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Dengue Seroprevalence in Different Geographic Zones of India: A Systematic Review and Meta-Analysis of Cross-Sectional Studies

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Abstract

Dengue is a highly prevalent mosquito-borne disease that is endemic in over 100 countries. It has a wider impact in terms of severity of illness and mortality risk in the absence of an effective vaccine as yet. The purpose of this study was to use meta-analysis to find out how common the dengue virus (DENV) is in India based on public data and to figure out how much of a problem. We searched, read, and reviewed about DENV in India that were available online. Forty-four cross-sectional studies were selected from the 178 records. There were reports of dengue cases in 14 out of the 28 states. Out of the patients presenting with symptoms of Dengue 27% of people were confirmed to have DENV infection with 82.29% (95% CI. 81-84%), having dengue IgM, 41.67% (95% CI: 40.16-43.43), having dengue IgG, and 23.97% (95% C.I. 14-43%), having both IgG and IgM from positive sample n=27156. Hospital-based cross-sectional studies on suspected Dengue-like illness (DLI) found that 99.48% of people had confirmed dengue out of the patients with features of DLI, and community-based studies found that 0.52% of DLI cases had dengue. The seroprevalence rates for East, South, North, and Western regions were 35.38% (95% C.I.14-31%), 11.57% (95% C.I. 2-69%), 38.10% (95% C.I. 9-61%), and 14.87% (95% C.I. 6-38%) correspondingly. DENV is interestingly spreading across the whole country, and the disease's frequency varies a lot from place to place and from 2010-2023. However this review does not find appropriate published literature from 50% of the Indian states. The identification of IgG-class antibodies to dengue virus is indicative of prior exposure to this pathogen. Almost all immunocompetent individuals should have developed IgG antibodies against the dengue virus within three weeks of exposure. The presence of dengue virus IgM-class antibodies is indicative of an acute phase of infection. National Vector borne Disease Control Programme (NVBDCP) has some surveillance information, appropriate designed research into prevalence and risk factors for DENV infection would be required to provide adequate information for public health intervention.

Keywords: Seroprevalence, Dengue Virus, Systematic Review, Meta-Analysis, Dengue-like Illness

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INTRODUCTION

Dengue fever transmitted by mosquitoes is a global health crisis and (DENV, serotypes 1-4) is a highly significant arbovirus found in the tropics and subtropics. India is host to numerous viral diseases, including Crimean-Congo hemorrhagic fever, Kyasanur forest illness, chikungunya fever, West Nile virus, and Japanese encephalitis. There has been an increase in dengue epidemics in Indian cities since the mid-1990s. The disease quickly spread to previously uncharted regions, including Orissa, Arunachal Pradesh, and Mizoram. In 1780, the city of Madras (now known as Chennai) experienced the first recorded incidence of dengue fever in India. India has had several epidemics since the initial outbreak in Kolkata in 1963.[1] There have been four different dengue serotypes in the country since 1956. There has been an explosion in dengue cases in India since 2001. During the early 2000s, dengue also severely affected the Indian states of Maharashtra, Karnataka, Pondicherry, Tamil Nadu, Delhi, Rajasthan, Haryana, Punjab, and Chandigarh. It has expanded to numerous states and regions of the union in recent years. The disease is increasing in both the quantity and severity of cases, and it has spread to numerous new regions. The spread of dengue fever from urban to rural areas has advanced.[2] Based on the historical records of the spread and transmission of DENV, In the last 50 years, the number of dengue cases worldwide has increased.[3] Approximately 50 million people are infected with dengue each year in over 100 countries and an additional 3.97 billion people from 128 nations are at risk of getting sick.[4-6] Dengue transmission in India has been associated with unplanned urbanization, environmental changes, host-pathogen interactions, and community immune system factors. Insufficient measures to regulate vectors have additionally facilitated the transmission of the dengue virus and its mosquito vectors. In India, the Dengue virus is transmitted primarily by *Aedes aegypti* and Aedes albopictus mosquitoes.[7] Symptoms of dengue can vary from non-existent to dengue shock syndrome. The Western Pacific and Southeast Asia (SEA) account for 75% of all dengue occurrences worldwide.[8] Numerous nations have approved Dengvaxia(R), a dengue vaccine. Live attenuated tetravalent vaccination Dengvaxia(R) is undergoing phase,[9] clinical trials in Asia and Latin America (Brazil, Honduras, Mexico, and Puerto Rico).[10] Dengvaxia(R) was protected against virologically confirmed dengue by 50.2% to 76.6% across age groups and serotypes in clinical trials.[11] Furthermore, Dengvaxia (R) has not received approval from the Indian Ministry of Health and Family Welfare. As evidenced by the increasing number of clinical trials, India requires them.[12] Though the vaccines against DENV has not got approval in India it is quite demanding for an early introduction. Since the first virologically proven evidence of Dengue, it is spreading all over the country. [13,14] Also there is an apparent increase in case fatality rate globally, including India.[15] A new serotype DENV-5 has also surfaced in the recent years (2013).[16]

Different studies on the prevalence of DENV in India have come up with different outcomes, likely because of changes in geography, time, and research methods.[17] Even places where DENV is common are seeing changes in the types of viruses circulating.[18] The goal of this study is to conduct a thorough review and meta-analysis of the high seroprevalence of Dengue virus infection in India. The purpose of this research is to understand the prevalence of Dengue in the country and also its clinical severity.

