

REVIEW ARTICLE

Exploring the landscape of Vector-Borne Diseases and Their Vectors in India's Endemic states: Bird's eye view

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ABSTRACT

Vector-borne diseases (VBDs) persist as a significant public health concern across the globe. Various arthropod vectors play pivotal roles in the transmission of diverse VBDs worldwide, notably mosquitoes, sandflies, blackflies, lice, ticks and tsetse flies. Among all, mosquitoes act as major vectors causing mosquito-borne diseases (MBDs). Mosquitoes predominantly serve as vectors for neglected tropical diseases, transmitting numerous pathogens due to their large number, attributed to the conducive tropical climatic conditions. Understanding the dynamics of vectors (mosquitoes) is imperative for effectively controlling and eliminating mosquito-borne diseases (MBDs). Extensive research conducted across India indicates commendable efforts towards comprehending the nature, prevalence, and breeding patterns of vectors, subsequently implementing measures to curb their proliferation. Endemic Indian states Jharkhand, Odisha, West Bengal, and Chhattisgarh are characterized by substantial forested areas and rugged terrain and emerged as focal points for mosquito-borne diseases (MBDs), including malaria, dengue, filaria, chikungunya, etc. Several studies emphasised how important it is to comprehend the presence and distribution of vectors to mitigate infections and eliminate them within the designated time limit. Earlier studies conducted in these endemic states of India give an idea of the presence of different vector species and their subspecies. This review is an attempt to offer important new information about MBDs, their status, and the vector prevalence in Jharkhand and other endemic areas of India. The review emphasizes the critical need for unified and collaborative efforts to tackle these diseases, both at the regional and national levels, by integrating various disciplines and strategies.

KEYWORDS

Vector; MBD; Anopheles; Dengue; Malaria; Endemic States; Jharkhand; Disease Burden.

INTRODUCTION

Vector-borne diseases (VBDs) that are transmitted via different vectors are one of the

major health issues across the globe. Vectors are organisms possessing the ability to transmit pathogens from one infected host to

another (either human or animal). These vectors may cause serious diseases in humans like malaria, dengue, filariasis, Leishmaniasis, and Chagas disease (WHO, 2014). Main vector categories include mosquitoes, sandflies, ticks, Fleas, Lice, bugs etc. Mosquitoes are the primary vectors for various diseases termed as mosquito-borne diseases (MBDs). Other vectors include rat fleas (plague), sandflies (kala-azar), and chigger larvae (scrub typhus). Ticks and lice also transmit diseases such as Lyme disease and louse-borne relapsing fever. The three major mosquito genera involved in disease transmission are *Aedes*, *Anopheles* and *Culex*. *Aedes* mosquitoes can transmit dengue, chikungunya, yellow fever and Zika whereas malaria is spread by infected *Anopheles* mosquitoes, and *Culex* mosquitoes are responsible for transmitting Japanese encephalitis and filariasis (Kaliappan et al., 2022).

The magnitude of MBDs depends on the prevalent infective vectors and their interactions with humans, which are further influenced by various factors, including vector bionomics (vector behavior, vector species, vector biting habits), ecological conditions, and social dynamics such as socio-cultural characteristics, human sleeping patterns, population density, human migration, and developmental activities (Ma et al., 2022).

MBDs- Diseases Burden

The yearly evaluation of worldwide trends in malaria management and eradication, depicts that approximately 249 million cases of malaria transpired across 85 nations endemic to malaria during 2022, resulting in a case incidence rate of 58 for every 1000 population that are at risk (WHO, 2023). Similarly, around 400 million people got infected with dengue, out of which only 100 million people presented clinical manifestation and accounts for approximately 40,000 deaths in year 2022 (Data and Maps | Dengue | CDC, n.d.). Further, the Zika cases have been seen in 89 countries infecting thousands of people (World Health Organization: WHO, 2022). According to WHO regional report 2023, the majority of vector borne diseases are prevalent in Africa region followed by South-east Asia region,

significantly contributing to a higher number of fatalities. Nine countries within the South-East Asia Region collectively represented 2% of the global disease burden of malaria with a tally of 5.2 million cases (World Malaria Report, 2023). The incidence of malaria in the region is notably concentrated in India, representing 66% of cases, with about 94% of related fatalities occurring in India and Indonesia (world malaria report, 2023). along with its neighbouring states of Odisha, Chhattisgarh and West Bengal, Jharkhand is a major malaria endemic state in India. (Pandey et al., 2015). These four states alone contribute almost 60% of the total malaria incidences in India (INDIA, 2024) (P. Kumari et al., 2020).

