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BEYOND THE BITE
THE PULSE OF VECTOR SCIENCE

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INSIDE THE PAGES

MESSAGE FROM THE PRESIDENT

I am delighted to present the June 2026 issue of the NAVBD Newsletter, featuring a fresh design and layout. For over three decades, the Academy has dedicated itself to addressing critical research gaps in vector-borne diseases, focusing on turning cutting-edge innovations into ground-level solutions. Our mission remains steadfast: to advance knowledge in combating major diseases like dengue, malaria, lymphatic filariasis, leishmaniasis and Japanese Encephalitis, alongside their vectors, including mosquitoes, ticks, mites, and sand flies.

With 60% of human pathogens being zoonotic in nature, exploring the "One Health" approach-which connects human, animal, and environmental health-is more vital than ever. To support this, we have launched several initiatives to build research capacity among young scientists and frontline workers, while supporting critical research into JE/AES, scrub typhus, and other viral outbreaks.

This momentum was in highlights during our 16th International Conference on Vector and Vector-Borne Diseases held in Cuttack from 21-23, November 2025, which served as a premier global platform for scientists to share their breakthroughs. Additionally, the Academy has reconstituted its Executive Committee, welcoming new members whose collective wisdom will further drive our vision forward. More recently, we marked World Malaria Day on April 25, 2026, by hosting a highly successful collaborative webinar supported by APMEN.

Looking ahead, we have an exciting lineup of academic activities in the coming year. We will continue to work closely with state governments, national programs, and scientific institutions to strengthen research, influence policy, and build a skilled workforce capable of eliminating targeted diseases and providing solutions to minimize the incidence of the others. This newsletter remains our flagship forum to showcase these milestones and share vital insights for the welfare of society. Wishing you all the very best in your endeavours.

(Dr Neena Valecha)
President

Dengue: an Emerging Vector Borne Disease - Challenges and Opportunities

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Dengue has emerged as one of the most important mosquito-borne viral diseases and a major public health challenge worldwide. Over past five decades, it has undergone a dramatic geographical expansion with increased incidence affecting populations in tropical, subtropical and increasingly temperate regions. World Health Organization (WHO) recognizes dengue as one of the fastest-growing vector-borne diseases (VBDs) globally and identified it among ten major threats to global health in 2019. Currently, dengue is endemic in 129 countries across Africa, the Americas, Eastern Mediterranean, South-East Asia and the Western Pacific. Nearly half of world's population now lives in areas at risk of dengue transmission.

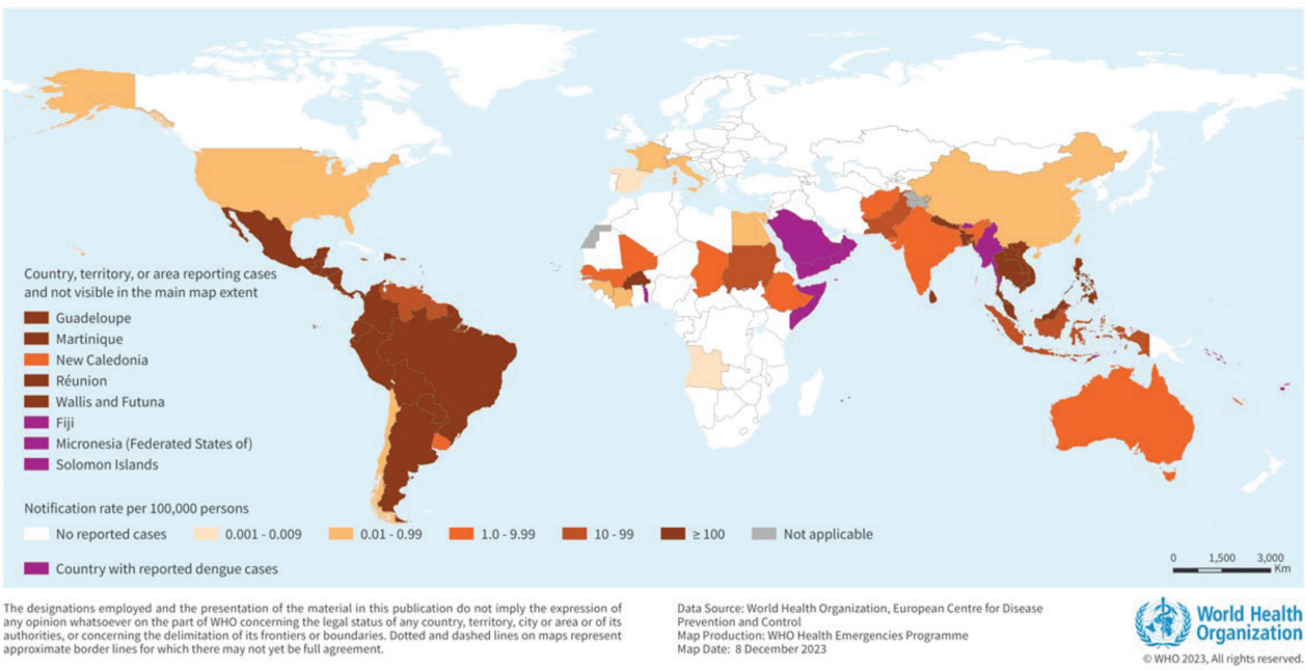


Fig.1. Global prevalence of Dengue 2023 – (Source WHO)

Global burden of dengue has increased substantially during past two decades. According to WHO estimates, number of dengue cases reported worldwide increased from approximately 505,430 cases in 2000 to more than 14.6 million cases in 2024. This remarkable increase reflects not only improvements in surveillance and reporting systems but also genuine expansion of dengue transmission resulting from rapid urbanization, globalization, population movement, climate variability, environmental changes and increasing human mobility. Dengue has become a disease of major public health significance because of its epidemic potential, economic impact and burden on health systems.

South-East Asia Region (SEAR) continues to experience a substantial dengue burden. Except for the Democratic People's Republic of Korea, all Countries in region including India are endemic for dengue. The disease has become deeply entrenched in the epidemiological landscape of South-East Asia, characterized by recurring outbreaks, circulation of multiple virus serotypes and increasing transmission intensity. Growing public health importance of dengue underscores need for sustained investments in surveillance, prevention, vector control, clinical management and research.

The year 2024 witnessed an unprecedented rise in dengue transmission globally, with more than 14.6 million cases and over 12,000 dengue-related deaths. The Americas contributed largest share of this burden accounting for more than 13 million reported cases. In response to this alarming situation, WHO assessed global risk of dengue as high and assigned as Global Internal Emergency Response Grade 3 (G3), emphasizing the urgent need for preparedness, surveillance strengthening and coordinated response measures.

Historical Perspective of Dengue in India

India has a long history of dengue transmission. Historical records indicate that a dengue-like illness was first reported from Madras (now Chennai) in 1780. Dengue virus was first isolated in India in 1945 during World War II. Subsequently, dengue fever was documented from Vellore district of Tamil Nadu in 1956 marking one of the earliest confirmed occurrences of the disease in the country. First recognized outbreak of Dengue Hemorrhagic Fever (DHF) occurred in Calcutta (now Kolkata), West Bengal in 1963 signifying the emergence of severe forms of dengue infection. During 90's, India experienced several significant dengue outbreaks, including a severe epidemic in Delhi in 1996 that caused high morbidity and mortality. Since then, dengue has evolved from a localized urban disease to a major nationwide public health challenge. Over the past 25 years, its geographic spread has expanded considerably, with all States and Union Territories (UTs) except Ladakh now reporting cases and deaths. The increasing incidence, recurrent outbreaks, and widespread distribution have established dengue as one of India's most important vector-borne diseases.

The National Vector Borne Disease Control Programme (NVBDCP), a centrally sponsored scheme under the overarching umbrella of National Health Mission (NHM), oversees the prevention and control of six vector-borne diseases in India. Dengue control was incorporated into NVBDCP in 2003 alongside malaria, lymphatic filariasis, kala-azar and Japanese encephalitis, while chikungunya was added in 2007. In 2022, NVBDCP was renamed as National Centre for Vector Borne Diseases Control (NCVBDC), which now implements the NVBDCP programme nationwide.

Epidemiology and Disease Burden in India

Epidemiological evolution of dengue in India reflects broader social, environmental and demographic transformations occurring in the Country. Rapid urbanization, population growth, expansion of transportation networks, increased mobility, changing water storage practices and environmental modifications have collectively contributed to establishment and spread of dengue vectors across

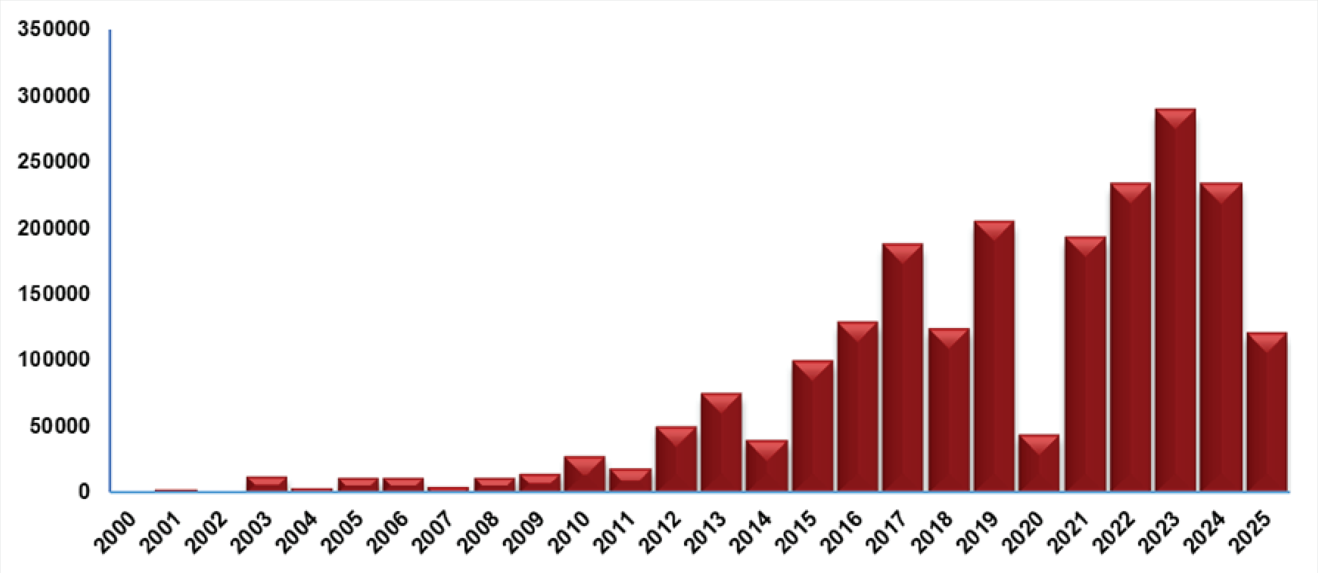


Fig.2. Dengue cases during last two decades

diverse ecological settings. Consequently, dengue transmission has become increasingly complex and difficult to predict.

