood of CHIKV. *Ae. aegypti*'s peak biting periods are early in the Morning, and in the period before

dusk [47]; the need to use outside toilet facilities increases the likelihood of mosquito bites and vector-borne diseases.

Individuals with less than 6 years of schooling have higher odds of dengue and CHIKV. Several studies have shown the association between low education levels and dengue [20, 48, 49]. Education helps in understanding the etiology of the disease, mode of transmission, symptoms, treatment, prevention and control measures [23]. Wealthy households have higher odds of dengue and CHIKV. Also, residents in pucca houses have higher likelihood of getting infected with CHIKV. Possible reasons include: 1) wealth is likely to be positively associated with urban residence; both dengue and CHIKV have higher prevalence in densely populated urban settings in India, and 2) health seeking behaviour may be better in wealthy households. In Delhi, dengue burden was higher in wealthier districts despite lower mosquito load [15]. In contrast, low SES is shown to be a key risk factor of dengue in Brazil [21, 22, 48, 50] and Cuba [51]. Unlike dengue hemorrhagic fever and dengue shock syndrome, dengue fever is self-limiting characterized by fever, myalgia, headache and constitutional systems [52]. The well-educated individuals from wealthy urban background are more likely to get diagnosed promptly compared to the lower socio-economic class, and this may have increased the odds of dengue and CHIKV in the former. Future studies in different SES settings of India should be carried out to better understand the association between SES and dengue/CHIKV incidence.

Among the different social groups, ST have lower odds of CHIKV. The forest dominated Northeast (except Assam) and Central India States (Chhattisgarh, Jharkhand, Odisha, and Madhya Pradesh), Odisha and the have a high percentage (>20%) of ST [53], and malaria [54–57]. Except Madhya Pradesh (2.9%), the CHIKV prevalence is very low in all the other ST dominated States. Furthermore, the share of the ST population in urban areas is a meager (2.4%) and could be a key reason behind the lower odds in the ST [53].

Conclusions

The major limitation of the study is that the data analyzed to understand the socio-economic and housing determinants are only from adults ≥ 45, therefore, it may not be appropriate to generalize these findings to all age groups. As the disease is self-reported, only respondents with symptomatic infection who got diagnosed may have reported, and this would affect the accuracy of the prevalence estimates. Furthermore, as LASI is a cross-sectional survey, the association of socio-economic and household variables with dengue or CHIKV in this study does not imply causation.

Abbreviations

CHIKV- Chikungunya

LASI- Longitudinal ageing study in India

IIPS- Indian Institute of Population Sciences

SES- Socio-economic status

Declarations

Ethical approval and consent to participate

This is a secondary data analysis of LASI wave 1, conducted by IIPS. Hence, ethical approval is not applicable.

Consent for publication

Not applicable

Availability of data and materials

The datasets analyzed during the study are available after submitting a data request form to IIPS, https://www.iipsindia.ac.in/content/lasi-publications.

Competing Interests

The authors declare that they have no competing interests.

Funding

Not Applicable

Author Contributions

WP and KB contributed to the study design, data analysis, interpretation and writing of the manuscript. PBN contributed to the conceptualization, data analysis, interpretation and writing. RD, SC and SKB contributed to the literature search and writing. All authors contributed to the article and approved the submitted version.

Acknowledgments

We thank IIPS for providing the datasets for analysis

References

1. Dengue **and severe dengue** [https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue (Accessed on 30 June 2021)]
2. Bhatt S, Gething PW, Brady OJ, Messina JP, Farlow AW, Moyes CL, Drake JM, Brownstein JS, Hoen AG, Sankoh O *et al*: **The global distribution and burden of dengue**. *Nature* 2013, **496**(7446):504–507.