As per the data available on National Centre Vector Borne Diseases Control (NCVBDC) website, Jharkhand, Odisha and Chhattisgarh, exhibit an API (Annual Parasite Incidence) exceeding national average 0.13 for malaria cases. Jharkhand, with several districts reporting an API surpassing 1, presents a few districts as hotspots for malaria, characterized by notably elevated API rates. Notably, Latehar (10.86) and West Singhbhum (5.43) emerge as major areas of concern, recording API figures significantly higher than the national average (Nath, 2022). study in Kalahandi district of Odisha gave API > 15, reason attributed to low socio-economic status and positive correlation with rainfall (Mishra et al., 2023).

The conducive weather conditions prevalent in the South-East Asia region provide a favorable climatic condition/environment for the proliferation of mosquitoes and subsequent transmission of disease (Servadio et al., 2018). Consequently, traditional mosquito-borne diseases with cases detected since long time poses as a significant public health concern within the region.

Unplanned urbanisation and migration of people to cities are among the major reasons for increase in breeding sites of mosquitoes (Neiderud, 2015). Large number of cases each year and fatalities caused attributes to inaccessibility of people to healthcare services and hence create a public health issue. Furthermore, for the implementation and success of a public health programme, community participation is a key factor which

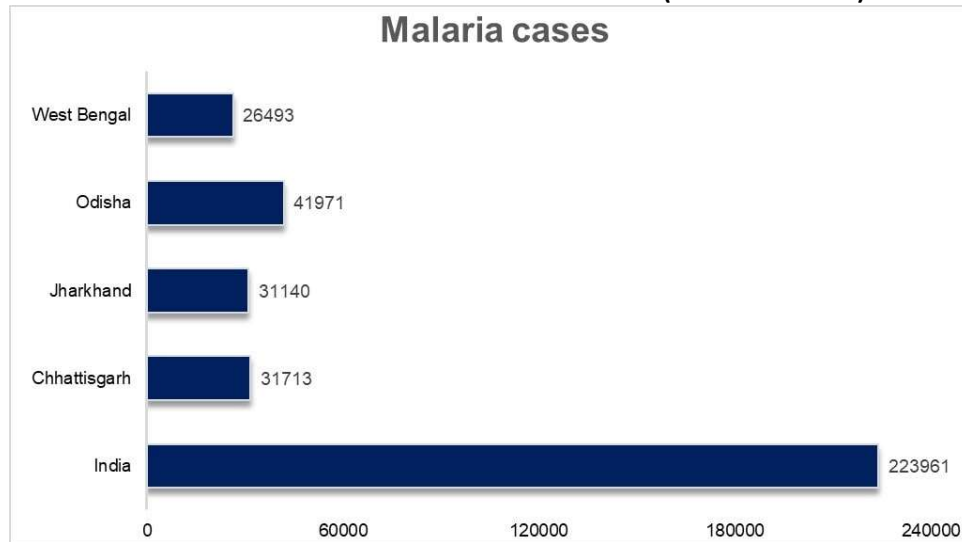
depends upon their knowledge and attitude towards that disease (Saha et al., 2022). Hence, the lack of awareness and preventive knowledge to people in tribal areas aggravates the problem. Eastern part of India is prone to natural calamities like flood, cyclone etc., that leads to an increased vector density and subsequently to an increase in MBDs (Quintanilla, 2022). Major vector borne diseases in India namely– malaria, dengue, filaria, kala azar, chikungunya and Japanese encephalitis (JE). Kala-azar, Lymphatic Filariasis (LF) and Malaria are planned for elimination with targeted efforts in near future (MoHFW, 2022). The distribution of mosquitoes and associated diseases in eastern states of India are reviewed here.