Dengue burden in India has increased substantially over past two decades. Reported cases have shown a continuous upward trend, with the highest number of cases recorded in 2023, when approximately three lakh cases were reported nationwide. A significant geographical spread has been observed since the beginning of the twenty-first century. In 2000, only a limited number of States reported dengue cases, however, by 2025, all States and UTs became endemic except Ladakh. Disease trend from 2000 to 2025 is in Fig. 2

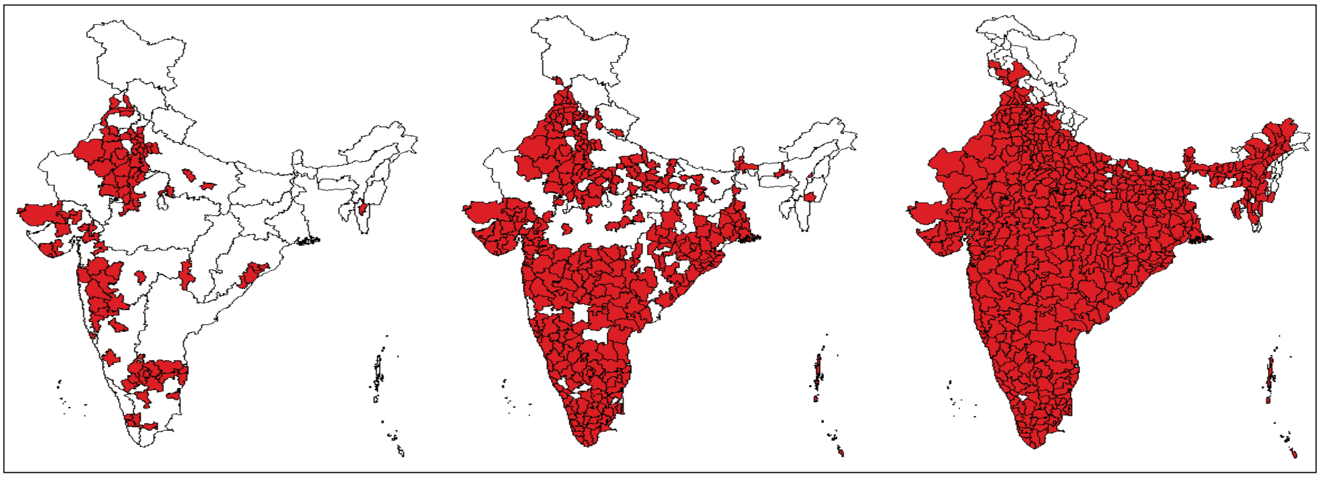
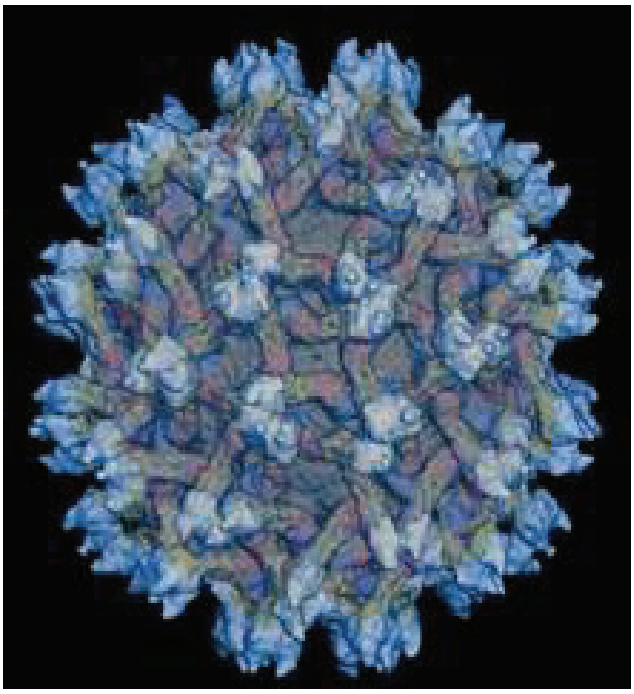


Fig. 2 Spacio- temporal expansion of Dengue in India

During the decade 2010-2019, India experienced an approximately eleven-fold increase in dengue cases compared to previous decade (2000-2009). Dengue burden in India varies across States. There are studies that categorized States and UTs into three broad groups

based on disease burden and transmission patterns- high burden, moderate burden and low burden categories. High-burden States, including Andhra Pradesh, Delhi, Gujarat, Karnataka, Kerala, Maharashtra, Tamil Nadu, Telangana, Uttar Pradesh, and West Bengal, characterized by hyper-endemic transmission, circulation of all four dengue virus serotypes. These states account for over 80% of reported cases and deaths due to sustained transmission and frequent outbreaks. Moderate-burden States include Assam, Bihar, Chandigarh, Chhattisgarh, Dadra and Nagar Haveli, Goa, Jammu and Kashmir, Madhya Pradesh and Uttarakhand. These areas exhibit seasonal transmission patterns with occasional outbreaks and generally have one or two circulating serotypes. Low-Burden States include Arunachal Pradesh, Himachal Pradesh, Jharkhand, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Andaman and Nicobar Islands, Lakshadweep and Daman and Diu. Historically, both these categories of States have experienced limited transmission and sporadic outbreaks. However, recent trends indicate increasing vulnerability, with several previously low-burden States reporting significant outbreaks.



Dengue virus under electron microscope

Dengue Virus and Serotypes

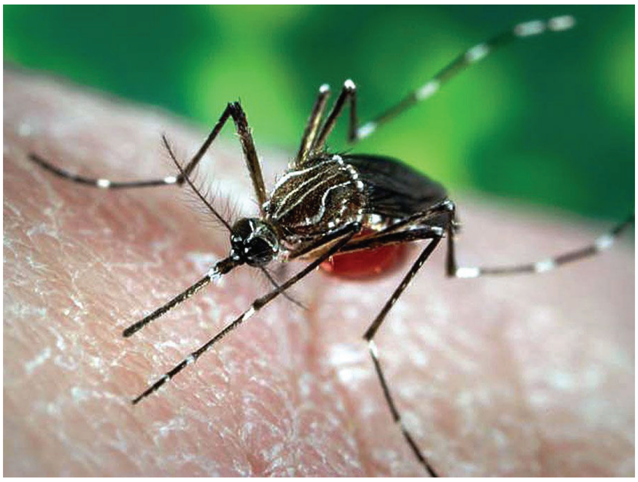
Dengue virus (DENV) is a single-stranded, positive-sense RNA virus belonging to the family Flaviviridae and the genus Flavivirus. The virus consists of four antigenically distinct serotypes: DENV-1, DENV-2, DENV-3 and DENV-4. All four serotypes circulate in India, often simultaneously, contributing to hyper-endemic nature of transmission. Infection with one serotype provides lifelong immunity against that particular serotype but only temporary cross-protection against others. Subsequent infection with a different serotype may increase risk of severe disease due to immunological mechanisms such as antibody-dependent enhancement. Consequently, areas where multiple serotypes circulate simultaneously often experience higher rates of severe dengue. Although many dengue infections remain asymptomatic or cause mild illness, severe manifestations including Dengue Haemorrhagic Fever and Dengue Shock Syndrome can occur, which may be life threatening. The determinants of disease severity still remain incompletely understood.

Vectors and Transmission Dynamics

Dengue virus is transmitted primarily through the bite of an infected female *Aedes* mosquitoes. In India, *Aedes aegypti* is the principal vector responsible for dengue transmission in most urban settings. *Aedes albopictus*, commonly known as the Asian tiger mosquito, also plays an important role in several regions, particularly peri-urban and rural areas.

Aedes aegypti is highly adapted to human environments and breeds predominantly in artificial water containers located in and around households. Common breeding habitats include water storage containers, overhead tanks, coolers, discarded tyres, flower pots, coconut shells, construction sites and various disposable containers. The mosquito exhibits strong preference for human blood and typically rests indoors in cool, shaded locations.

A remarkable biological characteristic of *Aedes* mosquitoes is the ability of their eggs to withstand desiccation. Eggs can survive in dry conditions for more than one year and hatch rapidly upon contact with water. This characteristic allows mosquito populations to persist even during unfavourable environmental conditions and contributes significantly to the difficulty of vector control. Life



Aedes aegypti

Aedes albopictus

cycle from egg to adult mosquito can be completed within 7-10 days under favourable environmental conditions. Adult mosquitoes are predominantly day-biting and typically remain within a flight range of approximately 400 meters. Their close association with human habitation and daytime biting behaviour make conventional vector control interventions particularly challenging.

Distribution and abundance of Aedes mosquitoes are influenced by climatic conditions, urbanization, water management practices, human behaviour and environmental factors. Rising temperatures, increased humidity and changing rainfall patterns are creating increasingly favourable conditions for vector proliferation and dengue transmission across many parts of the Country

Emerging Trends and Changing Epidemiology

The epidemiology of dengue in India has undergone substantial transformation during the last two

decades. While dengue was historically considered an urban disease with seasonal outbreaks, recent evidence suggests a paradigm shift in its transmission dynamics. The disease is no longer confined to large metropolitan cities and urban centers but is increasingly affecting peri-urban and rural populations. This shift reflects broader demographic, environmental and developmental changes occurring across the country. Improved road connectivity, rural development projects, water supply schemes, migration and changes in socio-economic conditions have facilitated the establishment of Aedes mosquito populations in rural areas. This expansion presents new challenges for surveillance and control.
Another important epidemiological trend is the extension of the dengue transmission season. Historically, transmission peaked during monsoon and immediate post-monsoon months. However, in several states, particularly in southern and western States, transmission occurs throughout the year. Moreover, seasonal peak of dengue transmission has gradually shifted from October towards November and, in some areas, transmission extends into winter months as well. Such changes indicate increasing adaptation of vectors to diverse climatic conditions and underscore the need for year-round surveillance and vector control activities.

Emergence of dengue in higher altitudes is another notable development. Several districts in Himachal Pradesh, Uttarakhand and other Himalayan foothill regions have reported outbreaks in recent years. These observations suggest that changing climatic conditions, urbanization, population movement are enabling vectors and viruses to establish transmission cycles in areas that were previously considered unsuitable. Co-circulation of all four serotypes has also become more common and it contributes to hyper-endemicity and increases the risk of severe dengue through secondary infections.

Challenges and Issues in Dengue Control

Rapid Urbanization-One of the most important drivers of dengue transmission is rapid and unplanned urbanization. India continues to experience substantial urban growth, resulting in expansion of informal settlements, overcrowding, inadequate sanitation and insufficient water supply infrastructure. Such conditions create ideal environment for *Aedes* breeding and facilitate close contact between vectors and human populations.