MATERIALS AND METHODS

Searching strategy

To conduct the literature review and extract records, several databases, such as PubMed Web of Science, Scopus, Sciences, Google Scholar, EMBASE and Medline, ScienceDirect were searched with the following combination of search terms: ("India") and "dengue" or "dengue fever" or "dengue prevalence" or "dengue incidence" or "Seroprevalence of Dengue" or "dengue virus" or "severe dengue" or "DENG" or "DENV" and the last search was conducted up to December 2023.

Criteria for inclusion

Studies were gathered irrespective of the type of research, geographical location, or year of survey implementation. Only Indian reports were incorporated. Case series, community and hospital-based studies, and case-control research that supplied information on dengue exposure

were incorporated into our analysis. For identifying DENV infection, enzyme-linked immunosorbent assays (ELISAs) for IgG and/or IgM were the primary laboratory tests utilized. However, certain IgM-based investigations incorporated additional PCR testing to validate the infection and ascertain the serotype.

Articles lacking clarity, study design, study setting, laboratory investigation (Dengue IgG/IgM) and there interpretation were excluded from the study.

Data extraction and validity assessment

The meta-analysis utilised the New Castle-Ottawa Scale (NOS) procedure to evaluate the absence of randomization in participant enrolment and any other possible bias in the studies.[18] The following information was extracted from each eligible study: demographics of the research participants, author, location, survey year, methodology, type of diagnostic testing, study design, sample size, and dengue testing results, prevalence and severity.

Statistical analysis

The study was done with STATA-13 from the School of Biotechnology, KSBT, KIIT, Odisha, India. The data was evaluated using random effects modelling to investigate the status of Dengue virus (DENV) infection in different regions of India. DENV seroprevalence was the main outcome measure. The binomial probability distribution was employed to calculate the standard error of the prevalence estimate from the cross-sectional studies. A random effects model was used to determine the overall and subgroup pooled effect size by finding the confidence interval and pooled proportion.[19,20] The chi-square (Q) value at the 10% significant level was used to measure how different the studies were from each other. It's not likely that the studies are similar because they were done by different experts in different places. Our research was conducted utilizing the random effect model, which postulated that the actual effect magnitude would vary across studies. A fixed-effect model, in contrast, calculates the mean of a collection of effects. In our analysis model, we incorporated

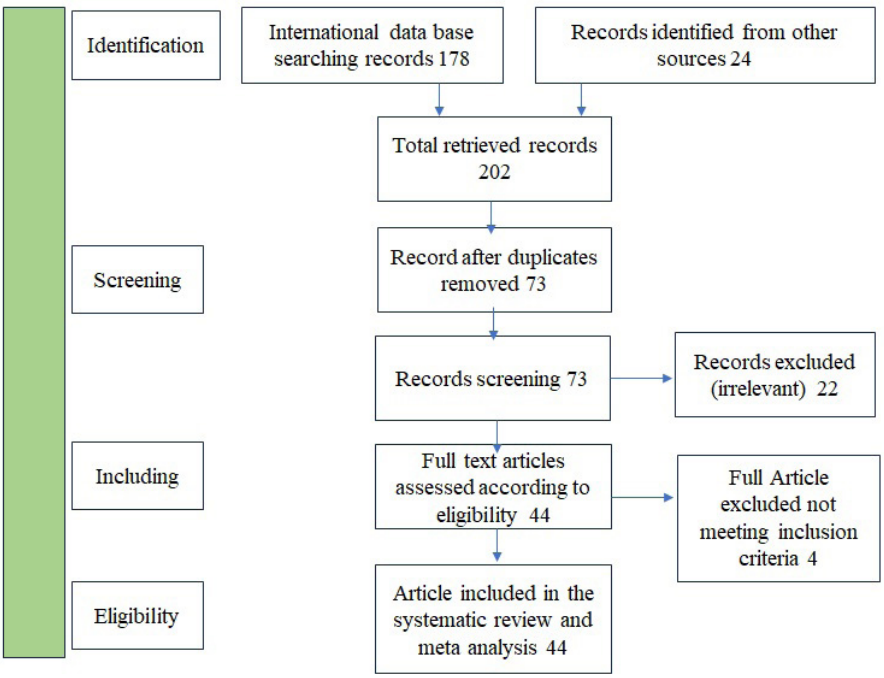

Figure 1. Flowchart for Study Inclusion

both within-study and between-study variance to ensure that no methodological bias existed. This model is predicated on the relative importance of each study. The objective is to obtain an approximation of the mean effect from multiple studies, irrespective of the sample sizes.[21]

RESULTS

Out of the 202 studies found, 10 duplicates were removed. Among the 73 remaining records, 29 were excluded for reporting diseases other than dengue yet referencing dengue reports. Forty-four studies were reviewed, and 4 more records were removed because they did not provide sufficient data on research participants and infection rates (Figure 1).

Forty-four papers met all the inclusion criteria and were included in the analysis. The studies selected encompassed various regions of India: five from the Eastern region, 11 from the West, 10 from south India, and 17 from North India (Table and Figure 2a).

