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Traditional Mosquito Repellent Practices in North-East India: A Study Based on a Comprehensive Survey

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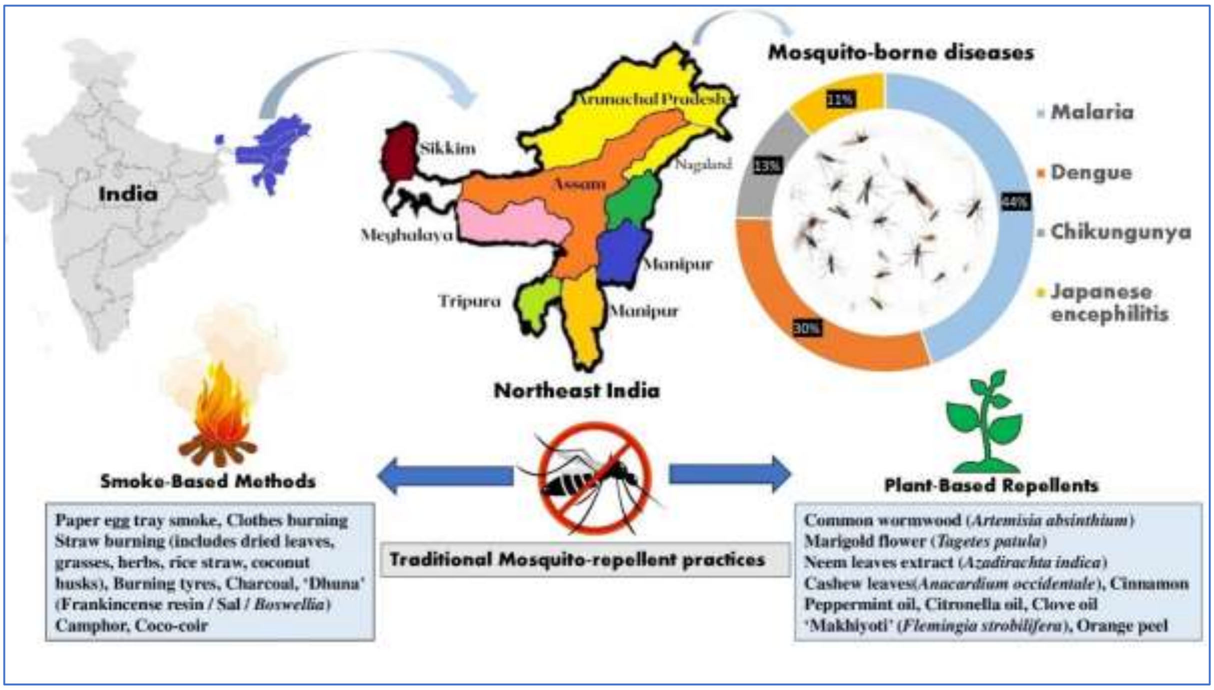
Abstract

Background: Northeast India, characterized by dense forests, humid climate, and abundant water bodies, offers a favourable breeding place for mosquitoes, challenging the health and resilience of communities due to the prevalence of endemic mosquito-borne diseases, such as malaria, dengue, and Japanese encephalitis, which disproportionately affect the rural and tribal populations in local areas. **Method:** A survey on traditional mosquito repellent practices was conducted in 2024 across 50 districts of Northeast India to document the various mosquito repellent practices of the tribes and communities. **Result:** The findings highlight the region's vulnerability to mosquito-borne diseases, including Malaria (44%), Dengue (30%), Chikungunya (13%) and Japanese Encephalitis (11%) which is mainly driven by its humid subtropical and tropical climates supporting mosquito breeding. The study documented the dependence on indigenous repellent methods, including burning egg trays (32.2%), using "Dhuna" (30.4%), essential oils and organic materials (24%), and neem leaves with camphor (13.4%). The effectiveness of these methods was widely affirmed by the community populations with 57.9% of respondents declaring their consent to the efficacy and 14.6% expressing a deep belief in these traditional practices. **Conclusion:** The broad adoption of the traditional mosquito repellent practices in Northeast India underscores their potential as effective substitutes for synthetic repellents, which often pose environmental and health risks. By adopting the cultural knowledge, the survey aims to leverage sustainable community-driven solutions for endemic mosquito-borne diseases that align with the region's ecological and cultural context, reducing reliance on synthetic repellents and proposing natural formulations for insect repellents based on traditional practices.