- *Population Growth* - further amplifies transmission risk by increasing human density and demand for water storage. In many urban areas, intermittent water supply compels households to store water in containers, many of which become breeding sites for Aedes mosquitoes. Construction activities associated with urban expansion also generate numerous temporary water-holding structures that support vector proliferation.
- Climate Change and Environmental Factors - Climate change and variability significantly influence dengue transmission by affecting mosquito breeding, survival, and virus development. Temperature, humidity, and rainfall create favourable conditions for vector proliferation, particularly during India's monsoon and post-monsoon seasons. Changing weather patterns and climate anomalies, including El Niño events, are altering transmission dynamics and increasing the risk of dengue outbreaks.
- *Human Mobility and Globalization* - Population movement significantly contributes to dengue spread. Domestic migration, tourism, pilgrimage, business travel and international travel enable infected individuals to carry the virus between endemic and non-endemic areas. As human are the primary reservoir, infected travellers can introduce dengue into regions where competent vectors already exist. Expanding road, rail, and air connectivity further facilitates virus dispersal, while imported cases often trigger local transmission, especially in areas with limited dengue awareness and diagnostic capacity.
- *Solid Waste Management and Consumerism* - Increasing use of disposable plastic products and inadequate waste management practices have significantly contributed to dengue transmission. Discarded plastic containers, bottles, cups, tyres, packaging materials accumulate rainwater and provide ideal breeding habitats for *Aedes* mosquitoes. Rapid urbanization has resulted in substantial increases in municipal solid waste generation. Improper disposal and inadequate collection systems allow waste materials to accumulate in residential and commercial areas. Numerous studies have demonstrated strong associations between poor solid waste management and increased *Aedes* breeding density.

- *Challenges in Entomological Surveillance* - Entomological surveillance is a cornerstone of effective vector control. However, many states continue to face challenges related to inadequate human resources and limited infrastructure. *Aedes* mosquitoes utilize a wide range of breeding habitats, many of which are small, cryptic, transient and difficult to identify during routine inspections. Furthermore, the ability of eggs to survive prolonged desiccation allows mosquito populations to re-establish rapidly following control interventions. Emerging resistance to commonly used insecticides threatens the effectiveness of chemical control measures and necessitates continuous surveillance and evidence-based selection of interventions.
- *Surveillance and Outbreak Detection* - Accurate and timely disease surveillance remains essential for dengue control. While Country has made significant progress in strengthening surveillance systems, underreporting remains a concern. Many dengue infections are asymptomatic or present with non-specific symptoms, resulting in missed diagnoses. Passive surveillance systems alone are insufficient for monitoring dengue transmission. laboratory-supported surveillance, proactive case detection and integration of epidemiological and entomological information is necessary for early identification of outbreaks and implementation of timely control measures. The ability to predict outbreaks remains limited because dengue transmission is influenced by numerous interacting factors. Nevertheless, improvements in surveillance systems, climate forecasting and predictive analytics offer opportunities for enhanced preparedness.

Opportunities for Strengthening Dengue Control

Despite the challenges, Country has numerous opportunities to strengthen dengue prevention and control through innovation, improved surveillance, health system strengthening and intersectoral collaboration.

- *Real-Time Disease Surveillance* - Integrated Health Information Platform-Vector Borne Disease (IHIP-VBD) portal is a major advancement in dengue surveillance. It enables real-time digital reporting from healthcare facilities/laboratories facilitating timely monitoring of disease trends and allows early recognition of outbreaks and supports rapid public health response. Timely availability of data enables evidence-based decision-making, identification of hotspots, targeted interventions and efficient allocation of resources. Strengthening reporting compliance and expanding integration with laboratory networks can further enhance the utility of this system.
- *Expanding laboratory capacity*-A network of laboratory has been established by identifying Sentinel Surveillance Hospitals (SSH) with laboratory facilities in All India Institutes of Medical Sciences (AIIMS), Medical Colleges, District and sub district Hospitals and a few public health laboratories. A few apex laboratories with advanced diagnostic facilities are brought under the network as Apex Referral laboratories for back up support of SSH. Role of these SSH and ARLs is crucial in strengthening laboratory-based surveillance, maintaining diagnostic quality, detection serotype/s, identification of hot spots in initial stage and timely deployment of rapid response teams for containment of any upsurge or outbreak.
- *Strengthening Primary Health Care* - Integrating dengue into the twelve Essential Service Packages under "Ayushman Arogya Mandirs (AAMs)" strengthens community-level prevention and management. As the first point of contact for most patients, primary healthcare facilities support early diagnosis, timely referral, community awareness, and outbreak detection, improving access to care and reducing severe disease and mortality.
- *Capacity Building and Clinical Management* - Subject experts from premier medical institutes in the Country are involved in development of National dengue case management guidelines and capacity building of master trainers from Medical colleges across the Country. Medical colleges play a key role in training healthcare professionals on standardized dengue case management practices, enhancing diagnostic accuracy, clinical care and averting deaths.
- *Strengthening Entomological Surveillance* - One of the most important opportunities lies in strengthening entomological surveillance systems. States have been advised to establish dedicated Entomological Zones with trained

personnel responsible for vector surveillance, insecticide resistance monitoring and evaluation of vector control interventions. Financial assistance under NHM supports procurement of laboratory equipment, surveillance tools, logistics and mobility for field investigations. Strengthened entomological surveillance enables evidence-based decision-making and facilitates more targeted and effective interventions.

- *Strengthening Vector surveillance and Control -* National Health Mission (NHM) has provided opportunities for strengthening vector control through dedicated human resources and infrastructure support to improve surveillance, monitoring and implementation of vector control interventions. Financial support for laboratory equipment, field mobility and infrastructure strengthening enables states to conduct effective surveillance and response activities. Dedicated budgetary provisions for ASHAs and Domestic Breeding Checkers (DBCs) support community-based larval source management activities.
- *Alignment with Global Vector Control Response, WHO* – The Global Vector Control Response (GVCR) provides a strategic framework for strengthening vector control through integrated approaches, evidence-based interventions, community participation, and intersectoral collaboration. Aligned with GVCR, India has developed the Mosquito and other Vector Control Response (MVCR) framework to strengthen vector control through coordinated, evidence-based action. Effective implementation of MVCR recommendations has the potential to significantly strengthen dengue prevention and control efforts across the country.
- *Research and Innovation -* Advances in science and technology are creating new opportunities for dengue control through the development of vaccines, antiviral therapies, improved diagnostics and innovative vector control strategies. Emerging approaches such as Wolbachia-based interventions, sterile insect techniques, genetically modified mosquitoes, remote sensing, GIS and AI-assisted surveillance, along with climate-informed disease forecasting, can enhance prevention and outbreak preparedness. Investment in research, innovation and operational studies will be essential for identifying effective local solutions and achieving long-term reductions in dengue burden.
- *Multi-sectoral Collaboration -* Dengue control cannot be achieved by the health sector alone. Sustainable reduction in transmission requires coordinated action involving multiple sectors, including urban development, water supply, sanitation, education, environment and local governance. Collaboration with the Ministry of Housing and Urban Affairs (MoHUA) and convergence with flagship programmes such as Swachh Bharat Mission (SBM) and Atal Mission for Rejuvenation and Urban Transformation (AMRUT) provide opportunities for addressing environmental determinants of dengue transmission. Improved water management, sanitation infrastructure and solid waste management contribute directly to reduction of vector breeding habitats.

Conclusion

India has significant opportunities to strengthen dengue control through digital surveillance (IHIP-VBD), expanded laboratory and entomological surveillance networks, integration of services within Ayushman Arogya Mandirs and adoption of WHO's GVCR framework. NHM investments, multisectoral collaboration and research on innovative vector control tools, vaccines and therapeutics further enhances preparedness and provide a strong foundation for future progress. Future success of dengue control in India will depend upon sustained commitments from policy makers, programme managers, evidence-based planning, community participation, strong surveillance and integrated vector management will be critical to reducing dengue burden and protecting vulnerable populations.

Lymphatic Filariasis in India: Road to Elimination

Dr P. K. Srivastava*

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Lymphatic filariasis is one of the diseases, grouped under neglected tropical diseases caused by parasitic filarial worms *Wuchereria bancrofti*, *Brugia malayi* and *B. timori*. This infection is mosquito-borne and known since ages with significant social stigma linked with financial burden to sufferers, their families and community as well. Most of the endemic countries had detection-cum-treatment for parasite control and vector control integrated with malaria control strategy for collateral benefits. This disease was targeted for global elimination and 83 countries were enlisted as endemic which was later reduced to 73 countries in which the population at risk of LF was considered to be covered with preventive chemotherapy for interruption of transmission[1]. In South East Asia Region (SEAR), out of 11 countries only 9 were LF endemic and among these, India's contribution was reportedly about 40%. In India, 20 states and UTs have been reported to be endemic excluding states in North-West and North-Eastern States (except Assam). The infection in India, is mainly due to *Wuchereria bancrofti (Bancroftian* filariasis) contributing 99.4% which is transmitted by the mosquito *Culex quinquefasciatus.* Diurnal sub-periodic form of *W. bancrofti* is reported in Nicobar Group of Andaman & Nicobar Islands[2]. This is transmitted by *Ochlerotatus (Finlaya) niveus* group of mosquitoes formerly classified as *Aedes (Finlaya) niveus* but now known as *Downsiomiya niviea*. The other species is *Brugia malayi* causing *Brugian filariasis which is* transmitted by *Mansonia* mosquito species. *Brugian filariasis* is limited in small pockets of Kerala and stray cases from Odisha.

India has long historical experience in control of LF which is evident from the fact that, the first pilot in Odisha for LF control during 1949 to 1954 was done using five day mass DEC therapy @ 4mg per kg body weight clubbed with indoor residual spray (IRS) and anti-larval measures. The project revealed about 30% reduction in transmission by each method individually. National Filaria Control Programme (NFCP) was launched in the year 1955 for the control of bancroftian filariasis with the objectives to delimit the endemic areas, implement control measures in selected areas and develop skilled human resource. The programme assessment resulted into paradigm shift like withdrawal of mass DEC therapy and IRS due to poor coverage and precipitation of resistance among vectors, however, the weekly anti larval operations were restricted to urban areas. Selective DEC therapy to microfilaria carriers at a dose of 6 mg per kg body weight per day for 12 days was also introduced.

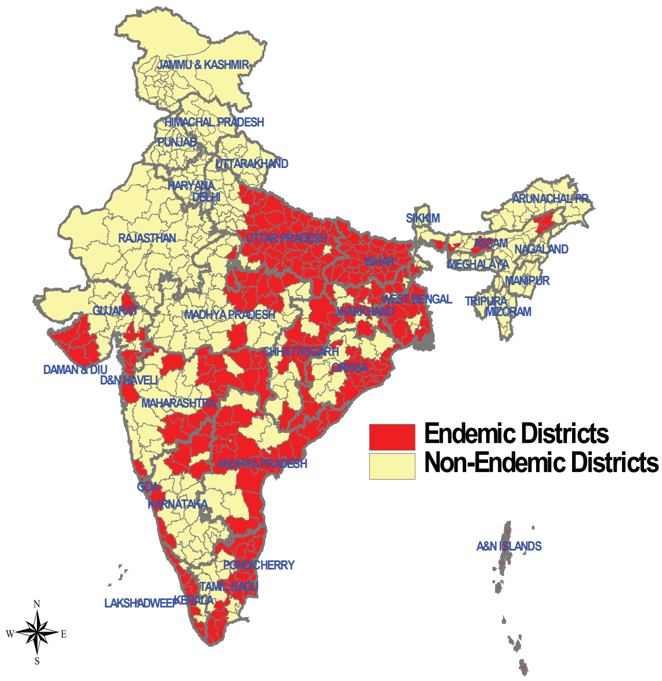
The consultative meeting of WHO/CTD/TDR at University Sains Malaysia in 1994 and two day WHO sponsored workshop in 1996 at Delhi, the mass drug administration (MDA) was recommended and the revised strategy for control of LF in India was formulated initiating a pilot of annual MDA with DEC in 13 districts of 7 states which was later extended for 5-year project on DEC+Albendazole trial[3].