3. Brady OJ, Gething PW, Bhatt S, Messina JP, Brownstein JS, Hoen AG, Moyes CL, Farlow AW, Scott TW, Hay SI: **Refining the global spatial limits of dengue virus transmission by evidence-based consensus**. *PLoS neglected tropical diseases* 2012, **6**(8):e1760.
4. Chakravarti A, Arora R, Luxemburger C: **Fifty years of dengue in India**. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 2012, **106**(5):273–282.
5. Mutheneni SR, Morse AP, Caminade C, Upadhyayula SM: **Dengue burden in India: recent trends and importance of climatic parameters**. *Emerging microbes & infections* 2017, **6**(8):e70.
6. Ganeshkumar P, Murhekar MV, Poornima V, Saravanakumar V, Sukumaran K, Anandaselvasankar A, John D, Mehendale SM: **Dengue infection in India**: **A systematic review and meta-analysis**. *PLoS neglected tropical diseases* 2018, **12**(7):e0006618.
7. Murhekar MV, Kamaraj P, Kumar MS, Khan SA, Allam RR, Barde P, Dwibedi B, Kanungo S, Mohan U, Mohanty SS *et al*: **Burden of dengue infection in India, 2017: a cross-sectional population based serosurvey**. *The Lancet Global health* 2019, **7**(8):e1065-e1073.
8. Waggoner JJ, Gresh L, Vargas MJ, Ballesteros G, Tellez Y, Soda KJ, Sahoo MK, Nunez A, Balmaseda A, Harris E *et al*: **Viremia and Clinical Presentation in Nicaraguan Patients Infected With Zika Virus, Chikungunya Virus, and Dengue Virus**. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America* 2016, **63**(12):1584–1590.
9. Kakkar M: **Dengue fever is massively under-reported in India, hampering our response**. *Bmj* 2012, **345**:e8574.
10. Weaver SC, Lecuit M: **Chikungunya virus and the global spread of a mosquito-borne disease**. *The New England journal of medicine* 2015, **372**(13):1231–1239.
11. **Guidelines on Mosquito and other vector control response** [https://nvbdcp.gov.in/Doc/Guidelines-Mosquito-and-other-vector-control-response-2020.pdf (Accessed on 30 June 2021)]
12. Kumar MS, Kamaraj P, Khan SA, Allam RR, Barde PV, Dwibedi B, Kanungo S, Mohan U, Mohanty SS, Roy S *et al*: **Seroprevalence of chikungunya virus infection in India, 2017: a cross-sectional population-based serosurvey**. *The Lancet Microbe* 2021, **2**(1):e41-e47.
13. **Establishment of a network of Laboratories for managing epidemics and Natural Calamities** (**VRDL**) [http://dhr.gov.in/schemes/establishment-network-laboratories-managing-epidemics-and-natural-calamities (Accessed on 30 June 2021)]
14. **Social determinants of health** [https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1 (Accessed on 30 June 2021)]
15. Telle O, Nikolay B, Kumar V, Benkimoun S, Pal R, Nagpal BN, Paul RE: **Social and environmental risk factors for dengue in Delhi city: A retrospective study**. *PLoS neglected tropical diseases* 2021, **15**(2):e0009024.
16. Telle O, Vaguet A, Yadav NK, Lefebvre B, Cebeillac A, Nagpal BN, Daude E, Paul RE: **The Spread of Dengue in an Endemic Urban Milieu–The Case of Delhi, India**. *PloS one* 2016, **11**(1):e0146539.
17. Swain S, Bhatt M, Biswal D, Pati S, Soares Magalhaes RJ: **Risk factors for dengue outbreaks in Odisha, India: A case-control study**. *Journal of infection and public health* 2020, **13**(4):625–631.