There were 43 cross-sectional studies conducted in hospitals, and one cross-sectional research conducted in the community. Most of

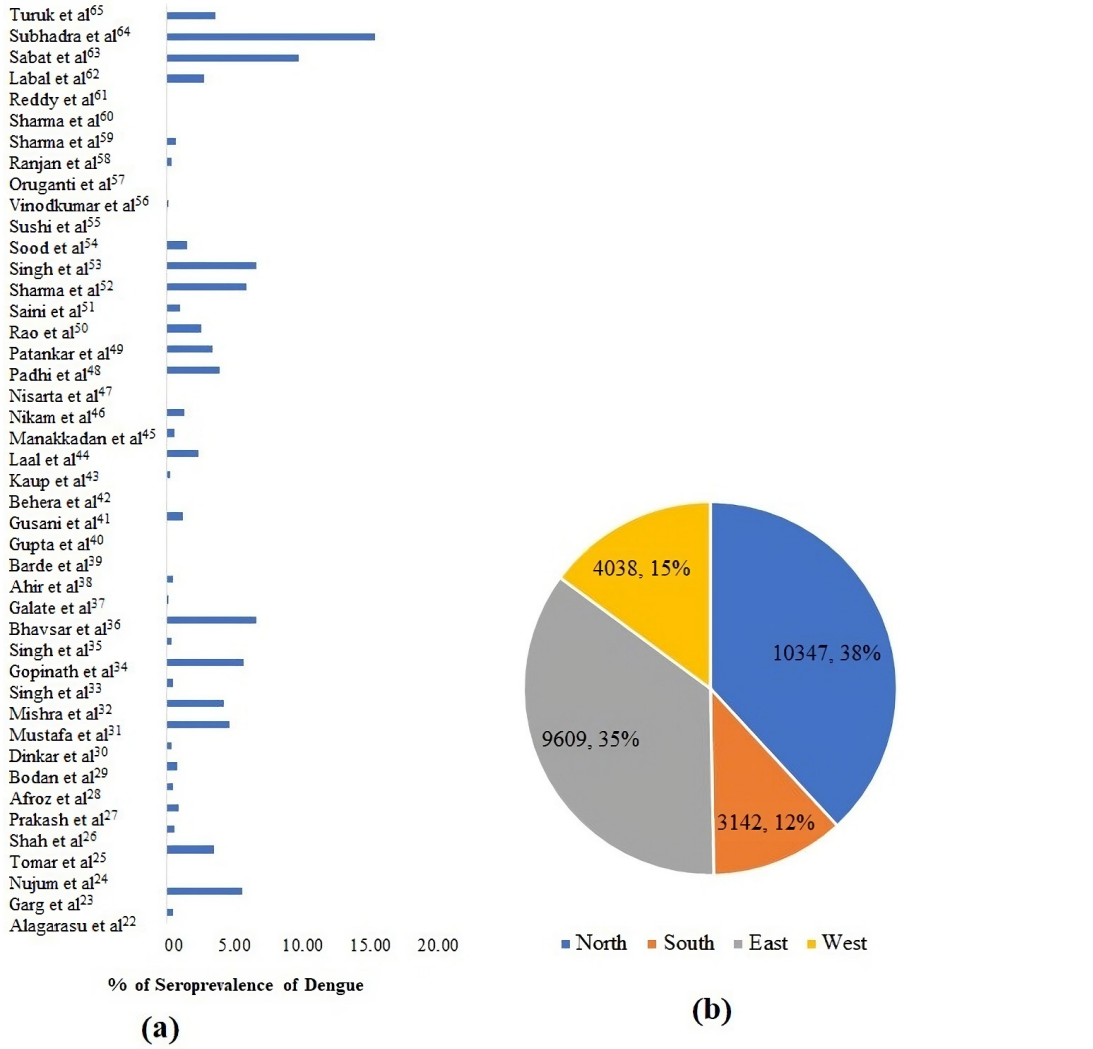

Figure 2. The approximated case study for seroprevalence percent in various Indian regions (n=27156)

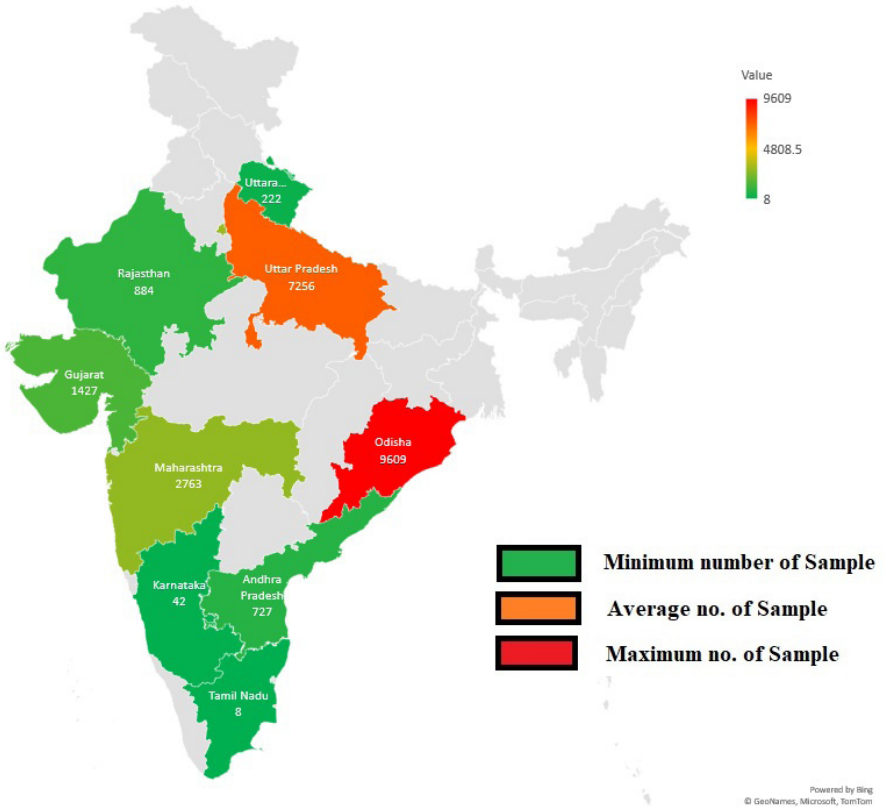

Figure 3. Displays a map of India highlighting states where dengue virus infection has been documented. States are color-coded to reflect the number of DENV found: red for extremely high, yellow for medium, and green for low