The World Health Assembly (WHA) in 1997 resolved for elimination of LF by the year 2020 and India was one of the signatories of the resolution. Subsequently, the global programme to eliminate lymphatic filariasis (GPELF) was launched in the year 2000 with its strategy of annual MDA and morbidity management[4]**.** In pursuit to achieve the global goal, India launched a massive campaign of annual MDA to all endemic states/UTs in 2004 which had record of microfilaria prevalence of one or above. The districts were selected as implementation unit (IU) on historical evidence of filaria endemicity, presence of Lymphedema and hydrocele cases and/or presence of microfilaria carriers[5,6]**.** The campaign started with 202 districts but scaled up to 256 districts in next 3-4 years and further scaled up to 345 districts. Since 2007, the programme introduced twin drug strategy with DEC+ALB (DA) in all districts. In 2018, Accelerated Plan for Elimination of Lymphatic Filariasis (APELF) was launched and triple drug therapy with Ivermectin + DEC + ALB (IDA) was also introduced as a pilot in 5 districts to hasten the process of interruption of transmission. IDA has been further scaled up to many more districts so that microfilaria prevalence is reduced below 1 percent in all the districts. The guidelines for programme implementation has been dynamic and has been revised from time to time aligning WHO guidance documents[7].

Substantial progress has been achieved under the Indian elimination programme, which is guided by a five-pronged strategy encompassing annual MDA, morbidity management and disability prevention (MMDP), vector control, surveillance, and social

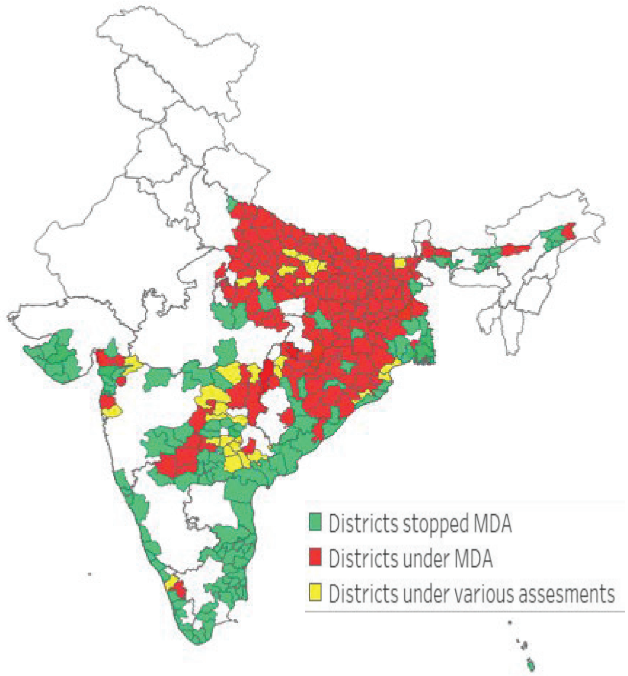
LF Elimination in India: Achievement

2004



MDA districts – 256
(in 21 States /UTs)
Total LF endemic District-256

2024



MDA Districts – 173
(in 13 States)
Total LF endemic District-348

mobilization. MDA had been stopped in 141 districts which indicated microfilaria prevalence below 1 per cent, however, the remaining districts are either continuing MDA or undergoing transmission assessment surveys (TAS) in accordance with WHO and national guidelines[8,9]. WHO recommends three rounds of TAS for stopping MDA. This assessment is done to detect circulating antigenemia for the presence of adult worm. TAS-2 and TAS-3 are to be conducted at two-year intervals after first TAS during post-MDA surveillance to confirm sustained interruption of transmission and readiness for validation of elimination. Successful completion of all TAS stages, with persistently low antigen prevalence in children, is required to confirm LF elimination as a public health problem.

The Indian Programme to eliminate LF is one of the largest programmes with various challenges including suboptimal drug compliance, operational and logistical constraints, scaling up of morbidity management, and variable programmatic performance across states. A critical remaining challenge is the timely completion of the required TAS in all endemic districts before 2030, as the period of 4 years before 2030 for national validation of elimination is too short.

The successful examples of tackling crucial challenges are: service providers reaching to the people of about 600 million, mobilization of resources, capacity building of ground level official, creating movement for LF elimination and providing treatment even to the districts with population at risk with borderline microfilaria prevalence i.e. below 1%. The other challenges faced have also been resolved *viz.*, introduction of strip packing of DEC tablets as distribution of loose tablets was one of the issues for low drug compliance; implementation of coadministration with DEC +Albendazole in 2007 and later triple drug therapy adding Ivermectin with DEC and Albendazole; flexibility to the states for extending implementation and mop up period of MDA from 1-3 days to 1 week and in certain states for about a month to ensure the desired drug compliance. The gap between reported coverage and actual drug compliance has been a major challenge in LF elimination and to resolve that, an in built assessment component by involving medical colleges and research institutes was introduced which helped programme to improve the compliance in subsequent years in many states. The mapping of uncertain areas to ascertain the current status of LF endemicity has been initiated and intensified by programme.

Morbidity Management and Disability prevention (MMDP) has been the second most important pillar of ELF strategy. Lymphoedema and Hydrocele are chronic manifestations of LF, occurring due to progressive and repeated acute attacks. The goal of MMDP programme is to provide access to essential care package for every person with lymphoedema or hydrocele which includes management of lymphedema, treatment of acute ADL, surgery for hydrocele and treatment for any remaining LF infection[10]. The home based morbidity management through washing and drying the affected limb with anti-bacterial or anti-fungal creams was augmented which is feasible under public health programme. The affected people with lymphoedema are provided with morbidity management kit and are explained on home based lymphoedema management procedure by simple washing and drying. The surgical interventions or other procedures could not see its popularity though recommended in guidelines which might be attributed to cost effectiveness, affordability and availability of experts in endemic districts.

To address such challenges and to enhance access to quality services in LF, programme involvement of medical colleges has also been initiated who can play a vital role in accelerating the elimination goal through their academic, research and service-delivery facilities. Medical Colleges can support in Early Diagnosis and treatment for LF cases, manage the treatment for episodes of *adenolymphangitis* (ADL) or acute attacks and monitoring of the programme. They can also support for surgical intervention for hydrocoele patients if required and management of lymphoedema patients with clinical, surgical, and psychosocial interventions[11].

The commitment and priority accorded to LF elimination programme in the country with intensified approach show an optimism in combating the challenges in pursuit to achieve the goal of ELF aligned with sustainable development goals (SDG).

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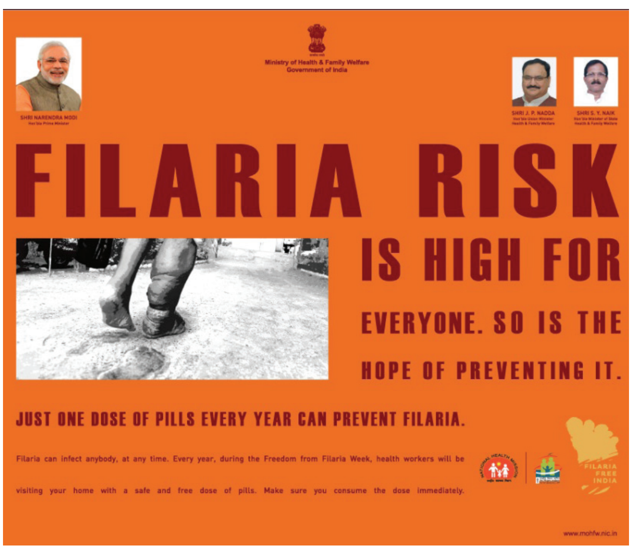
Commitment towards Achieving Lymphatic Filariasis Elimination

Orissa Capacity Building 2005



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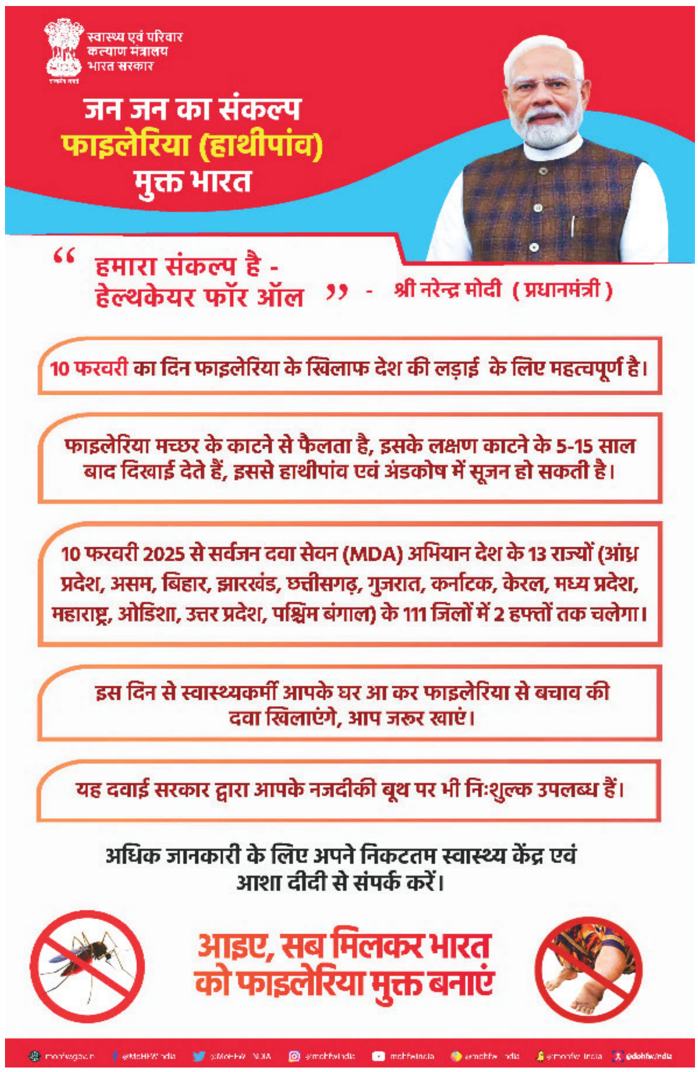

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Barrier and Facilitator of Malaria in Tripura: Role of Effective Communication

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Despite national progress, Tripura remains a high-priority state for malaria burden requiring effective strategy driven by robust communication. Tripura, reports a disproportionately high & increasing trend of malaria cases making it a state with 3rd highest malaria burden in India (reported in 2023), while population wise it contributes only 0.3% of the country's population. Dhalai, one of the most affected districts, has historically reported a high burden of *P. falciparum (<95%)*, but in the last two years there has been a rise in *P. vivax* cases, around 45% in Dhalai, highlights the need for follow-up for 14-day treatment adherence.