Anopheles

Anopheles act as vector of malaria and are found all over the globe mainly in the region of sub-Saharan Africa and southeast Asia

(Advances in Parasitology, 2013). India, continues to be a significant contributor to the annual incidence of all mosquito-borne diseases, resulting in the significant number of cases that lead to morbidity and mortality (world malaria report, 2023) (NCVBDC, n.d.). Although, India has made considerable strides in the control of MBDs and thereby reducing the number of malaria cases from 1.07 million in 2012 to 0.18 million in 2022 (NCVBDC, n.d.), yet every year large number of cases are seen, especially in eastern and North-eastern part of country including Jharkhand and its neighboring states. Eastern states of India remain a focal point for MBDs, with sporadic cases reported annually from different regions. It is very crucial to know the vector dynamics and understand the ecological characteristics of vectors to control and reduce the transmission of diseases. Malaria is a major mosquito-borne diseases spread all over India with large number of cases in eastern, central and north-east India (Figure 1)

Figure 1: Malaria cases in India and four endemic states in 2023 (source: NCVBDC).



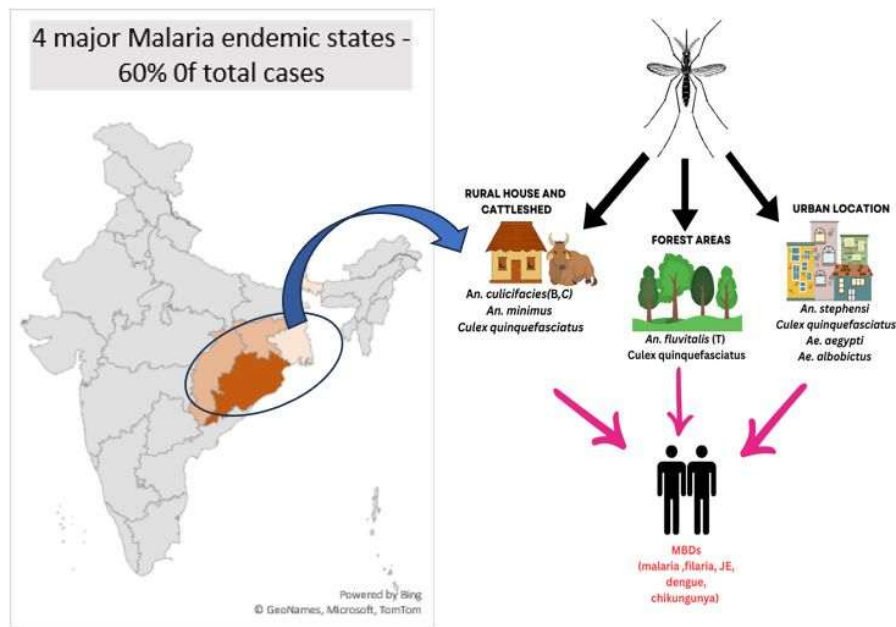
There are over 530 species of Anopheles, but only about 30 to 40 of them are known to naturally transmit malaria. The rest, however, are incapable of carrying out and maintaining the growth of malaria parasites in even after biting infected humans (Nicoletti, 2020). The Anopheles mosquitoes dwell in a diverse condition of habitats and may breed at small volumes of water bodies (Insect-Borne Diseases in the 21st Century, n.d.).

Malaria presents a complex epidemiological challenge, attributable in part to the presence of multiple vectors with distinct biological traits. In India the primary vectors responsible for transmission of malaria includes six Anopheles species- *An. culicifacies*, *An. stephensi*, *An. fluviatilis*, *An. minimus*, *An. baimaii*, and *An. sundaicus*. Moreover, the secondary or local vectors, such as *An. annularis*, *An. varuna*, *An. philippinensis*, and

An. nivipes, also contribute to malaria transmission alongside some primary vectors in various regions of the country (Subbarao et al., 2019) (Rani et al., 2017). These vectors exhibit disparate seasonal and ecological distributions with varied transmission potentials, and susceptibilities to insecticides. Furthermore, all five vectors, except *An. stephensi*, encompass complexes of species

containing sibling species that further diverge in their characteristic's behavior and ecological features (Kareemi et al., 2021). Sibling species shows diverse feature and distribution. Consequently, it becomes vital to ascertain the attributes of the locally found vector population to effectively devise and implement control strategies (Figure 2).

Figure 2: Four Malaria endemic states in India (Data Source-NCVBDC) and species in different settings (image created with MS Excel and Canva).