18. Kumar CJ, Baboo CA, Krishnan BU, Kumar A, Joy S, Jose T, Philip A, Sambasivaiah K, Hegde BM: **The socioeconomic impact of the chikungunya viral epidemic in India**. *Open Med* 2007, **1**(3):e150-152.
19. **The International Institute for Population Sciences** (**IIPS**) [https://www.iipsindia.ac.in/content/lasi-publications (Accessed on 30 June 2021)]
20. Sissoko D, Moendandze A, Malvy D, Giry C, Ezzedine K, Solet JL, Pierre V: **Seroprevalence and risk factors of chikungunya virus infection in Mayotte, Indian Ocean, 2005-2006: a population-based survey**. *PloS one* 2008, **3**(8):e3066.
21. Braga C, Luna CF, Martelli CM, de Souza WV, Cordeiro MT, Alexander N, de Albuquerque Mde F, Junior JC, Marques ET: **Seroprevalence and risk factors for dengue infection in socio-economically distinct areas of Recife, Brazil**. *Acta tropica* 2010, **113**(3):234–240.
22. Kikuti M, Cunha GM, Paploski IA, Kasper AM, Silva MM, Tavares AS, Cruz JS, Queiroz TL, Rodrigues MS, Santana PM *et al*: **Spatial Distribution of Dengue in a Brazilian Urban Slum Setting: Role of Socioeconomic Gradient in Disease Risk**. *PLoS neglected tropical diseases* 2015, **9**(7):e0003937.
23. Diaz-Quijano FA, Martinez-Vega RA, Rodriguez-Morales AJ, Rojas-Calero RA, Luna-Gonzalez ML, Diaz-Quijano RG: **Association between the level of education and knowledge, attitudes and practices regarding dengue in the Caribbean region of Colombia**. *BMC public health* 2018, **18**(1):143.
24. Bursac Z, Gauss CH, Williams DK, Hosmer DW: **Purposeful selection of variables in logistic regression**. *Source code for biology and medicine* 2008, **3**:17.
25. Halstead SB: **Dengue**. *Lancet* 2007, **370**(9599):1644–1652.
26. Ozair A, Khan DN, Prakash S, Bhagat A, Verma A, Shukla S, Jain A: **Upsurge of chikungunya cases in Uttar Pradesh, India**. *The Indian journal of medical research* 2020, **152**(5):527–530.
27. Kaur N, Jain J, Kumar A, Narang M, Zakaria MK, Marcello A, Kumar D, Gaind R, Sunil S: **Chikungunya outbreak in Delhi, India, 2016: report on coinfection status and comorbid conditions in patients**. *New Microbes New Infect* 2017, **20**:39–42.
28. Arankalle VA, Shrivastava S, Cherian S, Gunjikar RS, Walimbe AM, Jadhav SM, Sudeep AB, Mishra AC: **Genetic divergence of Chikungunya viruses in India (1963-2006) with special reference to the 2005-2006 explosive epidemic**. *The Journal of general virology* 2007, **88**(Pt 7):1967–1976.
29. Yergolkar PN, Tandale BV, Arankalle VA, Sathe PS, Sudeep AB, Gandhe SS, Gokhle MD, Jacob GP, Hundekar SL, Mishra AC: **Chikungunya outbreaks caused by African genotype, India**. *Emerging infectious diseases* 2006, **12**(10):1580–1583.
30. Lahariya C, Pradhan SK: **Emergence of chikungunya virus in Indian subcontinent after 32 years: A review**. *Journal of vector borne diseases* 2006, **43**(4):151–160.
31. Ray P, Ratagiri VH, Kabra SK, Lodha R, Sharma S, Sharma BS, Kalaivani M, Wig N: **Chikungunya infection in India: results of a prospective hospital based multi-centric study**. *PloS one* 2012, **7**(2):e30025.
32. Gubler DJ: **Dengue, Urbanization and Globalization: The Unholy Trinity of the 21(st) Century**. *Trop Med Health* 2011, **39**(4 Suppl):3–11.