MALARIA IN TRIPURA *Development of IEC Material for Creating Awareness*			
Tripura high-burden state	**Dhalai** highest-impact district	***P. vivax*** rising concern	**IEC-BCC** field-informed

Why Malaria needs a Customized Communication Approach in Tripura

Malaria transmission in Tripura is shaped by local geography, livelihood and access barriers. Many affected communities live in remote, forested tribal areas where Jhum, (Shifting/ Slash & Burn) cultivation, is practised in remote hilly forested plots, often causing prolonged absence from the village for weeks and months or daily long working schedule, that frequently result in non-availability issues for IEC-BCC campaigns. A mixed-method study was undertaken in collaboration with National Centre for Vector-borne Disease Control, State NHM, Panchayat and Education Depts, Model Rural Health Research Unit (MRHRU) Tripura in order to understand the status, barriers and facilitators.

Study identified multiple barriers to malaria prevention and care-seeking, including delayed treatment seeking behaviour, persistent traditional beliefs, poor treatment adherence, dissatisfaction with Long Lasting Insecticide Treated Nets (LLINs), seasonal inaccessibility of remote hamlets, difficulty following up with jhum cultivators, suboptimal spraying practices, high transportation costs, poverty, dependence on daily wages, and limited knowledge, education, awareness, behaviour and practices. Participants also showed low engagement in health surveys, often expecting gifts or other benefits from health workers.

Around 75% reported recognizing at least one malaria-related image, 22% saw the images in health camps, sub-centers, posters, & ~ 51% in community activities. Nearly 30% reported using bed nets during sleep. Only 10 % reported learning on keeping surroundings clean & about general awareness. Around 11% reported learning both preventive measures & bed net usage. However, 11.3% reported that they could not understand the messages.

Development of Information, Education and Communication (IEC) Material for Creating Awareness

Most participants reported that no malaria awareness or health education activities had been conducted in their villages, and health worker visits for community sensitization were infrequent. Although LLINs were distributed, little guidance was provided on their proper use, washing, or maintenance. Participants also noted that IEC materials were often available only in Bengali, limiting understanding among

Kokborok-speaking communities, who expressed a preference for engaging audio-visual materials in the local dialect (Kokborok)

These findings suggest that malaria messages must go beyond general awareness and directly address local misconceptions and should adapt to the model of customized content, timing and placement. Content Customization of the IEC materials were therefore developed to respond to these field realities. The messages focused on early fever reporting, malaria testing, completion of the full course of medicines, proper use and care of LLINs, and acceptance of indoor residual spraying. For *P. vivax* malaria, the materials highlighted the importance of completing the 14-day primaquine regimen, while the LLIN message addressed reported net damage by demonstrating repair, stitching, handling, washing and drying practices.

IEC Material developed from local insights

- The IEC materials were developed from field interactions related study findings rather than as generic posters.
- Posters were made in local languages (Bengali & Kokborok – Tripiri & Reang dialects, with rhyming catchy messages)
- Messages focused on the gaps found like preference of puja over testing, self-medication with market purchased paracetamol, insufficient bed net at home, concern about wall stains and property damage, fear of health effects from chemicals, stop of medication once fever subsides, 14-day regime causes fatigue & nausea, children refusing medication, & jhum relocation during treatment period.
- The *P. vivax* specific message explained why treatment must be completed, including the 14-day primaquine course where advised.
- The LLIN message addressed practical household issues such as torn nets, repair, washing and regular sleeping under the net.
- The IRS message framed spraying as family and community protection by targeting mosquito resting sites inside homes.

This approach connects malaria science with the actual conditions in which people live, work and seek care. For Tripura, IEC must therefore be practical, culturally understandable and closely linked with testing and treatment services.

Customized Timing & Place: Market Day & Markets, Schools, Core messages for Communities

Early fever action	Prevention at home	Treatment completion
Report fever early and get tested before symptoms worsen.	Use LLINs correctly, repair holes and support IRS activity.	Complete the full treatment course, especially for *P. vivax.*

IEC material on correct use and care of government medicated bed nets.

Strengthening Entomological Capacity in India: A Strategic Imperative for Sustaining Vector-Borne Disease Elimination

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India has achieved remarkable progress in the prevention, control, and elimination of several vector-borne diseases (VBDs) through sustained public health efforts, improved diagnostics, vector control interventions, and community participation[1,2]. Declining malaria burden, advances toward lymphatic filariasis elimination, reduction in kala-azar transmission, and strengthened responses to dengue and chikungunya outbreaks reflect the country's commitment toward improving public health outcomes.

However, sustaining these achievements requires renewed focus on one of the most critical yet gradually under-emphasized pillars of VBD control: entomological surveillance and vector intelligence systems[3].

Entomological Surveillance: The Scientific Backbone of Vector Control

Entomological surveillance is fundamental for evidence-based vector control planning and disease prevention[3]. Surveillance provides critical information regarding vector distribution, density, seasonality, biting and resting behaviour, insecticide susceptibility, breeding ecology, and pathogen circulation within vector populations. These indicators are essential for guiding interventions such as indoor residual spraying (IRS), long-lasting insecticidal net (LLIN) deployment, larval source management, and outbreak preparedness.

India has a strong legacy in medical entomology. Contributions from entomologists working under the Ministry of Health & Family Welfare (MoH&FW), National Centre for Vector Borne Diseases Control (NCVBDC), academic institutions, and research organizations have played a major role in shaping disease control strategies and vector management approaches.

Nevertheless, the present epidemiological transition demands modernization and strengthening of the country's entomological systems.

Current gaps in operational entomology

Despite significant advances in disease control programs, operational entomological surveillance remains variably integrated within public health systems. In several settings, surveillance activities continue to function in fragmented manners where field-generated entomological data are not optimally linked with timely programmatic decision-making. As a result, vector surveillance outputs often fail to effectively guide targeted vector control interventions, insecticide resistance management, hotspot prioritization, or outbreak preparedness.

State, Regional, and Zonal Entomologists under the National Health Mission (NHM) continue to support surveillance and outbreak response activities across endemic regions. However, variations in infrastructure, manpower availability, supervisory mechanisms, laboratory facilities, and operational autonomy influence the quality and utility of surveillance outputs.

A major concern is the gradual reduction in experienced technical manpower. Several senior entomologists have retired over recent years, while many sanctioned permanent posts under the MoH&FW and associated public health programs remain vacant. Unless systematic recruitment and institutional strengthening are prioritized, this may adversely affect operational continuity and technical expertise within vector surveillance programs.

In addition, many trained entomologists possessing advanced academic qualifications are often engaged predominantly in administrative or managerial responsibilities rather than technical and scientific activities. Limited technical involvement, inadequate recognition, and insufficient opportunities for professional growth may gradually weaken the operational and scientific backbone of public health entomology in India.

Need for integrated digital entomological surveillance

One of the most important future priorities is the integration of entomological surveillance within digital public health platforms such as the Integrated Health Information Platform (IHIP).

Currently, epidemiological surveillance data are increasingly being digitized; however, comprehensive integration of entomological indicators remains limited in routine operational systems. Development of a standardized national entomological surveillance database within IHIP could substantially strengthen evidence-based public health action[3].

Integration of entomological indicators such as vector density, breeding indices, insecticide resistance status, vector infection rates, and ecological observations with epidemiological data would support:

- Disease prediction models;
- Early warning systems;
- Identification of transmission hotspots;
- Localized outbreak preparedness;
- Real-time evidence-based vector control actions.

Importantly, such systems should not remain restricted only to routine health department data. Scientific institutions, including the Indian Council of Medical Research (ICMR) institutes, academic organizations, and collaborating research agencies, may also contribute validated entomological datasets into interoperable national surveillance platforms. Such collaborative data-sharing frameworks would improve real-time situational awareness and facilitate generation of context-specific operational research questions and policy recommendations.

India already generates substantial quantities of vector surveillance data through both programmatic and research activities. However, one of the major limitations remains insufficient integration of analysis with an actionable public health response. Surveillance becomes meaningful only when data are translated into timely interventions and policy decisions.

Strengthening surveillance, therefore, cannot depend upon isolated institutional efforts. It requires coordinated collaboration among public health programs, research institutions, academia, laboratories, and field-level surveillance teams.

Breaking the silo-based approach

At present, multiple institutions across India are conducting important vector-related research and surveillance activities. However, many initiatives continue to function in relative isolation with limited inter-institutional integration and data sharing. Fragmented surveillance ecosystems reduce the overall national capacity to generate unified vector intelligence.

A more coordinated framework involving public health programs, research institutions, universities, and international partners is needed to develop harmonized surveillance methodologies and interoperable databases. Sentinel surveillance sites and random surveillance components should be scientifically integrated to generate representative, longitudinal, and actionable vector intelligence across ecological settings.

The future of vector surveillance should evolve from isolated project-based activities toward collaborative national surveillance networks.

Molecular surveillance: an urgent public health need

Globally, molecular and genomic surveillance has become an essential component of modern vector-borne disease management[4]. Molecular approaches now support sibling species identification, pathogen detection, insecticide resistance monitoring, vector incrimination, and population genetic analysis.

Although India possesses significant scientific expertise in molecular biology and genomics, routine incorporation of molecular vector surveillance within public health systems remains limited. Importantly, molecular surveillance is still not widely supported as a core operational component under many routine public health funding mechanisms, including several state Program Implementation Plans (PIPs). This represents a critical gap considering the increasing complexity of vector ecology and emerging disease threats.

The absence of decentralized molecular surveillance capacity may delay early detection of:

- Insecticide resistance emergence;
- Introduction of invasive vector species;
- Silent pathogen circulation;
- Genetic changes influencing transmission dynamics.

India is globally recognized for leadership in multiple scientific and technological sectors. However, in routine public health entomological surveillance, there remains a substantial gap between current operational systems and evolving global practices. Strengthening molecular surveillance infrastructure, decentralized laboratory capacity, and genomic epidemiology platforms is therefore increasingly important.

Innovation and future technologies in vector surveillance and control

An equally important priority for India's future vector-borne disease preparedness is the strengthening of innovation-driven research and translational technologies in vector surveillance and vector control systems. Existing vector control approaches are increasingly challenged by insecticide resistance, behavioural adaptation of vectors, ecological transformation, urbanization, and climate variability[5]. Therefore, strengthening routine surveillance alone may not be sufficient unless accompanied by sustained investment in next-generation vector control research and technological advancement.

Research on development of novel insecticides and alternative vector control products should be encouraged through coordinated national programs and collaborative research platforms[5]. This includes biological control agents, plant-derived compounds, nano-particle-based insecticidal formulations, eco-friendly larvicides, and resistance-breaking vector control products. Development of safer, sustainable, and species-specific interventions will become increasingly important for maintaining long-term effectiveness of public health vector control programs.

Globally, advanced vector management technologies such as gene-editing-based vector control strategies, sterile insect techniques, Wolbachia-based interventions, genetic population suppression methods, and precision vector management approaches are rapidly evolving. India should actively participate in scientific evaluation, ethical assessment, operational feasibility studies, and contextual adaptation of such next-generation technologies to strengthen future preparedness against emerging and re-emerging vector-borne diseases.

Modernization of vector surveillance methodologies is also urgently required. Artificial Intelligence (AI), Machine Learning (ML), image-assisted vector identification systems, automated smart traps, drone-assisted habitat mapping, remote sensing technologies, and predictive modelling approaches are increasingly transforming global vector surveillance ecosystems. Integration of AI-ML-supported tools can substantially improve rapid vector identification, hotspot prediction, outbreak forecasting, insecticide resistance mapping, and evidence-based operational decision-making.