A study conducted in Ramgarh district of the Jharkhand state reported presence of 17 Anopheles species i.e., *An. culicifacies*, *An. fluviatilis* and *An. annularis* species, with *culicifacies* species being most abundant out of 6495 collected specimens (Pandey et al., 2015). Studies done in the Korea and Bastar districts of Chhattisgarh between 2012-15 shown the similar results, where a comprehensive collection of 13,186 Anopheles samples, encompassing 15 species from Bastar and 16 from Korea, was undertaken. *An. Culicifacies* emerged as the predominant species at both research sites (Kareemi et al., 2021). Another study conducted in eight southern districts of Odisha showed similar findings, where districts with more villages located in hill-top and foot-hill

areas had higher populations of *An. fluviatilis* mosquitoes, a primary malaria carrier, resulting in increased malaria rate. In contrast, villages in plain areas had more *An. culicifacies* mosquitoes, but lower malaria rates (Sahu et al., 2017). In Odisha *An. annularis* and *An. subpictus* are major vectors in several districts (Das et al., 2014) (Kumari et al., 2013). *An. culicifacies* was found in abundance throughout the year with peak density observed during monsoon and spring season. The studies in West Bengal produced similar results as of Odisha (Mandal et al., 2011). Different ecological features shown presence of different sibling species of *An. culicifacies* and *An. fluviatilis*. Sibling species 'BCE' of *An. culicifacies* and 'T' of *An. fluviatilis* were

observed as major vectors in the region (Kareemi *et al.*, 2021).

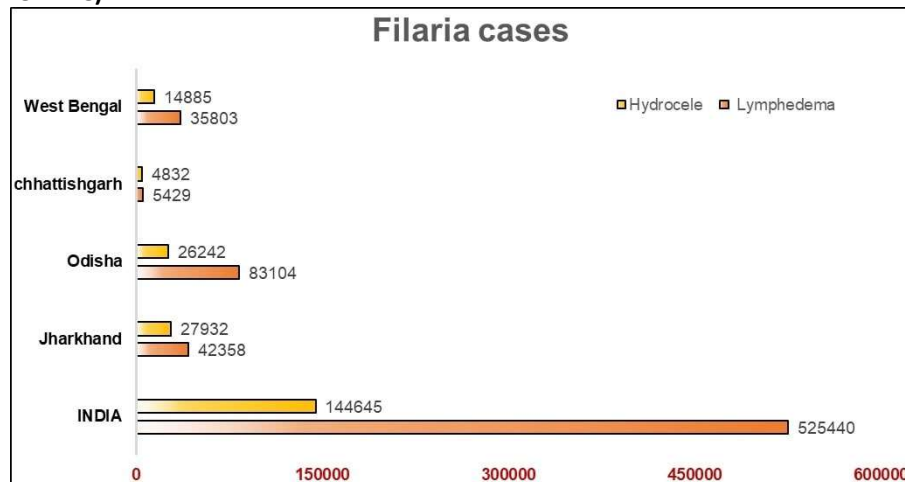
Culex

Culex species represent ubiquitous mosquitoes found across various ecological niches, displaying significant abundance. They are recognized as vectors for several vector-borne diseases, including Lymphatic filariasis (LF) and Japanese encephalitis (JE) (Nchoutpouen *et al.*, 2019). Lymphatic filariasis (LF) encompasses a group of disorders caused by parasitic nematodes related to the superfamily Filarioidea.

In 2021, India recorded 525,440 cases of Lymphoedema and 144,645 cases of Hydrocele ("NCVBDC," 2022). The states with the highest incidence of Lymphoedema were Bihar, Uttar Pradesh, Odisha, and Telangana. Meanwhile,

the states with the highest prevalence of Hydrocele were Odisha, Jharkhand, Uttar Pradesh, and Bihar ("NCVBDC," 2022). Jharkhand is identified as a significant hotspot for lymphatic filariasis, with all its 24 districts designated as endemic. In neighbouring states of Jharkhand almost all 24 districts have been designated as endemic (NCVBDC, n.d.). Study done in west Bengal showed coexistence of LF with malaria cases (26 Out of total 2106 malaria positive cases), but often neglected because of its less clinical severity (Acharya *et al.*, 2020). Jharkhand and its neighbouring states Bihar, Odisha and West Bengal are among the 10 filaria affected states fall in the focus area for LF elimination by 2027 targeted by government of India (Fig. 3).