33. **Promoting dengue vector surveillance and control** [https://www.who.int/activities/promoting-dengue-vector-surveillance-and-control (Accessed on 30 June 2021)]
34. Nsoesie EO, Ricketts RP, Brown HE, Fish D, Durham DP, Ndeffo Mbah ML, Christian T, Ahmed S, Marcellin C, Shelly E *et al*: **Spatial and Temporal Clustering of Chikungunya Virus Transmission in Dominica**. *PLoS neglected tropical diseases* 2015, **9**(8):e0003977.
35. Teixeira MG, Skalinski LM, Paixao ES, Costa M, Barreto FR, Campos GS, Sardi SI, Carvalho RH, Natividade M, Itaparica M *et al*: **Seroprevalence of Chikungunya virus and living conditions in Feira de Santana, Bahia-Brazil**. *PLoS neglected tropical diseases* 2021, **15**(4):e0009289.
36. Costa S, Branco M, Aquino Junior J, Rodrigues ZMR, Queiroz RCS, Araujo AS, Camara APB, Santos PSD, Pereira EDA, Silva M *et al*: **Spatial analysis of probable cases of dengue fever, chikungunya fever and zika virus infections in Maranhao State, Brazil**. *Rev Inst Med Trop Sao Paulo* 2018, **60**:e62.
37. Almeida AS, Medronho Rde A, Valencia LI: **Spatial analysis of dengue and the socioeconomic context of the city of Rio de Janeiro (Southeastern Brazil)**. *Rev Saude Publica* 2009, **43**(4):666–673.
38. do Carmo RF, Silva Junior JVJ, Pastor AF, de Souza CDF: **Spatiotemporal dynamics, risk areas and social determinants of dengue in Northeastern Brazil, 2014-2017: an ecological study**. *Infectious diseases of poverty* 2020, **9**(1):153.
39. **Level of Urbanisation** [http://mohua.gov.in/cms/level-of-urbanisation.php (Accessed on 30 June 2021)]
40. **Profile of Delhi**: **National Capital Territory** - **Delhi** [http://des.delhigovt.nic.in/DoIT/DOIT_DM/district%20profile.pdf (Accessed on 30 June 2021)]
41. Tissera HA, Jayamanne BDW, Raut R, Janaki SMD, Tozan Y, Samaraweera PC, Liyanage P, Ghouse A, Rodrigo C, de Silva AM *et al*: **Severe Dengue Epidemic, Sri Lanka**, 2017. *Emerging infectious diseases* 2020, **26**(4):682-691.
42. Hsu JC, Hsieh CL, Lu CY: **Trend and geographic analysis of the prevalence of dengue in Taiwan**, **2010**-2015. *International journal of infectious diseases: IJID : official publication of the International Society for Infectious Diseases* 2017, **54**:43-49.
43. Rajarethinam J, Ang LW, Ong J, Ycasas J, Hapuarachchi HC, Yap G, Chong CS, Lai YL, Cutter J, Ho D *et al*: **Dengue in Singapore from 2004 to 2016: Cyclical Epidemic Patterns Dominated by Serotypes 1 and 2**. *The American journal of tropical medicine and hygiene* 2018, **99**(1):204–210.
44. Teixeira MG, Costa MC, Coelho G, Barreto ML: **Recent shift in age pattern of dengue hemorrhagic fever, Brazil**. *Emerging infectious diseases* 2008, **14**(10):1663.
45. Shastri J, Williamson M, Vaidya N, Agrawal S, Shrivastav O: **Nine year trends of dengue virus infection in Mumbai, Western India**. *Journal of laboratory physicians* 2017, **9**(4):296–302.
46. Schmidt WP, Suzuki M, Thiem VD, White RG, Tsuzuki A, Yoshida LM, Yanai H, Haque U, Tho le H, Anh DD *et al*: **Population density**, **water supply**, **and the risk of dengue fever in Vietnam**: **cohort study and spatial analysis**. *PLoS medicine* 2011, **8**(8):e1001082.
47. Dengue **and severe dengue** [https://www.who.int/news-room/q-a-detail/dengue-and-severe-dengue (Accessed on 30 June 2021)]

48. de Mattos Almeida MC, Caiaffa WT, Assuncao RM, Proietti FA: **Spatial vulnerability to dengue in a Brazilian urban area during a 7-year surveillance**. *J Urban Health* 2007, **84**(3):334–345.
49. Zellweger RM, Cano J, Mangeas M, Taglioni F, Mercier A, Despinoy M, Menkes CE, Dupont-Rouzeyrol M, Nikolay B, Teurlai M: **Socioeconomic and environmental determinants of dengue transmission in an urban setting: An ecological study in Noumea, New Caledonia**. *PLoS neglected tropical diseases* 2017, **11**(4):e0005471.
50. Costa JV, Donalisio MR, Silveira LV: **Spatial distribution of dengue incidence and socio-environmental conditions in Campinas, Sao Paulo State, Brazil, 2007**. *Cad Saude Publica* 2013, **29**(8):1522–1532.
51. Spiegel JM, Bonet M, Ibarra AM, Pagliccia N, Ouellette V, Yassi A: **Social and environmental determinants of Aedes aegypti infestation in Central Havana: results of a case-control study nested in an integrated dengue surveillance programme in Cuba**. *Tropical medicine & international health: TM & IH* 2007, **12**(4):503–510.
52. Singhi S, Kissoon N, Bansal A: **Dengue and dengue hemorrhagic fever: management issues in an intensive care unit**. *J Pediatr (Rio J)* 2007, **83**(2 Suppl):S22-35.
53. **Scheduled castes and scheduled tribes** [https://censusindia.gov.in/census_and_you/scheduled_castes_and_sceduled_tribes.aspx (Accessed on 30 June 2021)]
54. Sarma DK, Mohapatra PK, Bhattacharyya DR, Chellappan S, Karuppusamy B, Barman K, Senthil Kumar N, Dash AP, Prakash A, Balabaskaran Nina P: **Malaria in North-East India: Importance and Implications in the Era of Elimination**. *Microorganisms* 2019, **7**(12).
55. Zomuanpuii R, Hmar CL, Lallawmzuala K, Hlimpuia L, Balabaskaran Nina P, Senthil Kumar N: **Epidemiology of malaria and chloroquine resistance in Mizoram, northeastern India, a malaria-endemic region bordering Myanmar**. *Malaria journal* 2020, **19**(1):95.
56. Karuppusamy B, Sarma DK, Lalmalsawma P, Pautu L, Karmodiya K, Balabaskaran Nina P: **Effect of climate change and deforestation on vector borne diseases in the North-Eastern Indian State of Mizoram bordering Myanmar**. *The Journal of Climate Change and Health* 2021, **2**:100015.
57. Mohan I, Kodali NK, Chellappan S, Karuppusamy B, Behera SK, Natarajan G, Balabaskaran Nina P: **Socio-economic and household determinants of malaria in adults aged 45 and above: analysis of longitudinal ageing survey in India, 2017-2018**. *Malaria journal* 2021, **20**(1):306.