Development of indigenous, cost-effective, and field-adaptable surveillance technologies should therefore become a strategic national priority. Such efforts will require strong collaboration among entomologists, epidemiologists, molecular biologists, engineers, bioinformaticians, data scientists, and public health program managers.

In the era of climate-sensitive and rapidly emerging vector-borne diseases, strengthening innovation and translational research capacity in vector surveillance and vector control is no longer optional. It is an essential investment for sustaining India's public health security, strengthening disease elimination programs, and supporting the vision of a scientifically empowered and future-ready "Viksit Bharat."

Importance of global collaboration and technology transfer

To strengthen future-ready surveillance systems, India should actively encourage international scientific collaboration, technology transfer, and collaborative funding opportunities in the field of vector surveillance and molecular entomology.

Many advanced surveillance technologies currently undergo prolonged lag periods before operational adaptation within public health systems. Collaborative partnerships with global institutions can accelerate:

- Technology transfer;
- Workforce training;

- Genomic surveillance capacity;
- Data science integration;
- Predictive modelling approaches;
- Artificial intelligence-supported vector surveillance systems.

Such collaborations should complement and strengthen national public health priorities while building long-term indigenous technical capacity.

Multi-vector and multi-disease complexity

India's epidemiological landscape is becoming increasingly complex due to rapid urbanization, climate variability, ecological transformation, and increasing human mobility. Multiple vector species coexist across ecological settings and contribute to transmission of diverse pathogens.

Aedes mosquitoes continue to drive dengue and chikungunya outbreaks, *Anopheles* mosquitoes sustain malaria transmission in difficult terrains, while *Culex* species remain important vectors for lymphatic filariasis and Japanese encephalitis transmission.

Disease elimination does not imply elimination of vectors. Even after interruption of transmission, vectors continue to persist within ecosystems. Without sustained surveillance and preparedness, the possibility of disease resurgence or re-introduction remains a significant public health concern.

This becomes particularly important for India due to extensive domestic and international migration. As the most populous country within the WHO South-East Asia Region, India experiences continuous human movement through labour migration, trade, tourism, and urban expansion. Imported infections entering vector-receptive areas may rapidly trigger localized outbreaks if surveillance systems fail to detect early warning signals.

Conclusion

As India advances toward the vision of "Viksit Bharat," strengthening entomological systems should be recognized as a strategic investment in national health security.

Renewal of public health entomology requires:

- Sustainable investment in surveillance systems;
- Filling vacant technical posts;
- Strengthening laboratory infrastructure;
- Integration of molecular surveillance into routine programs;
- Functional digital surveillance platforms;
- Collaborative national vector intelligence networks;
- Continuous technical training and capacity strengthening.

India possesses a strong scientific foundation and a distinguished history in medical entomology. The current public health landscape offers an important opportunity to modernize and integrate entomological surveillance systems capable of supporting predictive, preventive, and precision public health approaches.

Protecting communities from existing and emerging vector-borne diseases will require sustained political commitment, scientific collaboration, operational integration, and long-term investment in entomological capacity. The future sustainability of disease elimination programs in India will depend not only upon clinical and epidemiological surveillance, but equally upon how effectively the country understands, monitors, and responds to its vectors.

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An Insight into Major Arboviral Diseases of Public Health Importance and their Control

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Arboviral diseases are emerging as major public health challenges across the world. The term "arbovirus" refers to arthropod-borne viruses that are transmitted through blood-feeding insects such as mosquitoes, ticks, and sandflies[1]. Over the past few decades, the incidence and geographic spread of arboviral infections have increased significantly because of climate change, rapid urbanization, globalization, population growth, and increased human mobility.

Among the many arboviruses known today, Dengue virus, Chikungunya virus, Zika virus, Japanese Encephalitis virus, and West Nile virus are considered the most important due to their frequent outbreaks and serious health impacts. These infections are mainly transmitted by mosquitoes belonging to the Aedes and Culex genera. Common symptoms include fever, headache, body ache, rash, and joint pain, while severe infections may lead to neurological complications, hemorrhage, paralysis, or even death.

The history of arboviral diseases dates back more than a century. In 1881, Cuban scientist Carlos Finlay first proposed that mosquitoes could transmit yellow fever, laying the foundation for vector-borne disease research[2]. Later, increasing international travel and changing environmental conditions allowed mosquito vectors to spread rapidly into urban settings, leading to repeated outbreaks across continents.

Dengue Fever is currently one of the fastest-growing vector-borne diseases globally. Historical descriptions of dengue-like illness date back to ancient China, while the first documented outbreak in India was reported in Chennai in the eighteenth century[3]. Today, dengue is endemic in more than 100 countries. It is transmitted mainly by *Aedes aegypti* mosquitoes and can range from mild fever to severe dengue hemorrhagic fever and shock syndrome. Rapid urbanization, poor sanitation, and water storage practices favour mosquito breeding and contribute to repeated outbreaks[4-6]. Although there is no specific antiviral treatment, early diagnosis and supportive care significantly reduce mortality. Vaccines such as Dengvaxia and newer tetravalent vaccine candidates are helping to strengthen prevention strategies.

Chikungunya was first identified in Tanzania in 1952. The name "Chikungunya" means "that which bends up," referring to the severe joint pain experienced by patients. The disease spread rapidly across Asia and Africa and caused major outbreaks in India during 2005-2007, affecting millions of people. Chikungunya infection is rarely fatal but can lead to prolonged joint pain and disability. In recent years, vaccine research has shown encouraging progress, and the vaccine Ixchiq was approved in 2023 for adults at risk[7].

Zika Virus Disease gained global attention after the large outbreak in Brazil during 2015–2016. The virus was originally discovered in Uganda in 1947 during yellow fever surveillance studies. For decades, only sporadic human cases were reported until outbreaks occurred in Pacific islands and later in the Americas. Zika infection is generally mild, but its association with microcephaly and neurological disorders in newborns raised international concern. In 2016, the World Health Organization declared Zika a Public Health Emergency of International Concern. India has also reported outbreaks from several states, indicating local transmission[8-10]. At present, no licensed vaccine is available, although several vaccine candidates are under development.

Japanese Encephalitis remains one of the leading causes of viral encephalitis in Asia. The disease was first recognized in Japan in the nineteenth century and later spread widely across the Asia-Pacific region. It is transmitted mainly by *Culex tritaeniorhynchus* mosquitoes, with pigs and water birds acting as important reservoir hosts. In India, Japanese Encephalitis has caused repeated outbreaks in states such as Uttar Pradesh, Assam, Bihar, and West Bengal. Eastern Uttar Pradesh, especially Gorakhpur and nearby districts, have experienced severe outbreaks over the years[11-12]. Vaccination campaigns, vector control, and improved surveillance have played important roles in reducing disease burden. Indigenous vaccines such as JENVAC has further strengthened India's public health response.

West Nile Fever was first identified in Uganda in 1937 and is now considered one of the most widely distributed arboviruses globally. Most infections are asymptomatic, but severe neurological disease can occur in elderly or immunocompromised individuals. The virus is maintained in nature through a bird-mosquito cycle and is transmitted mainly by Culex mosquitoes. In India, evidence of West Nile virus circulation has been reported from Maharashtra, Karnataka, Kerala, Tamil Nadu, and West Bengal[13]. Although vaccines are available for horses, no licensed human vaccine exists yet.

The increasing burden of arboviral diseases highlights the urgent need for effective prevention and control measures. Since most of these diseases lack specific antiviral treatment, vector control remains the primary strategy. Elimination of stagnant water, proper waste management, use of mosquito nets and repellents, and community awareness are essential steps in reducing mosquito breeding and disease transmission.

Integrated Vector Management (IVM), strengthened disease surveillance, rapid diagnostics, and vaccination programs where available are important tools for controlling outbreaks. Recognizing the growing global threat, the World Health Organization launched the Global Arbovirus Initiative in 2022 to improve preparedness and response against emerging arboviral diseases.

Arboviral infections continue to evolve alongside environmental and social changes. Understanding their history, transmission patterns, and public health impact is essential for developing effective prevention strategies. Continued research, public awareness, and coordinated global action will be crucial in reducing the burden of these diseases in the future.

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Elimination of Designated Vector Borne Diseases in India-Where do we Stand?

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India has commitment for eliminating kala azar, malaria and lymphatic filariasis. The kala azar elimination has already been achieved by evidencing the reported less than one case per ten thousand population at block level and it is being sustained in all the four endemic states. Though official certification is still to be made. Though the efforts of its elimination were very challenging as the disease has been deceptive in the past, it involved only one parasite-*Leishmania donovani* and one vector in India which is *Phlebotomus argentipes*. Malaria and Lymphatic filariasis elimination to be achieved by the year 2030 to meet the sustainable development goals (SDG). The causative agents involved for Lymphatic filariasis (LF) infection in India are *Wuchereria bancrofti* (WB) and *Brugia malayi* (BM). LF in India is mainly transmitted by one vector-*Culex quinquefasciatus* for WB except in few pockets of mainland by Mansonia species for BM and small pockets in islands of Andaman & Nicobar by *Downsiomyia nivea*. The significant achievement has been achieved in overall LF elimination evidencing that half of endemic population has been brought below the threshold level of microfilaria (MF) prevalence to less than one percent at community level. The disease had been endemic across 345 districts in 20 states and Union Territories in which the efforts of mass drug administration (MDA) was undertaken to reduce MF prevalence and reportedly 141 districts have stopped MDA. The challenges were many as the disease by nature is perceived as curse in low socio-economic group and drug consumption was not traditionally believed because it is given to all who do not have any sign and symptoms. Overcoming such beliefs and tradition which is still continued has been remarkable especially in a magnitude of burden targeting more than 650 million population on a single day with mop up in next 2-3 days. The achievement may also be attributed that one parasite and one vector are responsible for about 99% infection in India.

Malaria in India is also targeted for elimination aligning with sustainable development goal (SDG) by 2030. The significant progress has been achieved in reducing the disease burden and the endemicity level has been brought down showing the shrunken map of malaria endemicity. However, the challenges in malaria elimination technically may be attributed due to involvement of 4 species of malaria parasites and 9 vectors established with 3 more suspected. The parasites species are *Plasmidum vivax, P. falciparum, P. malariae* and *P.ovale*. The first two are predominant species in India, whereas *P. malariae* is reported in few tribal pockets. The cases of *P.ovale* has been reported from very few pockets. The malaria vectors are divided into two categories and the primary vectors are six in numbers - *Anopheles (An) culicifacies*, *An. stephensi*, *An. minimus*, *An. fluviatilis*, *An. baimaii* and *An. epiroticus*. However, *An. annularis*, *An. varuna*, and *An. philippinensis* are vectors of secondary importance. The other vectors are *An. jeyporiensis*, *An. maculatus* and *An. subpictus* which have been incriminated and established to transmit malaria in localized areas. The different vectors have different bionomics and display different transmission dynamics which has been documented since 1934 onwards indicating the prevalence of different *Anophelines* in different geographical areas and incriminating them for sporozoite establishing as vectors of malaria transmission. The other challenges in malaria elimination are emerging drug and insecticide resistance. The estimation of real magnitude of disease burden has been very challenging so the dependence is mainly on reported data from public and private system which also has its complexities. The delivery system of drugs, diagnostics etc., and entire supply chain management for logistics with its monitoring from process to impact has been dynamic affecting both ways impacting the elimination progress and sustaining it. However, dealing with so many complexities and tackling the combination of 4 parasite with so many primary and secondary vectors, the achievements shown by the country is remarkable. The process of verification of elimination has been initiated in those districts which have reported zero cases since last three years and indicated to be on way to achieving malaria elimination. With zero indigenous case making a showcase globally that yes, we can achieve and we will.