Figure 3. Comparison of cases (%) of Lymphedema and Hydrocele in India and Jharkhand in 2021 (source; NCVBDC)



Filaria predominantly transmitted by the widespread vector, *Culex quinquefasciatus*, accounts for 99.4% of infections in the country (MoHFW, 2022). In 1997, world Health Assembly declared filaria as public health problem and robust steps should be taken for its elimination. Subsequently, in 2000, WHO launched Global Programme to Eliminate Lymphatic Filariasis (GPELF) with a target to eliminate the disease by 2020. Recently WHO revised the year targeted for elimination of LF to 2030 due to delayed transmission assessment survey (TAS) and setbacks caused by COVID-19 (Control of Neglected Tropical Diseases (NTD), 2021). The disease is pervasive

in both urban and rural areas, that has its vector species breeding in contaminated and stagnant water (Bueno-Marí & Jiménez-Peydró, 2013).

Japanese encephalitis (JE) is a viral disease known to be transmitted by *Culex* genus mosquitoes. JE stands as a crucial yet relatively underexplored mosquito-borne disease, serving as a principal cause of viral encephalopathy in Asia (LaBeaud, 2008). Culicine mosquitoes, mainly the *Culex vishnui* group (*Culex vishnui*, *Culex pseudovishnui*, and *Culex tritaeniorhynchus*), are the chief vectors of JE in different parts of India. *Culex bitaeniorhynchus* and *Culex whitmorei* are

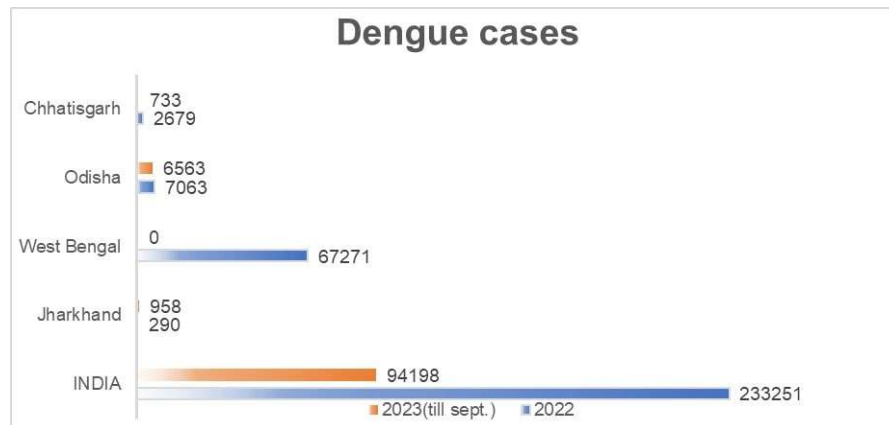
among the other common vector species of JE (MoHFW, n.d.). A study conducted in Odisha's Malkangiri district between 2014 to 2019 revealed the presence of *Culex* species acting as vectors, namely *Cx. vishnui* (32%), *Cx. whitmorei* (27.1%) and *Cx. tritaeniorhynchus* (18%) (Thankachy et al., 2022). The chances of JE outbreaks rise during the rainy season, as heavy rainfall and waterlogging create favorable conditions for extensive breeding of *Culex* mosquito vectors (Sahu et al., 2018). Key factors increasing transmission risks include close proximity to rice fields, where Culicine mosquitoes thrive, the presence of pigs (which serve as amplifier hosts) in areas near homes, and changes in climatic conditions like temperature and rainfall (Nyari et al., 2015). Survey done in North Bengal district at 1157 breeding sites showed presence of vectors in

274 sites (23.7%) viz. *Culex quinquefasciatus*, *Cx. tritaeniorhynchus*, *Cx. gelidus*, *Cx. Vishnui* etc (Mariappan et al., 2014). In the state of Odisha, the initial occurrence of JE was documented in Rourkela city in 1988, followed by multiple outbreaks in 1992 and 1995. Presently, as per NCVBDC, among the 30 districts in Odisha, 17 districts exhibit endemicity for JE (Thankachy et al., 2019).

Aedes

Two of the major VBDs- Dengue and Chikungunya are transmitted by *Aedes* mosquitoes. Besides this Zika, Yellow fever and Rift valley fever are also transmitted by the *Aedes* vector. The spread of Dengue and Chikungunya is seen all over India with outbreak seen every year following monsoon season (Sahana, 2018) (Fig. 4).