Keywords: Mosquito borne diseases, Traditional Mosquito repellents, North East India

Graphical abstract



1. INTRODUCTION

Mosquitoes are disease-carrying insects that spread a wide variety of pathogens to healthy individuals through biting. Southeast Asia, Africa and Latin America are among the tropical and subtropical locations where mosquito-borne diseases are more prevalent (Siriyasatien & Thavara, 2006; Kumar & Hwang, 2006; Shaalan & Canyon, 2009). Mosquitoes breed well in the warm and humid atmosphere while their numbers fluctuate with the seasons. They flourish in warm and humid environments which causes increased frequency of disease transmission at specific seasons (Laith et al., 2024; Anoopkumar & Aneesh, 2022). Global public health is greatly impacted by mosquito-borne diseases like Malaria, Dengue fever, Chikungunya, Yellow fever, West Nile virus and Zika virus which causes millions of infections, transmission and fatalities every year. Africa bears a disparately heavy burden of mosquito-borne illnesses with 95% of malaria cases reported worldwide and over 550,000 deaths are reported every year. The Dengue disease which is common in Tropical/subtropical regions like Southeast Asia, Americas and Western Pacific region has been documented to cause 390 million infections per year with haemorrhage/shock reported to be the severe consequence of this disease while the Zika disease whose outbreak took place recently in America is known to cause microcephaly and Guillain-Barre syndrome. Japanese Encephalitis, which predominantly hits rural Asia is reported to cause 20–30% mortality with 68,000 cases documented globally per year. The Yellow Fever is endemic in Africa and South America whereas the West Nile Virus mostly occurs in Africa, Europe, Middle East, North America (Lee et al., 2018; Coalson et al., 2021; Rochlin et al., 2025; Okumu et al., 2025). Causative organisms, vector, hosts and symptoms of a few major mosquito-borne diseases are mentioned in Table 1.

Table 1. Causative organisms, vector, hosts and symptoms of a few major mosquito-borne diseases

Disease	Causative Organisms	Vector	Hosts	Symptoms	References
Malaria	*Plasmodium falciparum*, *Plasmodium vivax*	Female *Anopheles* (primary or final hosts)	Man (intermediate hosts)	Shivering, chills and sweating. As chills subside body temperature rises as high as 106° F. When temperature comes down patient sweats profusely and becomes comfortable until next attack which takes place at regular intervals	Baxromovna, 2024
Dengue	Arbovirus	*Aedes aegypti*	Man	Sudden high fever, severe headache, muscle and joint pain, and a rash	Pourzangiabadi et al., 2024
Zika	Zika virus	*Aedes aegypti* and *Aedes albopictus*	Man (primary hosts), Monkey and ither primates (reservoir host)	Fever, rash, headache, joint and muscle pain, and red eyes	Cuapa-Gonzalez et al., 2025
Chikungunya	Chikungunya virus	*Aedes aegypti* and *Aedes albopictus*	Man (primary host)	Severe joint pain often affecting multiple body joints, muscle pain particularly generalized myalgia, Erythematous or maculopapular rash particularly on the limbs and trunk region of body, sudden rise in body temperature with severe fever and headache	Arce Jr et al., 2024
Yellow fever	Yellow fever virus	*Aedes aegypti*, *Haemagogus* mosquito, *Sabethes* mosquito	Man (primary hosts), Monkey and other primates (reservoir host)	Muscle pain particularly generalized myalgia in the back and knees, Blood in vomit or faecal matter along with bleeding from eyes, nose, mouth and stomach	Kuno, 2024
West Nile	West Nile virus	*Culex pipiens*, *Culex tarsalis*	Birds (primary host), Man, Horses (incidental hosts)	Swollen lymph nodes, Encephalitis, Meningitis, acute flaccid paralysis	Argirova et al., 2024
Japanese Encephalitis	Japanese Encephalitis virus	*Culex tritaeniorhynchus*	Man (primary hosts), Pigs and birds	Neurological sequelae such as paralysis, impaired memory or changes in behaviour, Stiff neck, Seizures or epilepsy, fever	Mulvey et al., 2021