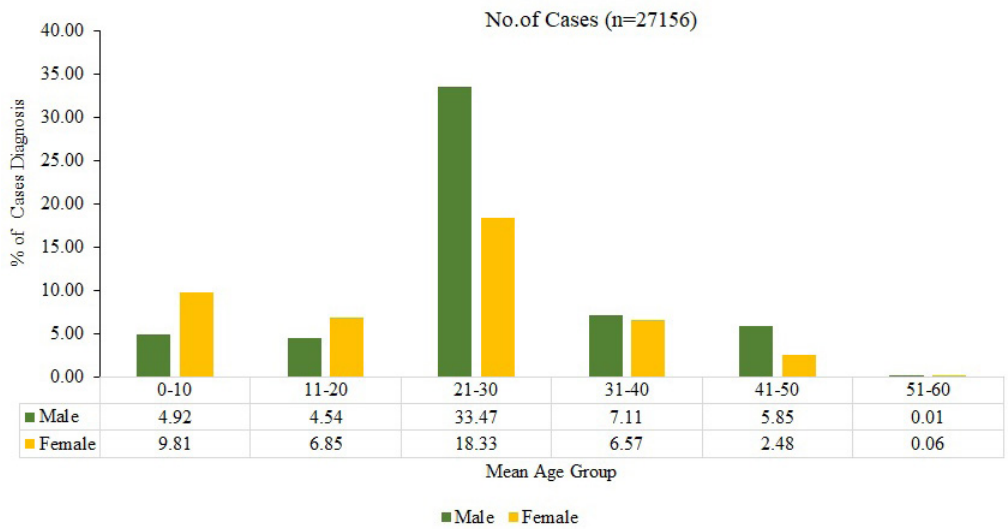

Figure 4. displays the estimated percentage of DENV seroprevalence according to the mean age group between male and female from the analysis of all studies included

Table. List of studies that met the criteria to be included in the analysis

No.	Author/Year of Publication	Region	State	Study type	Diagnostic test	Sample size	No. of case	Reported Prevalence (%)	Detected Serotype	Age Group	Sex	Ref
1.	Kalichamy Alagarasu et al.	West	Pune, Maharastra	Population-based	ELISA-IgM & IgG	230	141	61.30	DENV1 to 4	>60	M+F	22
2.	Suneela Garg et al.	North	Delhi	Cross-sectional hospital-based	ELISA-IgG	2609	1511	57.91	DENV1 to 3	5 to 10	M+F	23
3.	Zinia T. Nujum et al.	South	Thiruvanan-thapuram	Cross-sectional hospital-based	ELISA-IgG	126	16	12.70	DENV	24	F	24
4.	Shilpa Jagatram Tomar et al.	West	Pune, Maharashtra	Cross-sectional hospital-based	ELISA-IgM & IgG	2520	948	37.62	CHIKV	25	M+F	25
5.	Paresh S. Shah et al.	West	Pune, Maharastra	Cross-sectional hospital-based	ELISA-IgG	819	168	20.51	DENV1 to 5	10	M+F	26
6.	Prabhu Prakash et al.	North	Rajstan	Cross-sectional hospital-based	ELISA-IgM & IgG	1664	250	15.02	DENV	10 to 40	M+F	27
7.	Pragya Ranjan et al.	North	Delhi	Cross-sectional hospital-based	ELISA-IgM & IgG	200	144	72.00	DENV	19 to 51	M+F	28
8.	Gaurav Badon et al.	North	Uttarakhand	Cross-sectional hospital-based	ELISA-IgM & IgG	279	222	79.57	DENV & CHIKV	>80	M+F	29
9.	Anju Dinkar et al.	North	Banaras	Cross-sectional hospital-based	ELISA-IgM	186	108	58.06	DENV	20 to 50	M+F	30
10.	Zeeshan Mustafa et al.	North	Uttar Pradesh	Cross-sectional hospital-based	ELISA-IgM	7256	1277	17.60	DENV1 to 4	>40	M+F	31
11.	Akhilesh C. Mishra et al.	West	Pune, Maharastra	Cross-sectional hospital-based	ELISA-IgG	1434	1163	81.10	DENV	>70	M+F	32
12.	Sweta Singh et al.	North	UP India	Prospective Cross-Sectional study	ELISA-IgM	1,067	138	12.93	DENV	18 to 62	M+F	33
13.	Kanwardeep Singh et al.	North	Amritsar	Cross-sectional hospital-based	ELISA-IgM	2709	1538	56.77	DENV	21 to 40	M+F	34
14.	Jitendra Singh et al.	West	Banaras	Cross-sectional hospital-based	ELISA-IgM	161	110	68.32	DENV	>18	M+F	35
15.	Amit Bhavsar et al.	South	Hydrabad	Cross-sectional hospital-based	ELISA-IgG	2556	1789	69.99	DENV	5 to 10	M+F	36
16.	Lata Baswanna Galate et al.	West	Mumbai	Cross-sectional hospital-based	ELISA-IgM	200	62	31.00	DENV & CHIKV	13 to 60	M+F	37

Table. Cont...