Tables

Table 1: Distribution of socioeconomic and housing variables in older adults in India, LASI-1 (2017-2018)

Variables	n	%
Chikungunya	1628	2.30
Dengue	620	0.87
Age Group		
45-54 years	28952	40.70
55-69 years	28765	40.44
≥ 70 years	13417	18.86
Sex		
Female	41111	57.79
Male	30023	42.21
Residence		
Rural	49234	69.21
Urban	21900	30.79
MPCE Quintile		
Poorest	14904	20.95
Poorer	15128	21.27
Middle	14347	20.17
Richer	13870	19.50
Richest	12885	18.11
Education		
0 School years	35279	49.60
1-5 School years	12425	17.47
6-12 School years	19036	26.76
College	4391	6.17
Caste		
Scheduled tribe	6104	8.90
Scheduled caste	13682	19.96
Other backward castes	31712	46.26
Forward caste	17049	24.87
Occupation		
Not Woking	35590	50.11
Agricultural and Allied	19961	28.10
Self-employed /Wage/Salary	15478	21.79
Household-Size		
1-5 members	44815	63.00
≥ 6 members	26319	37.00
House Type		
Pucca/Semi Pucca	58912	83.27
Kutcha	11834	16.73
Water Source		

Own dwelling	31657	47.05
Own yard/plot	14574	21.66
Outside dwelling	21056	31.29
Toilet		
Improved sanitation	51973	73.33
Unimproved	18905	26.67
Cooking fuel		
Clean	36915	52.32
Unclean	33695	47.68
Damp wall/ceiling		
No	14871	20.98
Yes	56004	79.02

Table 2: Prevalence of dengue and chikungunya by socioeconomic and housing variables in older adults in India, LASI-1 (2017-2018)