Pages from the History

Malaria in Panjab and the Historic Malaria Early Warning System

Between 1850 and 1947, Punjab region was infamous for some of the most devastating, explosive malaria epidemics in modern history. The unique geography of the plains, combined with colonial-era, environmental changes and severe economic distress, caused recurrent outbreaks that claimed millions of lives[1]. Historical data and medical research from pioneers like Sir Rickard Christophers and Dr. C.A. Gill outline the intricate mechanics of Punjab's malaria crises:

Between 1850 and 1947, 15 massive epidemics swept the region. In total, autumnal malaria claimed 5.17 million documented lives across British Punjab. The epidemic of 1908 was the most destructive on record. Malaria prevailed to a severe and unusual extent across every single district in the plains. In designated "epidemic areas," the disease was universal, driving localized mortality rates up by several hundred per thousand. The epidemics routinely brought society to a standstill. During the late 19th-century outbreaks, entire villages were left too physically weak to reap overripe crops, leading to severe agricultural labour shortages, inflation, and localized food deprivation.

Epidemiologists categorized Punjab as an area of marginal or unstable transmission. Unlike Southern India, where malaria was constant but less explosive, Punjab went months with little to no transmission, meaning the population lacked natural immunity. When conditions aligned, the epidemic broke out via three triggers: Outbreaks were fundamentally linked to heavy, stagnant flooding caused by the monsoon. Conversely, cycles of intense drought preceding heavy monsoons dried up natural predators, leading to an exponential surge in the primary vector population (*Anopheles culicifacies*) once rains arrived. Food scarcity was a primary driver of high mortality. High grain prices forced widespread nutritional deprivation. While the parasite infected many, it was the underlying starvation that crushed human immunity and turned manageable *Plasmodium falciparum* infections into lethal cerebral malaria.

The rapid expansion of unlined canal irrigation systems inadvertently altered the regional water table. It blocked natural drainage channels and created thousands of miles of permanent, slow-moving water bodies perfect for vector breeding. Because blood film microscopy was difficult to scale across millions of rural villagers, Christophers and Gill relied on the "*Spleen Rate*". They measured the percentage of local children with enlarged spleens, a clinical sign of chronic or repeated malaria infection. A sudden drop in the regional spleen rate over consecutive dry years signalled that communal immunity had waned. This drop warned health officials that the population was prime for an explosive outbreak if a heavy monsoon hit. By 1930s and 1940s, autumnal malaria mortality dropped to less than one-third of its historical levels. While vector transmission remained high, the decline was achieved by *mitigating famines and improving grain distribution*, which kept the population healthy enough to survive infections. By the mid-20th century, the introduction of synthetic residual insecticides (like DDT), the distribution of anti-malarial medications, and active vector control permanently broke the back of these massive historical cycles.

The *historical Malaria Early Warning System (MEWS) in Punjab* was pioneering work developed by Colonel Clifford Allchin Gill (often cited as C.A. Gill), a British researcher and health officer[2,3]. Formulated in 1921–1923, Gill's model was one of the world's earliest documented forecasting frameworks for vector-borne diseases and remained actively used by the Government of Punjab until 1946.

Gill's system was tailored to the arid and semi-arid conditions of northwest India. Because the region faced massive epidemics post-monsoon, he identified that outbreaks could be predicted weeks in advance by observing four ecological and sociological pillars:

- **Monsoon Rainfall**: Total accumulated rainfall in July and August dictated the survival rates and breeding capacity of vector mosquitoes.

- **Spleen Rate (Spleen Index):** The percentage of children with enlarged spleens served as a direct indicator of residual malaria and local transmission intensity.
- **Population Immunity Levels**: An evaluation of how recently the local population had been exposed to an outbreak. If public immunity was low, the risk of an epidemic escalated.
- **Economic Conditions**: Socio-economic factors such as famine or previous crop failure, which left populations physically vulnerable.

While Gill's model provided a functional lead time for epidemic preparedness, it is no longer used today due to sweeping developments in public health - Changes in Malariometric Indices; Sociological progress and broad healthcare infrastructure modified the correlation between childhood spleen size and actual disease prevalence. Modern Interventions like the introduction of residual indoor spraying, novel anti-malarial drugs, and rapid diagnostic tests changed malaria transmission dynamics. Contemporary frameworks lean toward satellite-derived climate modelling, El Niño Southern Oscillation (ENSO) data, and Artificial Intelligence (AI)-driven forecasting rather than manual historical indices.

Today, Punjab is in the malaria elimination phase, sustaining an Annual Parasite Incidence (API) of fewer than 1 case per 1,000 people across all districts. Surveillance is now executed via modern digital web portals and strict local health regulations.

References:

1. R. Christophers (1911), Malaria in the Punjab. Scientific memoirs by officers of the medical and sanitary departments, Govt of India, Superintendent Govt Printing, Calcutta.
2. Gill CA. The role of meteorology in malaria. *Indian Journal of Medical Research*. 1921;8:633–693.
3. Gill CA. The prediction of malaria epidemics. *Indian Journal of Medical Research*. 1923;10:1136–1143.

Revisited and Framed by: Dr Rajni Kant

Innovation Note

Fever Tracker App

ICMR-NIHR, Dibrugarh has developed and patented the Fever Tracker App. It supports systematic fever recording and follow-up by health workers, strengthening malaria surveillance, enabling early testing, and improving timely public health response.

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Malaria elimination by 2030 in focus

Experts stress collaboration, research, resource mobilisation

RAJEEV RATHAN ■ Bhubaneswar

A joint meeting held here to mark the World Malaria Day highlighted the urgency of eliminating malaria by 2030 by bringing together leading experts, policymakers, researchers and public health professionals to deliberate on strategies to achieve the target.

The meeting was organised by NAVBD and RMRC-Bhubaneswar and saw participation from key stakeholders across government bodies, academic institutions and research organisations.

Among the dignitaries present were CUTN former Vice-Chancellor and WHO-SEARO Regional Adviser Padma Shri awardee AP Dash, Sanghamitra Pati, Suchitra Sasmal, Subhasisha Mohanty, V Arun Nagaraj and Jayakrushna Panigrahi.

NAVBD Secretary Dr MR Ranjit emphasised the importance of global public health campaigns like World Malaria Day in sustaining awareness and collective action against the disease.

Dr Sanghamitra Pati underscored the urgent need for mobilisation of government resources and reaffirmed India's commitment to achieving malaria elimination by 2030. Dr Suchitra Sasmal presented an overview of the global malaria situation highlighting both the progress made and the persistent challenges.

Dr Subhasisha Mohanty showcased Odisha's success in malaria control and reiterated the government's strong commitment to achieving elimination targets within the stipulated timeline. Dr Nagaraj spoke about promising research developments, particularly the potential discovery of highly effective new antimalarial drugs.

Prof AP Dash emphasised the critical role of public-private partnerships in malaria elimination.

The session concluded with a shared resolve to strengthen collaboration, innovation and resource mobilisation to accelerate progress towards a malaria-free future by 2030.

National Dengue Day at DHQ Hospital, Angul, presided over by Abdaal M. Akhtar, IAS, and jointly organized by NAVBD and the NVBDCP Wing, Angul

Vector of the Month
An. stephensi

On 20 August 1897, while doing research in Secunderabad, Sir Ronald Ross demonstrated the role of female Anopheles mosquito in malaria transmission-that unveiled the mystery of the spread of this dreaded disease. He called that insect a 'dapple-winged' mosquito, today we know it as An. stephensi. His monumental discovery earned him the 1902 Nobel Prize in Medicine.

***An. stephensi* Liston, 1901. *The Indian Medical Gazette*,36: 361-366,441-443**

Credit: https://commons.wikimedia.org/wiki/File:Anopheles_stephensi.jpeg

Derivative: Liston named it after J. W. W. Stephens

Species Complex: Classified into two varieties on the basis of ridges on egg float. These are named as *An. stephensi stephensi* or type form and *An. stephensi mysorensis*. Type form is mainly urban dweller, whereas, mysorensis is rural in nature

Sitting posture: Body and mouth-parts are at an angle to resting surface.

Resting habit: Adults rest in houses, cattle sheds and barracks, etc.,

Breeding habits: In urban areas, this species predominantly breed in wells, overhead or ground-level water tanks, cisterns, tanks, coolers, roof gutters, swimming pools, earthen pots, and other artificial containers. Scanty breeding is also reported in recent time from rice fields, and polluted and brackish water habitats. Larvae are shade lovers.

Biting time: Peak biting activity is generally between 22.00 and 24.00 hrs, but varies from area to area and season to season. The adult mosquito bite both indoor and outdoor.

Feeding Preference: The mosquito predominantly feed on humans in urban areas and on cattle in rural areas.

Flight range: Varies between 0.5-2.5 km.

Resistance to insecticide: Have shown multiple resistance.

Relation to Disease: Major urban malaria vector in India, Pakistan, Iran, Iraq, Sri Lanka, and South Africa

Reported Distribution: Afghanistan, Bangladesh, China, Indonesia, Iran, Iraq, Myanmar, Nepal, Pakistan, Sri Lanka, South Africa, Tiwan, and Thailand. In India recorded from A&N islands, Andhra Pradesh, Bihar, Delhi, Goa, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kashmir, Kerela, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Uttar Pradesh, and West Bengal.

The Invasive Spread of *An. Stephensi* beyond its native boundaries

The mosquito is rapidly invading Sub Saharan Africa and other new territories. It was first detected in Djibouti (2012), and has since expanded to Ethiopia, Sudan, Somalia, Nigeria, Kenya, and Ghana. Genomic tracking indicates it was likely seeded by maritime and human transit from Asia. The WHO considers the rapid spread of *An. stephensi* a major threat to global malaria elimination. As it targets dense urban centres where populations lack natural immunity, it has already triggered massive urban malaria surges.