No.	Author/Year of Publication	Region	State	Study type	Diagnostic test	Sample size	No. of case	Reported Prevalence (%)	Detected Serotype	Age Group	Sex	Ref.
17.	Hitesh R et al.	West	Gujrat	Cross-sectional hospital-based	ELISA-IgM	1146	148	12.91	DENV		M+F	38
18.	Pradip V Barde et al.	Centre	Madhya Pradesh	Cross-sectional hospital-based	ELISA-IgM	119	21	17.65	DENV		M+F	39
19.	Ekta Gupta et al.	West	Delhi	Cross-sectional hospital-based	ELISA-IgM	75	19	25.33	DENV	10 to 86	M+F	40
20.	Jigar Kiritkumar Gusani et al.	West	Gujrat	Prospective & observational study	ELISA-IgM	765	331	43.27	DENV	21 to 30	M+F	41
21.	Arshi Islam et al.	North	Delhi	Cross-sectional hospital-based	ELISA-IgM	62	18	29.03	DENV1 to 4	21 to 30	M+F	42
22.	Soumya Kaup et al.	South	Tumkur	Cross-sectional hospital-based	ELISA-IgM & IgG	278	91	32.73	DENV	>75	M+F	43
23.	H. Lall et al.	North	Delhi	Retrospective study	ELISA-IgM	3163	646	20.42	DENV	11 to 30	M+F	44
24.	Anoop Manakkadan et al.	South	Kerala	Cross-sectional hospital-based	ELISA-IgG	709	162	22.85	DENV	>55	M+F	45
25.	Nikam AP et al.	North	Delhi	Observational study	ELISA-IgM & IgG	1090	354	32.48	DENV	0 to 15	M+F	46
26.	Ankita Nisarta et al.	West	Gujrat	Cross-sectional hospital-based	ELISA-IgM & IgG	90	21	23.33	DENV	16 to 35	M+F	47
27.	Sanghamitra Padhi et al.	east	Odisha	Retrospective study	ELISA-IgM & IgG	5102	1074	21.05	DENV	>60	M+F	48
28.	Manisha Patankar et al.	West	Gujrat	Cross-sectional hospital-based	ELISA-IgM	4401	927	21.06	DENV	18 to 35	M+F	49
29.	Srinivas Rao M.S et al.	South	Andhra Pradesh	Cross-sectional hospital-based	ELISA-IgM & IgG	1327	706	53.20	DENV	>50	M+F	50
30.	S. Saini et al.	South	Maharastra	Cross-sectional hospital-based	ELISA-IgM & IgG	917	281	30.64	DENV	>60	M+F	51
31.	Yukti Sharma et al.	North	Delhi	Cross-sectional hospital-based	ELISA-IgM & IgG	8138	1600	19.66	DENV	>50	M+F	52
32.	Kanwardeep Singh et al.	North	Amritsar	Cross-sectional study	ELISA-IgM	5781	1790	30.96	DENV	>60	M+F	53

Table. Cont...

No.	Author/Year of Publication	Region	State	Study type	Diagnostic test	Sample size	No. of case	Reported Prevalence (%)	Detected Serotype	Age Group	Sex	Ref.
33.	Smita Sood et al.	North	Rajasthan	Cross-sectional hospital-based	ELISA-IgM & IgG	2169	412	18.99	DENV	>90	M+F	54
34.	K. Mary Sushi et al.	South	Tamilnadu	Prospective study	ELISA-IgM	100	8	8.00	DENV	20 to 45	M+F	55
35.	C.S. VinodKumar et al.	South	Karnataka	Cross-sectional hospital-based	ELISA-IgM & IgG	72	42	58.33	DENV	5 to 10	M+F	56
36.	Ganesh Oruganti et al.	South	Andhra Pradesh	Cross-sectional hospital-based	ELISA-IgM	200	21	10.50	DENV	25 to 45	M+F	57
37.	Pragya Ranjan et al.	North	Delhi	Cross-sectional hospital-based	ELISA-IgM	200	116	58.00	DENV	>51	M+F	58
38.	Kritika Sharma et al.	North	Rajasthan	Cross-sectional hospital-based	ELISA-IgM & IgG	200	196	98.00	DENV	15 to 24	M+F	59
39.	Sharma G.K et al.	North	Rajasthan	Prospective cross sectional study	ELISA-IgM & IgG	107	26	24.30	DENV	3 to 11	M+F	60
40.	M.N Reddy et al.	South	Kerala	Cross-sectional hospital-based	ELISA-IgM	100	26	26.00	DENV	30 to 40	M+F	61
41.	Saloni Labalaet al.	East	Odisha	Cross-sectional hospital-based	ELISA-IgM	2892	763	26.38	DENV	31-40	M+F	62
42.	J. Sabat	East	Odisha	Cross-sectional hospital-based	ELISA-IgM	5320	2644	49.69	DENV	>60	M+F	63
43.	Subhra Subhadra	East	Odisha	Cross-sectional hospital-based	ELISA-IgM	5198	4154	79.91	DENV	>60	M+F	64
44.	Jyotirmayee Turuk	East	Odisha	Cross-sectional hospital-based	ELISA-IgM	2902	974	33.56	DENV	>40	M+F	65

these investigations were conducted during or after well-known disease epidemics.

A total of 27136 cases registered in these studies, highest number of cases reported from North India (38%) followed by East (35%) ,West (15%) and South (12%) respectively (Figure 2b).

As per the meta-analysis, the aggregate seroprevalence of cases presenting with DLI in India is 35.43% (95% C.I. 13-32%). The differences in DENV infection estimates (p = 0.11 and 99.46%) may be attributed to differences in disease transmission/infection rate-related factors such as the diagnostic methodologies used to assess DENV infection, the study design and spatiotemporal variance (Figure 3 and Table).