Figure 4. Comparison of Dengue cases in India and other Eastern states in 2022 and 2023 (source- NCVBDC)



Aedes aegypti and *Aedes albopictus* is referred as most established species resulting in spread of dengue. *Aedes aegypti* found to have wide spread distribution in cities and towns, but now also moving towards rural areas (Djiappi-Tchamen et al., 2021). Study conducted in Ranchi, showed presence of *Aedes aegypti* throughout and *Aedes albopictus* in few municipal areas. Before 2006 no cases of dengue were reported from Jharkhand (Singh et al., 2008). However, the recent data shows increasing trend of dengue cases every year since 2018- except 2020 and 2021, the reason might because of less surveillance and reporting due to COVID-19 (Mohan et al., 2021) (Shah et al.). The neighbouring states of

Jharkhand i.e. Chhattisgarh, Odisha and West Bengal also shows increase in number of Dengue cases every year (MoHFW, n.d.). A Study conducted in rural and urban areas of Kolkata reported presence of *Aedes aegypti* and *Aedes albopictus* in different breeding sites almost equally (Banerjee et al., 2015). The unique behaviour of *Aedes* such as day-biting habit, multiple cycles of eggs laying in its life time, etc. makes it more dangerous as compared to other vectors. They feed upon multiple hosts, hence the transmission rate of viral diseases (dengue and chikungunya) (Facchinelli et al., 2023). The water storage practices of the community align with the breeding preferences of *Aedes aegypti* and it

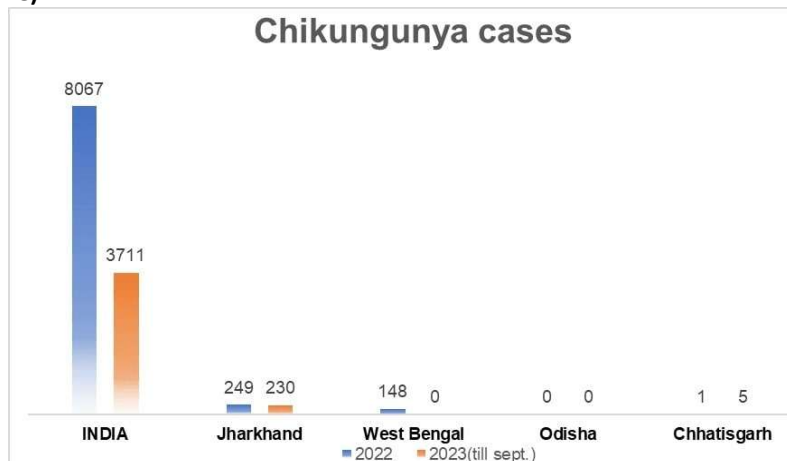
can breed well in low precipitation condition. However, precipitation is more limiting factor for *Aedes albopictus* as it has larger temperature tolerance (Hussain & Dhiman, 2022).

Chikungunya fever (CHIKF) is an arboviral disease caused by the chikungunya virus (CHIKV), an alphavirus from the *Togaviridae* family (Tripathi et al., 2020). Diagnosing and treating this illness is challenging due to its overlapping symptoms with dengue and malaria, as well as its shared vector with these diseases (Jagdish et al 2021) (Sinha et al, PNAS India). The initial emergence of CHIKF was documented in India in 1963 in West Bengal. After remaining inactive for up to 32 years, CHIKV reemerged in India in 2005 (Sunil, 2021). Currently, all regions of the country are affected by endemic transmission of the disease, with resulting outbreaks every year in

different regions which causing significant economic and productivity losses (Sunil, 2021). In Jharkhand, chikungunya is a major health concern as every year cases are seen in different district of Jharkhand with *Aedes aegypti* as major vector. The pronounced burden of chikungunya infection was observed in the urban area of Kolkata, situated in West Bengal, India, along with its neighbouring districts, namely South 24 Parganas, Howrah, Hooghly, and North 24 Pargana (Sengupta et al., 2020).

Due to unavailability of specific drug, chikungunya diseases cause huge amount of economic burden (M. Kumar et al., 2021). Although the number of cases in Jharkhand and its neighbouring states remains low, presence of vectors in these areas is shown in different studies which poses risk of transmission of diseases (Fig. 5).