			(reservoir host)		
Lymphatic Filariasis	*Wuchereria bancrofti, Brugia malayi, Brugia timori*	*Culex* mosquitoes, *Anopheles* mosquitoes, *Aedes* mosquitoes	Man (primary host)	Acute Adenolymphangitis characterized by inflammatory lymph nodes, episodic filarial fever accompanied by chilling and malaise, lymphedema which is characterized by swollen legs due to lymphatic damage, hydrocele in men causing swelling in scrotum due to accumulation of fluid, chyluria or milky urine due to leakage of lymphatic fluid causing them to get mixed in urinary system	Bagonza et al., 2025
Rift valley fever	Rift valley virus	*Culex* mosquitoes, *Anopheles* mosquitoes, *Aedes* mosquitoes	Sheep, goats, cattle and camels (primary hosts), Man, wildlife (incidental hosts)	Ocular disease due to inflammation of retina, haemorrhagic fever characterized by jaundice, liver damage and severe bleeding, encephalitis leading to coma, seizures and headaches	Connor & Hartman, 2022

Significant progress has been made in controlling mosquito-borne diseases with insecticides; however, these efforts are jeopardised by their quick growth, transmission and acquisition of genetic resistance. Furthermore, disease burden is made more worsened by the transmission of other mosquito-borne arboviruses (Connor & Hartman, 2022). India has been struggling for long with the transmission of the widespread diseases like Chikungunya, Dengue and Malaria; however, Indian people have been historically utilizing the natural resources to innovate a wide variety of traditional insect repellent approaches. One such age-old method is the application of plant-based essential oils which have been used for ages to repel mosquitoes and other disease-carrying pests due to their strong insecticidal qualities. The leaves and stems of some plants are dried, crushed or burned and are applied directly to exposed skin to repel mosquitoes (Dagar & Ramakrishna 2024; Nwagwu et al., 2024). Apart from essential oils, Indian societies have also utilized a variety of smoke-based repellents including burning incense, dried herbs, natural woods or cow dungs. Some fragrant herbs with strong aromas are also grown close to homes and gardens which are thought to keep mosquitoes away. These eco-friendly, natural methods of controlling mosquitoes have stood the test of time, proving the creativity and resourcefulness of Indian tribes in acclimating to their local conditions for tackling diseases (Champakaew et al., 2023). Herbal pastes, essential oils, coconut oil, smoke from firewood or cow dung, neem leaves, camphor, Tulsi (holy basil), lemon and cloves are a few other traditional insect repellent methods that are frequently employed in the villages of India. Neem leaves possess inherent insecticidal qualities which makes it a valuable candidate for topical application for mosquito repellent action. Similarly, mosquitoes can be repelled by spreading Tulsi throughout the home or by making a paste using its leaves (Nyasvisvo et al., 2024; Sharma et al., 2024; Akintelu et al., 2021). Cutting a lemon in half and inserting cloves into it is another classic home treatment for repelling mosquitoes. Additionally, oils like citronella, eucalyptus and lavender had also been used since ancient times to repel mosquitoes using topical application or diffusers. Applying coconut oil in combination with essential oils to the skin before venturing outside is yet another promising strategy for mosquito-repelling action. In rural areas, mosquitoes are known to be repelled by smoke from burning firewood or cow dung while turmeric, garlic and other spices are used in rural areas to make a variety of herbal pastes that are applied topically as a natural mosquito repellent (Banik et al., 2021; Shibeshi et al., 2024; Salunke et al., 2024; Umar et al., 2021).