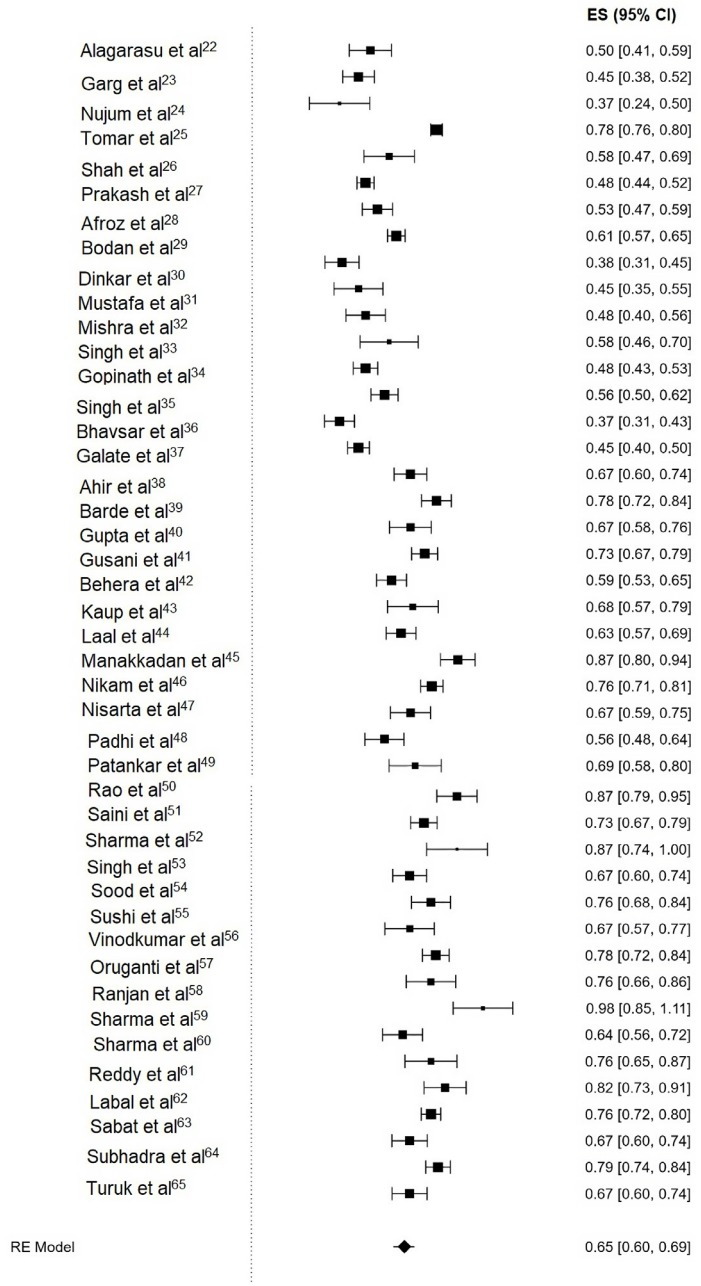

Figure 5. displays the estimated dengue burden in India

The meta-analysis indicated that different mean age groups had varying impacts on the total seroprevalence of DENV in India: 0-10 age group (14%)(95% CI: 11.1-16.6), 11-20 age group (11.39%)(95% CI: 10.1-13.6), 21-30 age group (51.81%)(95% CI: 50.13-54.43), 31-40 age group (13.68%)(95% CI: 11.32-15.16), 41-50 age group (8.33%)(95% CI: 7.45-9.32), and 51-60 age group (0.07%)(95% CI: 0.01-0.6), (p=0.239) (Figure 4). The study revealed a spectrum of DENV seroprevalence, ranging from 21 to 30 in all age groups. The highest prevalence was detected in both male and female individuals compared to others. Additionally, the percentage of males in the mean age group of 21 to 30 was higher than that of females (Figure 3).

By conducting sub-group analysis according to the geographic location of the study site in North, East, South, and Western India, the regional malady prevalence was ascertained. It was estimated that the seroprevalence of DENV infections in East India was 35.38% (95% C.I. 14-31%), in South India it was 11.57% (95% C.I. 2-69%), in North India it was 38.10% (95% C.I. 9-61%), and in Western India it was 14.87% (95% C.I. 6-38%).

Additional statistical analyses were performed to investigate the significance and variation of the DENV seroprevalence in general, as well as the seroprevalence pertaining to the types of studies, geographic regions, and diagnostic approaches utilised for DENV detection. The analysis reveals substantial heterogeneity, which explains 99.46% (95% CI 15-30%) of the estimated seroprevalence (p = 0.17) (Figure 5). As a result, the influence of confounding variables on the results is significantly reduced.

Figure 6 displays the estimated dengue burden based on subgroup analysis categorized by the geographical location of the research regions. Region: North India South India, West India East India.