Variables	Dengue				Chikungunya			
Age Group	**No (%)**	**Yes (%)**	**Total**	**χ^2 p-value**	**No (%)**	**Yes (%)**	**Total**	**χ^2 p-value**
45-54 years	98.99	1.01	28830	0.208	97.46	2.54	28828	0.028
55-69 years	99.23	0.77	28660		97.74	2.26	28661	
≥ 70 years	99.19	0.81	13374		98.15	1.85	13374	
Sex								
Female	99.03	0.97	40981	0.042	97.52	2.48	40985	0.021
Male	99.26	0.74	29884		97.95	2.05	29878	
Residence								
Rural	99.24	0.76	49091	0.002	97.98	2.02	49090	0.000
Urban	98.88	1.12	21774		97.08	2.92	21773	
MPCE Quintile								
Poorest	99.32	0.68	14822	0.074	98.22	1.78	14818	0.003
Poorer	99.19	0.81	15082		97.93	2.07	15081	
Middle	99.22	0.78	14297		97.48	2.52	14301	
Richer	98.98	1.02	13824		97.47	2.53	13820	
Richest	98.88	1.12	12840		97.33	2.67	12843	
Education								
0 School years	99.04	0.96	35205	0.195	97.54	2.46	35203	0.328
1-5 School years	99.12	0.88	12366		97.90	2.10	12367	
6-12 School years	99.20	0.80	18921		97.83	2.17	18921	
College	99.52	0.48	4371		97.88	2.12	4371	
Caste								
Scheduled tribe	99.45	0.55	6076	0.035	98.82	1.18	6073	0.000
Scheduled caste	98.88	1.12	13644		97.36	2.64	13643	
Other backward caste	99.22	0.78	31629		97.89	2.11	31624	
Forward caste	99.03	0.97	16936		97.05	2.95	16942	
Occupation								
Not a current worker	98.97	1.03	35460	0.000	97.75	2.25	35461	0.862
Agricultural and allied	99.47	0.53	19911		97.63	2.37	19910	
Self-employed /Wages	99.03	0.97	15389		97.68	2.32	15387	
Household-Size								
1-5 members	99.12	0.88	44708	0.1289	97.74	2.26	44698	0.639
≥ 6 members	99.14	0.86	26157		97.65	2.35	26165	
House Type								
Pucca/Semi Pucca	99.07	0.93	58664	0.111	97.51	2.49	58670	0.000
Kutcha	99.39	0.61	11817		98.70	1.30	11809	
Water Source								
Own dwelling	98.97	1.03	31545	0.775	97.37	2.63	31550	0.226
Own yard/plot	99.47	0.53	14521		98.65	1.35	14526	
Outside dwelling	99.09	0.91	20980		97.48	2.52	20971	
Toilet								
Improved sanitation	99.08	0.92	51767	0.159	97.77	2.23	51764	0.366
Unimproved	99.25	0.75	18845		97.54	2.46	18846	

Cooking fuel								
Clean	99.03	0.97	36915	0.099	97.50	2.50	36911	0.047
Unclean	99.22	0.78	33695		97.93	2.07	33697	
Damp wall/ceiling								
No	99.23	0.77	14778	0.265	96.90	3.10	14774	0.000
Yes	99.10	0.90	55832		97.93	2.07	55834	
Total	99.13	0.87	70865		97.70	2.30	70863	

Table 3: Odds ratios of dengue and chikungunya by socioeconomic and housing variables in older adults in India, LASI-1 (2017-2018)

Variables	Dengue			Chikungunya		
Age Group	**UOR**	**OR**	**95% CI**	**UOR**	**OR**	**95% CI**
45-54 years	1	1		1	1	
55-69 years	0.76*	0.69**	0.53 – 0.91	0.89	0.87	0.72 – 1.05
≥ 70 years	0.80	0.65	0.42 – 1.01	0.72*	0.70**	0.55 – 0.89
Sex						
Female	1			1		
Male	0.75*			0.82		
Residence						
Rural	1	1		1	**1**	
Urban	1.48*	1.57**	1.17 – 2.10	1.46**	1.56**	1.20 – 2.02
MPCE Quintile						
Poorest	1	1		1	1	
Poorer	1.19	1.36	0.92 – 2.00	1.17	1.30	1.00 – 1.68
Middle	1.15	1.34	0.89 – 2.02	1.43*	1.57**	1.12 – 2.20
Richer	1.50*	1.81**	1.23 – 2.68	1.43**	1.60**	1.23 – 2.09
Richest	1.64*	2.10**	1.33 – 3.31	1.52**	1.73*	1.30 – 2.28
Education						
0 School years	1	1		1	1	
1-5 School years	0.91	0.81	0.52 – 1.27	0.85	0.76*	0.61 – 0.95
6-12 School years	0.84	0.59**	0.41 – 0.83	0.88	0.65**	0.52 – 0.81
College	0.49*	0.24**	0.12 – 0.49	0.86	0.51**	0.34 – 0.77
Caste						
Scheduled tribe	1			1	1	
Scheduled caste	2.06*			2.28**	1.92**	1.29 – 2.86
Other backward caste	1.42			1.81*	1.51*	1.06 – 2.17
Forward caste	1.77			2.56**	2.21**	1.52 – 3.21
Occupation						
Not a current worker	1	1		1		
Agricultural and allied	0.52**	0.54**	0.39 – 0.77	1.06		
Self-employed /Wages	0.94	0.90	0.67 – 1.20	1.03		
Household-Size						