There is currently no specific antiviral treatment for several mosquito-borne illnesses like Dengue and Chikungunya which calls for thorough investigation into new therapies, vaccinations and vector control strategies. Traditional methods of repelling mosquitoes offer a number of benefits over synthetic methods owing to the presence of natural components which are less likely to cause irritation to skin or trigger allergic reactions. In contrast to synthetic repellents which are likely to destroy ecosystems, natural repellents are biodegradable and do not contribute to generation of chemicals-based pollution. Traditional repellents are easily accessible and more economical for rural communities owing to their ease in manufacturing at home with easily procurable components. The use of conventional techniques reduces exposure to artificial chemicals which may cause endocrine disruption and other long-term health issues in humans. In the long term, traditional methods may be more sustainable since they adopt a more comprehensive approach to pest control by utilizing community knowledge for mosquito repelling approaches (Kaur et al., 2022; Chinthaka et al., 2023; Nguyen et al., 2023; Hazarika et al., 2022). This survey study underscores the rich cultural legacy of traditional mosquito repellent practices in North East India for managing mosquito-borne illnesses and proposes natural formulations for insect repellents based on these traditional strategies.

2. MATERIALS AND METHODS

2.1. Study area

The states of North East India namely Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Sikkim are located between 22°00′ to 29°30′ N latitude and 89°40′ to 97°25′ E longitude (Fig. 1) which covers 8 per cent area of India with about 3.78% population occupancies. The region, characterized by humid subtropical and tropical climates, dense forests and abundant water bodies provide an ideal breeding ground for mosquitoes, leading to persistent challenges related to vector-borne diseases. Malaria, Dengue and Japanese encephalitis are endemic in the region and are disproportionately affecting rural and tribal communities where access to healthcare is limited. High rainfall and stagnant water accumulation exacerbate mosquito proliferation while inadequate drainage systems and poor waste management further aggravate the problem. Remote geographical locations and difficult terrain hinder timely intervention and vector control measures, making disease surveillance and healthcare delivery challenging. Despite governmental efforts including insecticide-treated nets awareness campaigns and vaccination programs, the lack of sustained community participation and infrastructural constraints pose significant barriers to effective mosquito control.

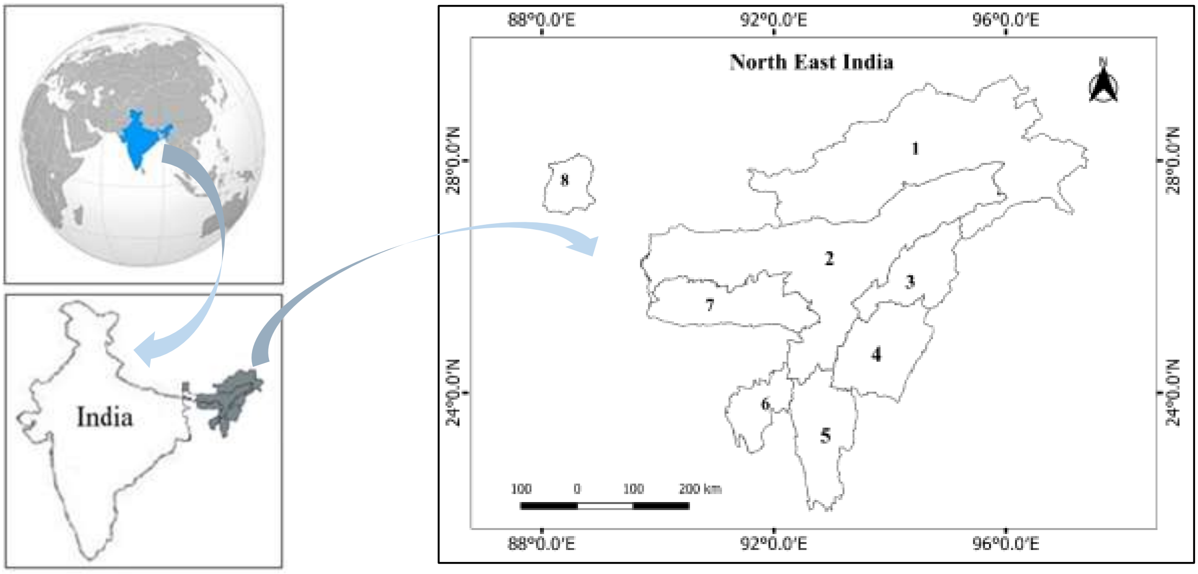


Figure 1: Location map of North East India
(1: Arunachal Pradesh, 2: Assam, 3: Nagaland, 4: Manipur, 5: Mizoram, 6: Tripura. 7: Meghalaya, 8: Sikkim)