Subsequent examination was conducted by subdividing and scrutinizing the studies by the laboratory test employed to distinguish between recent acute infection (IgM) and prior exposure to DENV (IgG) (Figure 7). As determined by IgM ELISA, the estimated seroprevalence of DENV was 82.29% (95% CI. 81-84%), and the I^2 was 94.02%. IgG ELISA estimated the seroprevalence of DENV to be 41.67% (95% C.I. 14-43%), and the I^2 was

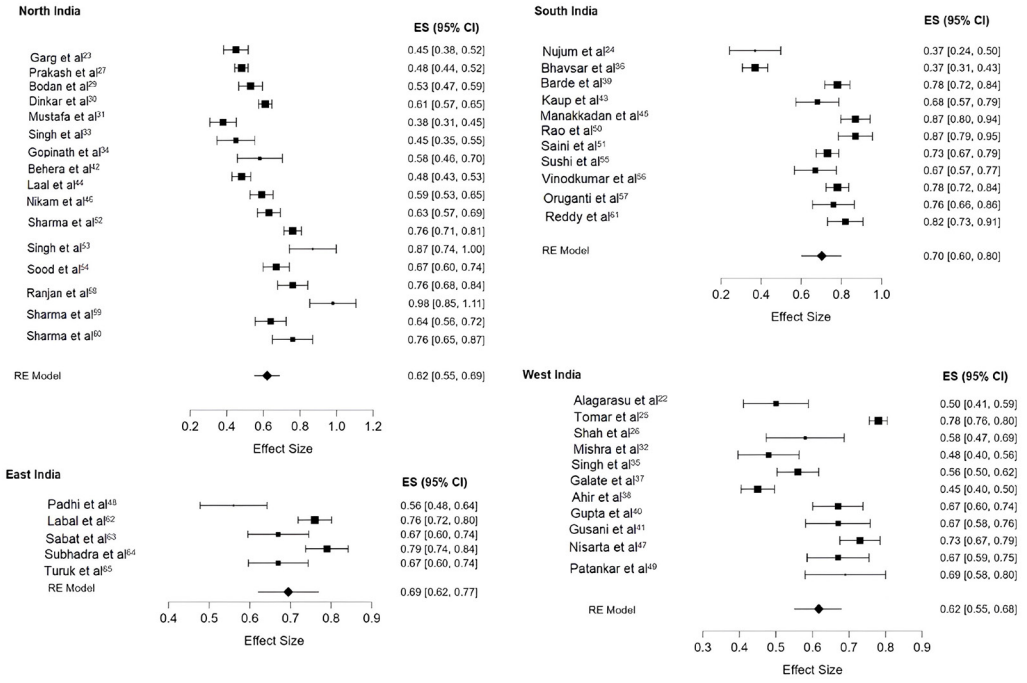

Figure 6. Shows the estimated dengue burden based on sub-group analysis categorized by the geographical location

96.04%, which is consistent with the IgG antibody response being more durable.

DISCUSSION

This research endeavoured to conduct an exhaustive review and meta-analysis of the serotype prevalence of DENV in India from 2010 to 2023. Finally, the meta-analysis showed that 35.43% of people in India have DENV and that the virus is common in many parts of the country. Still, this study showed that India's people are at high risk for DENV and other arboviral infections because of the abundance of vector and conducive environment. In some cases, surveys were done up to 21 years apart. Arbovirus surveillance needs to be more thorough and consistent right away to find epidemics and move valuable public health resources in the right direction.[66] This monitoring system needs to have a good way for people to talk to each other so that information about disease outbreaks and prevalence can be shared quickly.[67]

Subgroup analysis was performed in order to improve the accuracy of the disease prevalence estimates and reduce the potential for bias that may have been introduced by combining multiple studies. This involves conducting a subgroup analysis of the studies according to their location, study type, and the DENV infection detection test utilized. Temporal variation was examined in subgrouping studies based on the diagnostic test conducted (IgG for prior exposure to the virus and IgM for the most recent acute infection).[68] DENV-IgM was much more common than DENV-IgG