1-5 members	1			1		
≥ 6 members	0.97			1.04		
House Type						
Pucca/Semi Pucca	1			1	1	
Kutcha	0.66			0.51**	0.53**	0.40 – 0.71
Water Source						
Own dwelling	1	1		1	1	
Own yard/plot	0.51**	0.55**	0.37 – 0.80	0.51**	0.58**	0.46 – 0.73
Outside dwelling	1.05	1.02	0.73 – 1.41	0.96	1.20*	0.96 – 1.50
Toilet						
Improved sanitation	1			1		
Unimproved	0.81			1.11		
Cooking fuel						
Clean	1			1		
Unclean	0.8			0.83*		
Damp wall/ceiling						
No	1			1	1	
Yes	0.86			1.51**	0.62**	0.50 – 0.77

UOR: Unadjusted Odds Ratio; AOR: Adjusted Odds Ratio, * p value< 0.05** p value: < 0.01

Figures

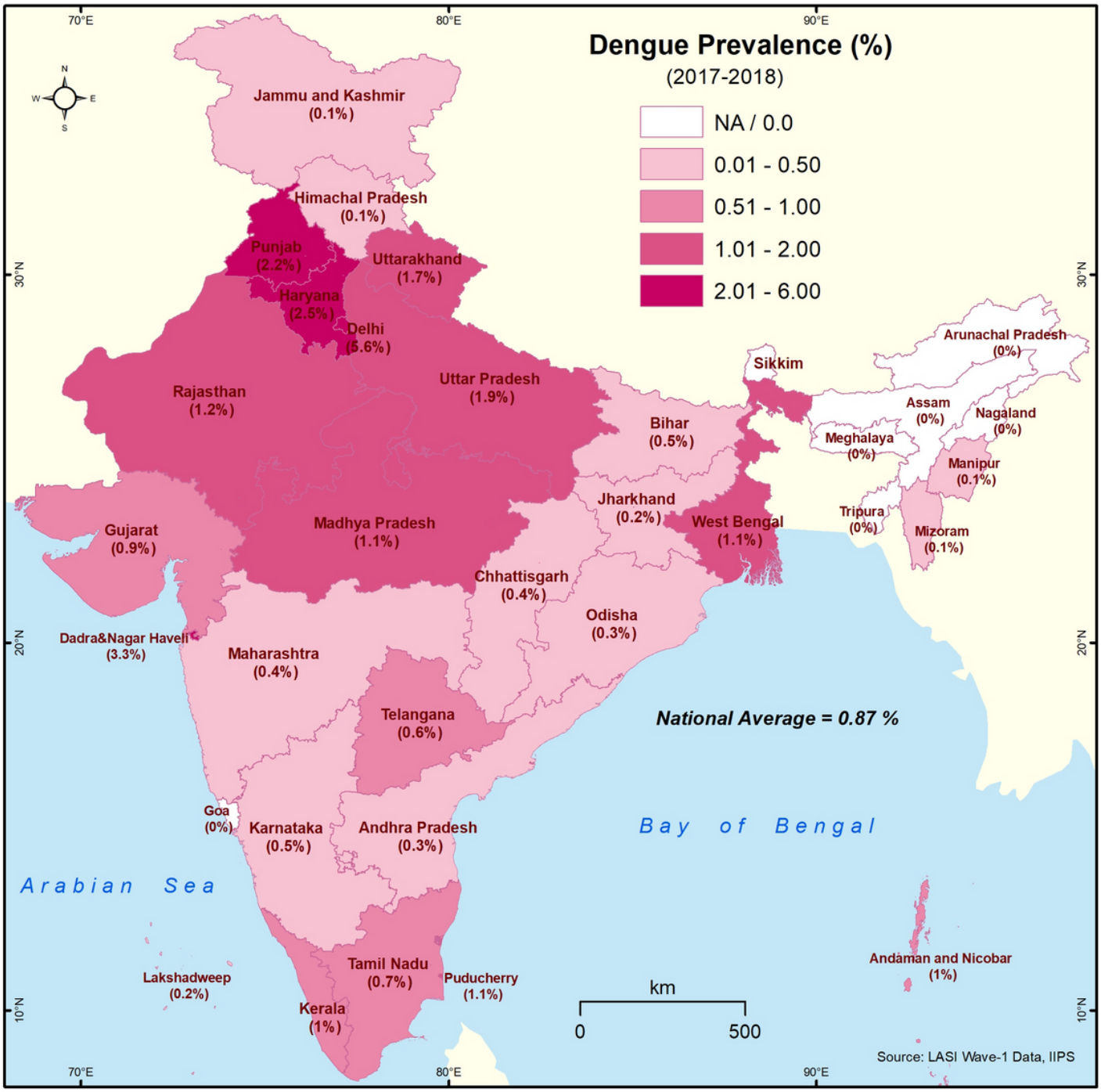

Figure 1

Legend not included with this version

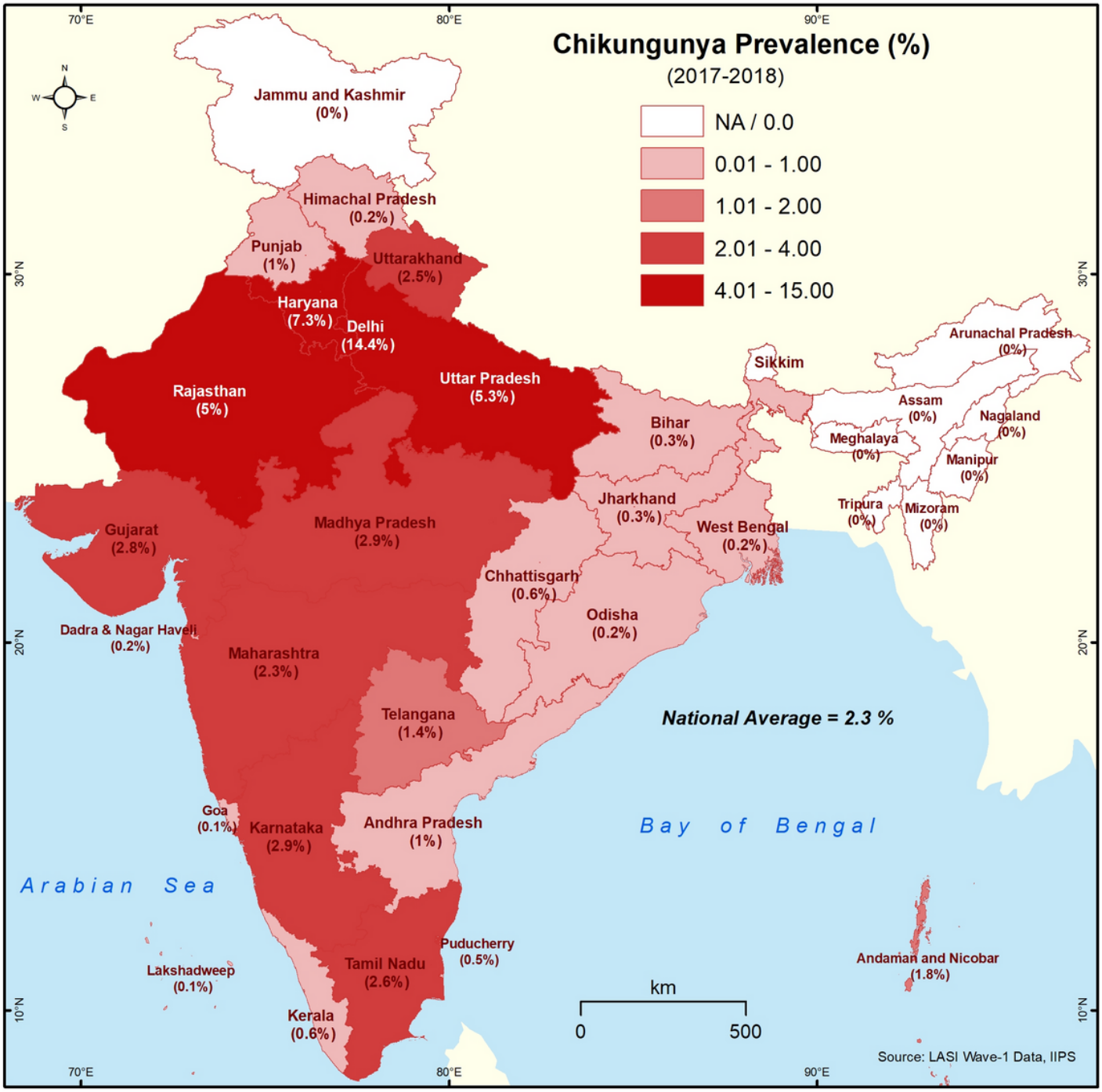

Figure 2

Legend not included with this version

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1.txt