2.2. Data collection

An extensive survey was conducted in the year 2024 in 8 states of North East India using interview schedule and online Google form with both close ended and open questions. Questions were related to respondents' personal information, prevalence of mosquito and mosquito borne diseases in their locality and benefits and limitations of those practices. Data collected from 50 districts of North East India were analysed for useful information and interpretation.

3. RESULTS AND DISCUSSIONS

3.1. Mosquito borne-diseases in North East India

According to population distribution, roughly 72% of respondents were from plains and 28% were from mountainous areas. The respondents came from semi-urban (14%) and urban (24%) as well as rural (59%). The prevalence of disease includes: Malaria (44%), Dengue (30%), Chikungunya (13%), & Japanese Encephalitis (11%). Of those surveyed, 70% believed that mosquitoes are present, while 12% disagreed. In urban areas, mosquitoes are observed all year round (35%) and in rural regions mostly during the summer (50%) of the year. A graphical representation of the findings is highlighted in Fig. 2

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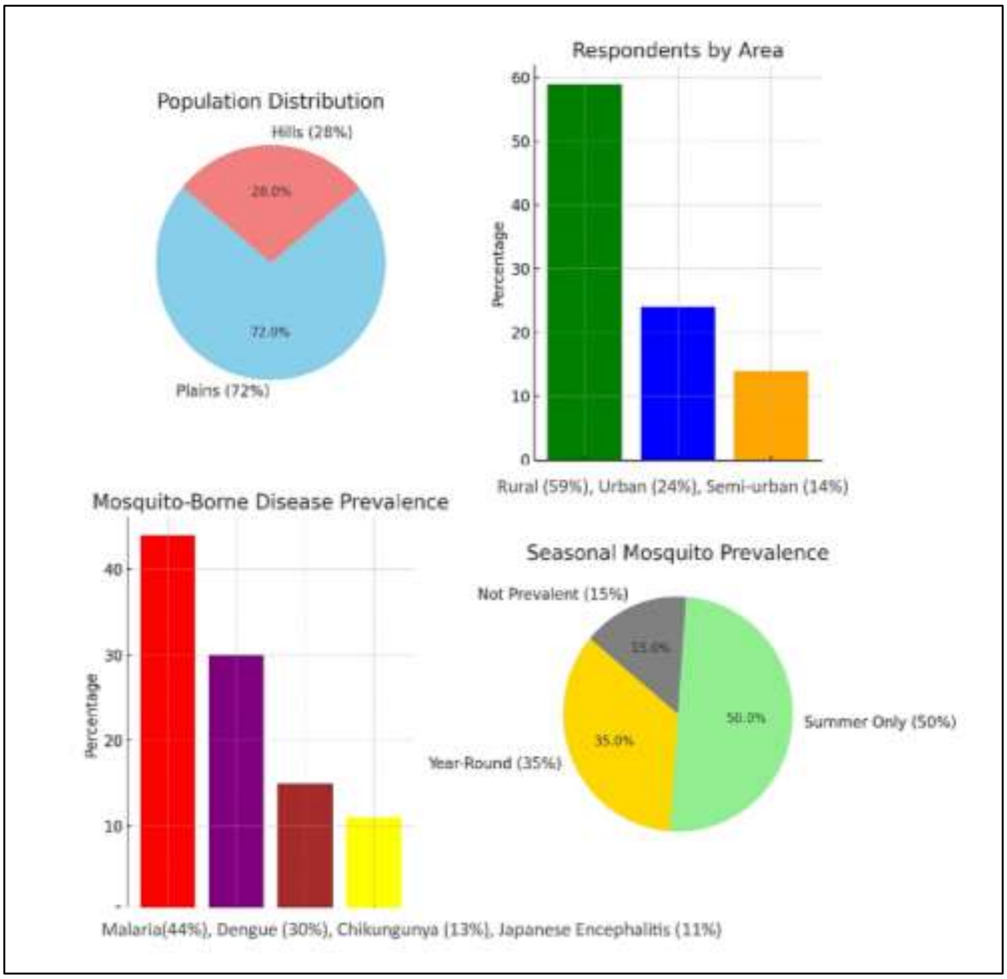