Figure 5. Comparison of Chikungunya cases in India and other Eastern states 2022 and 2023 (source-NCVBD)



DISCUSSION

Mosquito-borne diseases represent a major public health threat in India, resulting in considerable mortality and economic strain each year. The area is inhabited by sizable tribal populations living in remote, hard-to-reach, hilly, and forest-bordered villages and hamlets, making them especially vulnerable. These conditions facilitate perennial transmission of malaria (Rao and Das 2021). Malaria is among of the most prevalent mosquito-borne disease in Jharkhand, Odisha and Chhattisgarh because of large population living in tribal forested areas where they come

in close counter with the major vectors of Malaria. Data shows that Dengue and Chikungunya have become a very serious public health problem in leading to large number of cases in recent times, due to fast growing urban population and changing living habits of individuals (Shrivastava et al., 2014). Government is working extensively for the elimination of these vector-borne diseases using vector control methods and early diagnosis and treatment, before the target given by WHO (Naik et al., 2023) (Khan, 2018). Extensive research has documented a diverse array of vector species and their sibling species

across various locales, with certain species emerging as dominant vectors. Therefore, precise identification of these key vector species is crucial to implement targeted and effective vector control strategies (Dengue: Guidelines, WHO, 2009). Various mosquito species have demonstrated resistance to different classes of insecticides, which exacerbates the challenge and may complicate control efforts (Das *et al.*, 2021). It is, therefore, imperative to conduct detailed studies on the susceptibility profiles of these vector species to various insecticides. Such knowledge may enable public health agencies to devise and implement control measures that are both efficient and effective, ensuring the selection of the most potent insecticides against the relevant vector species.

The mechanisms by which migration influences spread vector-borne diseases are not well established and can have unknown effects. These effects may be influenced by various factors, including the demographics of the migrating population, their destinations, and the impacts of migration on health outcomes throughout the migration process (Sutherst, 2004). Traditionally, research has primarily viewed migration as a threat, emphasizing its role as a transmission vector. However, recent studies have also highlighted the potential developmental benefits of migration, such as the spread of health information, preventive measures, and behavioral practices between host and native communities, referred to as the diffusion mechanism. Additionally, rising global temperatures and extreme weather events are creating conditions that are increasingly favorable for the continued presence, geographic expansion, and potential resurgence of VBD targeted for elimination (Duval, 2022).

CONCLUSION

Vectors of all major MBDs are found in eastern states of India comprising *Anopheles*, *Culex* and *Aedes*. Considering the climatic conditions prevalent in this part of country, it is imperative that the vector control program is both robust and consistently executed, with regular monitoring conducted on an annual

basis. Different nature of the subspecies needs to be studied and understood to take effective and long-lasting initiatives for their control. Initiatives such as public awareness programs, the distribution of medication, and diligent surveillance of breeding sites are crucial components for effectively managing the growth and dissemination of vector-borne diseases. Despite India's considerable progress in controlling various vector-borne diseases, particularly those transmitted by mosquitoes, sustained efforts are still required to achieve disease elimination and ensure the success of national elimination programs. Therefore, a comprehensive and coordinated (entomological and epidemiological) approach is essential, involving ongoing commitment and resources to address the multifaceted challenges posed by vector-borne diseases in Jharkhand and across the country.

RECOMMENDATION

Knowledge of prevailing vectors in high burden states will definitely help in understanding the situation and formulation of steps and actions related to public health, that will impact population health.

RELEVANCE OF THE STUDY

The study provides accumulated data of eastern endemic states at one place which helps in comparing and evaluating the status of all 4 states at same time.

AUTHORS CONTRIBUTION

MK: Conceptualized the review and prepared the initial manuscript draft. SS: Contributed significantly to writing and refining the script. PKS & PKT: provided overall supervision, critical guidance, and intellectual input throughout the development of the manuscript. All authors reviewed and approved the final version of the manuscript. MK and SS share equal first authorship.

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Nil

CONFLICT OF INTEREST

There are no conflicts of interest.

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DECLARATION OF GENERATIVE AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the author used ChatGPT in order to correct the sentences grammatically and put sentences in order. After using this tool/service, the author reviewed and edited the content as needed and take full responsibility for the content of the publication.

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