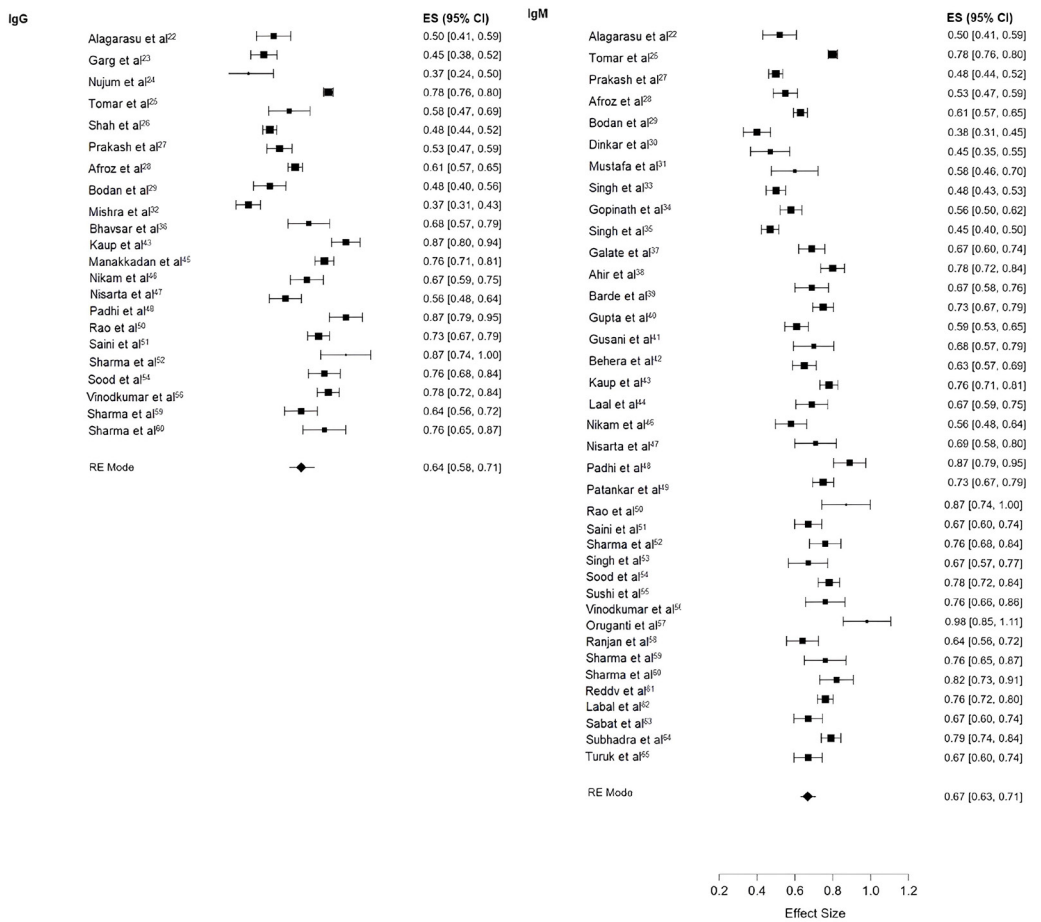

Figure 7. The estimated DENV seroprevalence by scrutinizing the studies as per laboratory test employed

n=22347; 82.29% (95% CI 10-28%) vs n=11317; 41.67% (95% C.I. 14-43%) which suggests that DENV transmission was widespread.[69] The seroprevalence of DENV is higher in hospital-based studies compared to community-based research. This means that DENV is common all over the country. To look at how DENV seroprevalence changes with space, studies were divided into groups based on the parts of the country where they were performed.

The present investigation reported a pooled seroprevalence of dengue infection, as determined by indicators such as IgM and IgG antibodies, which were found to be 41.67% and 23.97% respectively. After doing a study, it was found that the highest rates of DENV were found in northern (38%) and eastern (35%) part of India. The seroprevalence was 15% and 14% for Southern and Western part of India, respectively. The values align with those documented by Li et al., who observed a global seroprevalence of dengue infection at 38%. The South East Asia region had the highest seroprevalence of dengue, namely 56%, while the European arena had the lowest, specifically 4%.[70] Nevertheless, the combined prevalence of IgM, IgG, and DENV-RNA in febrile individuals from Africa was documented as 8.4%, 10.8%, and 24.8%, respectively.[71] Humphrey et al. reported a seroprevalence of 25% (ranging from 0% to 62%) in the general population in the Middle East and North Africa from 1941 to 2015.[72]

Our investigation unveiled that a mean of 51% of dengue-positive patients were between the ages of 21 and 30. The elevated incidence of dengue-positive infections among individuals aged 21-30 could potentially be attributed to daytime Aedes mosquito bite susceptibility caused by local activities, such as attending school or college and engaging in outdoor pursuits.[73] According to additional research conducted in Delhi, West Bengal, Odisha, and Central India, dengue fever is most prevalent among those aged 11 to 20, with those aged 21 to 30 following suit.[74-77] To prevent dengue, there should be increased public awareness. It is advisable to use insect repellents, particularly on small children, and to dispose of trash and obstruct rainwater collection in waste containers, tyres, bags, and other suitable locations.[78-81] The majority of dengue patients in this study presented with retro-orbital pain, arthralgia, myalgia, fever, headache, and shivers. Prior research conducted in Delhi, Assam, Uttar Pradesh, and West Bengal has documented that dengue patients exhibit similar symptoms.

Several types of the dengue virus were found in different parts of the country, as our study showed. The DENV-2 strain is thought to have more severe manifestation of the four serotypes.[82] Different DENV strains may be more common in some places than others. This could be because of selection pressures during DENV evolution or because some lines are more fit to live in humans or mosquitoes than others.[83] As a result, serotype variation kinetics are complex processes. Additionally, during the 2016 season, a new subgroup of DENV-4 (genotype I) emerged in Pune, India despite the fact that all four varieties were prevalent in India.[84]

DENV serotypes all four are reported in India.[85] All four DENV serotypes are present in dengue outbreaks in Uttar Pradesh. According to a study conducted in Uttar Pradesh between 2009 and 2012, serotype-2 of DENV was the most prevalent, followed by serotype-3 and serotype-1. There was no detection of serotype-4.[86] Separate studies conducted in Delhi, North India, between 2013 and 2015 identified serotype-2 as the prevailing DENV serotype, with serotype-1 following suit.[87-89] Conversely, an alternative investigation conducted in the midst of the 2014 dengue outbreak in New Delhi revealed serotype-1 to be the most prevalent, with serotype-2 following suit.[90] DENV serotype-3 was the most prevalent during the 2016-2017 dengue outbreak in New Delhi, according to one study.[91,92] Serotype-2 was the most prevalent. While these studies do not provide a definitive trend in the evolution of serotypes across time and space, this aspect can be further investigated in the future to gain a clearer understanding of the epidemiologic risks associated with the dissemination to uninformed regions.

India urgently needs to strengthen the existing arboviral disease surveillance programme to assess DENV prevalence, vector distribution, and virus serotypes and genotypes. It should aim to depict DENV risk and dynamics with precision and assist in disease prevention and control. It

would oversee vector management and identify risk factors for disease transmission in India in light of the country's current dynamic environmental conditions.

To investigate, prevent, and control endemic diseases, we, therefore, urge international donors, research and disease control funding agencies, health partners, and research institutes to establish coordinated funding mechanisms, develop capacity, and collaborate with institutions in endemic countries.

CONCLUSION

In conclusion, dengue is still an ongoing health challenge for the country despite efforts taken by the national health program. It affects all zones of India with the potential to spread over time and geographical locations that need comprehensive and integrated attention.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

Not Applicable.

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