Figure 2: Representation of population distribution, Area-wise responses, Mosquito-Borne diseases prevalence and seasonal mosquito prevalence in North-east India

3.2. Strategies to repel mosquitoes

According to the survey, 37% of people in Northeast India use coils or incense sticks, 21.4% prefer conventional techniques, 30% use artificial liquid repellents and 11.6% say they don't use any repellents because mosquitoes aren't that common (Fig. 3).

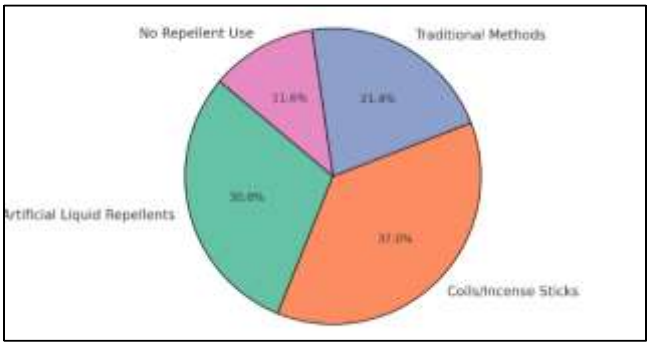

Figure 3: Graphical representation of the mosquito repellent methods in North East India with regions indicating response percentages

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3.3. Smoke producing traditional methods used to repel mosquitoes

According to the data, 32.2% of respondents primarily use smoke from burning egg trays, 30.4% use "Dhuna," 24% use other traditional methods (such as citronella oil, peppermint oil, clove oil, charcoal, coco-coir and cinnamon) and the remaining 13.4% use other methods like burning clothes, neem leaves, straw (also known as "Kher"), "Makhiyoti" and camphor (Fig. 4).

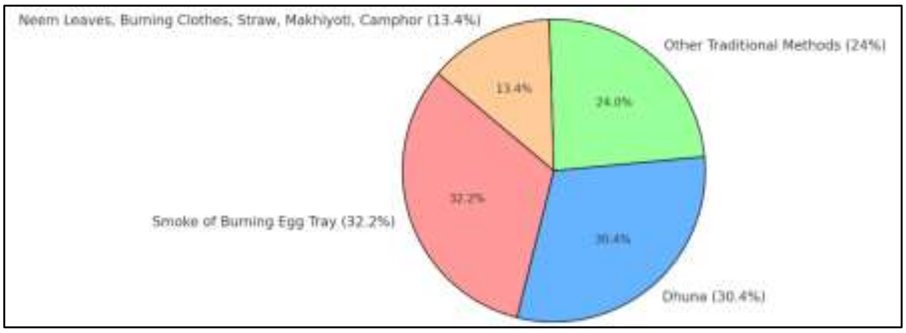

Figure 4: Various traditional mosquito repellent methods of North East India highlighting response percentages

3.4. Effectiveness of traditional mosquito repellent approaches

When asked if folk wisdom is efficient in keeping mosquitoes away, 58% of respondents agree with the statement, and 14.5% strongly agree (Fig. 5).

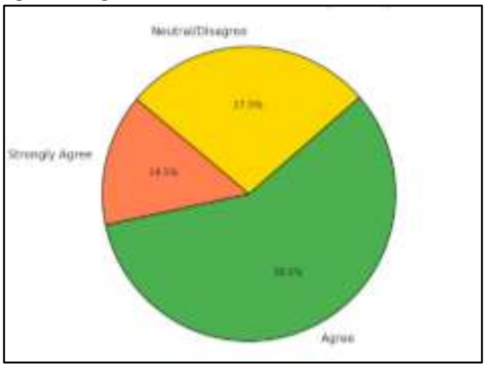

Figure 5: Effectiveness of traditional approaches for mosquito repellent action with response percentages