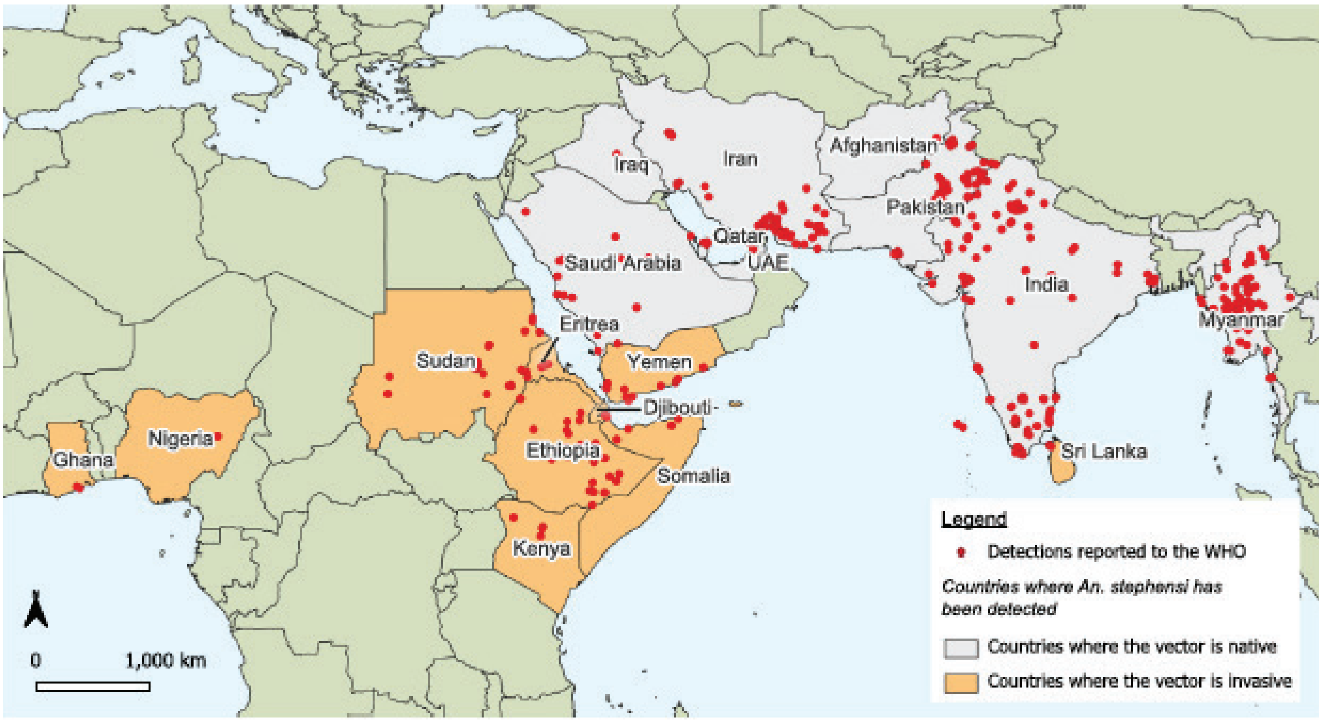
Unlike native African mosquitoes that prefer rural breeding sites, *An. stephensi* thrives urban environment, exploiting artificial water containers and expanding malaria risk to immunologically naïve populations.

Key Invasion Hotspots and Dynamics

Historically Native to South Asia and the Arabian Peninsula-Middle East, this highly competent malaria vector has aggressively expanded far beyond its traditional boundaries and territory, exposing millions of previously low-risk and immunologically naïve populations to *Plasmodium falciparum* and *Plasmodium vivax*.

Changing Climate: Warmer and expanding urban centres provide ideal temperature conditions for the continuous breeding and survival of this mosquito species.

Global Response and Containment Strategies: Because of the rapid range expansion, the World Health Organization (WHO) launched the *Anopheles stephensi* Elimination Strategy. Key measures being implemented include:



*Distribution pattern of An stephensi, where it has historically been found are in grey while the regions where it is considered invasive are in yellow (source: Taylor R et al. Invasive An. stephensi in Africa:Insights from Asia. Trends Parasitol,*2024;40, 8 https://doi.org/10.1016/j.pt.2024.06.008 (https://apps.who.int/malaria/maps/threats/).

The Urban Shift: Because these mosquitoes breed in small, man-made water sources like overhead tanks, barrels and discarded tires, they facilitate year-round urban malaria transmission.

Why the Invasion is Alarming

Immunological Naivety: Millions of urban residents in these newly colonised African regions have little to no prior exposure to malaria parasites (*Plasmodium falciparum* and *P. vivax*) leading to highly severe infections and rising mortality rates.

Insecticide Resistance: Invasive populations have repeatedly shown high resistance to standard insecticides used for vector control such as pyrethroids.

- **Enhanced Surveillance:** Tracking port entries, airports and urban settlements to catch incursions early.
- **Larval Source Management**: Treating and modifying water storage containers with sealed lids or larvicides.
- **Integrated Management:** Combining standard Long-Lasting Insecticidal Nets (LLINSs) and Indoor Residual Spraying (IRS) with urban planning and community engagement.

Compiled and Crafted:

Dr B N Nagpal & Dr Rajni Kant

World Malaria Day Webinar

Malaria: Global Trends, Regional Insights and Country Action Plans

National Academy of Vector Borne Diseases organised a webinar on 22nd April 2026 in partnership with the APMEN on the theme 'Driven to End Malaria-Now We Can, Now We Must'**.** The webinar was opened with **the welcome address by Dr. Neena Valecha**, President of the National Academy of Vector-Borne Diseases and Chair of the APMEN Vivax Working Group. She explained the importance of World Malaria Day and the theme for the year 2026 and emphasised the need for renewed urgency and collective action for malaria elimination. The introduction underscored recent global progress alongside persistent challenges, positioning the webinar to examine malaria trends from global, regional, and country perspectives while linking scientific advances to actionable policy and programmatic responses.

Dr. Andrea Bosman, Head, Diagnosis, Medicines and Resistance, WHO's Malaria and Neglected Tropical Diseases, Geneva presented a global overview of emerging malaria threats, warning that a convergence of financial, biological, and systemic risks could trigger a "perfect storm" capable of reversing decades of progress. Drawing on Global Technical Strategy (GTS) targets, he showed that malaria incidence and mortality remain more than three times higher than 2025 targets, with global funding gap at USD 3.9 billion in 2024. Key threats highlighted included the spread of antimalarial drug resistance, HRP2 gene deletions undermining diagnostics, widespread pyrethroid resistance, and the expansion of *Anopheles stephensi* in Africa. Despite these risks, he also underscored important advances, including improved case management for children under five, expanded chemoprevention and vaccine rollout, and recent WHO prequalification of new rapid diagnostic tests. Dr. Bosman emphasized that sustained political leadership, multi-stakeholder involvement, community engagement, and sustainable financing are essential to safeguard gains and keep malaria elimination within reach.

Dr. Risintha Premaratne, Regional Advisor (Malaria), WHO Regional Office for South-East Asia presented a regional analysis highlighting that the WHO South-East Asia Region has achieved the largest reduction in malaria burden globally and remains the only WHO region to have met the GTS 2020 milestone and stay broadly on track for future targets, despite emerging signs of plateauing progress. He underscored major elimination successes in Sri Lanka, Maldives, Timor-Leste, and noted that Bhutan is preparing for WHO malaria-free certification, reflecting the region's strong technical capacity and long-term commitment. However, he cautioned that progress is increasingly threatened by two major converging drivers: a severe funding collapse (a 64% decline in regional malaria funding) and escalating conflict and population displacement. These pressures are compounded by additional biological and operational challenges, including *Plasmodium vivax* predominance, HRP2 gene deletions, insecticide resistance, expansion of *Anopheles stephensi*, climate variability, antimalarial drug resistance, population mobility, and cross-border transmission, all converging simultaneously at a critical phase of elimination. Dr Premaratne stressed that sustaining gains will require sub-national strategies tailored to local epidemiology, strengthened provincial and district ownership, data-driven surveillance, and grassroots actions that translate national political commitment into local impact. He emphasized the need to increase domestic financing, strengthen cross-border collaboration, and empower communities, particularly among hard-to-reach and mobile populations. He reaffirmed that the goal of malaria elimination remains within reach, but only if countries act decisively now to protect and accelerate recent gains.

Dr. Tanu Jain, Director, National Centre for Vector Borne Diseases Control (NCVBDC), India, presented India's progress toward malaria elimination, highlighting a decisive shift from nationwide burden reduction to localised, sub-national elimination. She highlighted that the Country has demonstrated an over 80% reduction in malaria cases and an 85.6% reduction in deaths between 2015 and 2025, with the Annual Parasite Incidence declining from 0.92 to 0.17. India has narrowed transmission to 32 high-burden districts, which contribute the majority of remaining cases, while 160 districts across 23 States/UTs reported zero indigenous malaria cases between 2022 and 2024, triggering Sub-National Malaria Elimination Verification (SNMEV) processes. Programmatic strengths emphasized included village-level stratification, the 1-3-7 surveillance strategy, real-time monitoring through the Integrated Health Information Platform (IHIP), robust microscopy quality assurance via the National Reference Laboratory, and decentralized case management and vector control. Tailored tools and delivery models adapted to specific local contexts would be needed. She also highlighted India's transition away from Global Fund support, increased reliance on domestic systems, and ongoing innovations such as point-of-care G6PD testing, radical cure regimens, and operational research. Dr. Jain concluded by underscoring that sustained vigilance, political commitment, and targeted action to address internal migration are essential to prevent resurgence and achieve India's goal of zero indigenous malaria by 2027.

The webinar generated significant engagement, with many interesting questions and answers. There were around 1,009 registrations from 87 countries, with 498 participants from 67 countries attending the live session with 39.4% being females and 60.4% males. Total 35.7%, represented government agencies 34.6% academic and 13.5% research institutions and NGOs each. Around 97.8% participants rated the webinar as excellent/good in terms of usefulness, 89.7% rated the overall quality as excellent/good and 96.3% expressed interest in attending the future webinars as well.

Community Connect Programme in Tripura on World Malaria Day

Launching the Model on Malaria: Two-day outreach activity with NAVBD

The two-day Community Connect Programme was organised in Tripura on 24 and 25 April 2026 by the ICMR-NIHR, Dibrugarh/MRHRU Tripura field team on the occasion of World malaria day. The activity aligns with NAVBD's role in advancing knowledge, disseminating field-based public health experience, and promoting action on vector-borne diseases. It brought together community interaction, school outreach, IEC-based discussions, malaria RDT screening, and practical demonstrations on prevention. The newly developed IEC materials were displayed and distributed during community interactions with villagers and school students across six locations. Activities included poster-based discussions, demonstrations on mosquito net use and maintenance, interactive sessions with community members, student quizzes, and health screening.

A malaria model was also launched on the occasion & field-tested in an event jointly organized by ICMR-NIHR, Dibrugarh in collaboration with National Academy of Vector Borne Diseases (NAVBD), MRHRU, Tripura, Integrated Child Development services (ICDS) supervisor, ICDS workers & helpers District Magistrate, Deputy Collector (DC), District Health Officials, Dhalai, Tripura and community stakeholders including Gunin & Ochai.

The programme linked awareness with direct field action. IEC materials were used for discussion, demonstrations and screening, helping bring malaria messages closer to students, vendors, Jhumia families and villagers in field settings.

Stakeholders who strengthened the outreach

The outreach activity was supported by local administration, ICDS representatives, Satyaram C.P.R. H.S. School, Sikaribari, the State Health Team, frontline health workers, and community members.

Stakeholders included the Deputy Collector, ICDS Supervisor, ICDS workers and helper, MPHW/MPW staff, ASHA workers, ANMs, State Volunteers, school authorities, headmaster, teachers, students, villagers, market vendors, Jhumia community members, women participants, village elders, Gunin or traditional healers, and the ICMR-NIHR, team.

Ending malaria in Tripura will require science, services and community trust moving in the same direction.
Now we can. Now we must.

WORLD MALARIA DAY 2026

Community Connect Programme in Tripura | Driven to End Malaria: Now We Can. Now We Must

406 people participated	**6** field locations	**97** malaria RDTs	**7** P. vivax cases