3.5. Active Traditional Repellents & Chemical Compounds in Mosquito Repellent Methods

i) Common Wormwood (*Artemisia absinthium*) – Thujone, Camphor, Cineole
ii) Marigold (*Tagetes patula*) – Pyrethrum, α-Terthienyl, Limonene, Linalool
iii) Paper Egg Tray Smoke – Aluminium Sulphate, Cellulose, Lignin
iv) Clothes Burning – Cotton, Synthetic Fibres
v) Straw & Agricultural Waste – Pyrethrins, Terpenes, Citronella, Eugenol, Limonene
vi) Burning Tyres – Sulfur Dioxide, Benzene, Heavy Metals, Dioxins, PAHs
vii) Cashew (*Anacardium occidentale*) – Anacardic Acids, Terpenoids, Tannins, Flavonoids, Limonene, α-Pinene
viii) Charcoal – Carbon, Hydrogen, Oxygen
ix) 'Dhuna' (*Frankincense/Sal/Boswellia*)–Monoterpenes (α-Pinene, Limonene, β-Caryophyllene), Sesquiterpenes
x) Camphor – Volatile Monoterpenoid, Borneol
xi) Coco-Coir – Tannins, Phenols, Ketones, Lauric Acid

xii) Neem Leaves (*Azadirachta indica*) – Azadirachtin
xiii) Cinnamon – Cinnamaldehyde, Eugenol, Safrole, Tannin, Calcium Oxalate
xiv) Peppermint Oil – Menthol, Menthone
xv) Citronella Oil – Citronellal, Geraniol
xvi) Clove Oil – Eugenol
xvii) 'Makhiyoti' (*Flemingia strobilifera*) – Flavonoids, Terpenoids
xviii) Orange Peel – Limonene, Linalool, Citronellal, Myrcene

3.6. Proposed mechanism of action of the chemical constituents of traditional repellents

Based on the literature review, the mechanism of action of the traditional mosquito repellent practices in North-east India are demonstrated below in Table 2.

Table 2: Mechanism of action of active constituents of traditional mosquito repellents

Traditional mosquito repellent	Mechanism of action	Reference
Common wormwood (*Artemisia absinthium*)	(i) Thujone and other terpenes cause disorientation or repelling effects by blocking octopamine receptors and disrupting mosquito brain communication. (ii)Wormwood's essential oil components display neurotoxic, olfactory and sensory deterrent properties to keep mosquitoes away. By interfering with mosquito olfactory receptors, camphor and cineole (eucalyptol) cover up human attractant substances (lactic acid and CO_2). The substances found in wormwood essential oils block human-derived Kairomones, making it harder for mosquitoes to identify their hosts. The compounds also trigger mosquitoes irritating receptors which prevents mosquitoes from landing or biting.	Ali et al., 2018; Baitha et al., 2020; Liu et al., 2019
Marigold flower (*Tagetes patula*)	(i) Linalool, Ocimene and Limonene which are released by marigolds hide human attractant substances (lactic acid and CO_2) and directly repel mosquitoes by interfering with their olfactory receptors. (ii) Phototoxic larvicidal action is exhibited by sulphur-containing compounds such as α-terthienyl which produces reactive oxygen species (ROS) that harm mosquito larvae in water when exposed to sunlight. (iii) Pyrethrum interferes with the neurological and olfactory systems of insects.	Hajra et al., 2016
Paper Egg Tray smoke	(i) The binding of aluminium sulphate to dendritic cell membranes changes the shape of lipid membranes and renders the venom in mosquito bites and stings inactive. It accomplishes this by reacting with the venom's long-chain carbohydrate and protein constituents and also possesses larvicidal qualities. (ii) Burning cellulose releases smoke which may contain several substances that discourage insects. Small particles and chemicals in the smoke created during burning can obstruct mosquitoes' ability to recognise scents and find hosts.	Henderson & Easton; 1980; Voignac et al., 2023; Urrutia et al., 2022

	(iii) Burning lignin can release aromatic molecules that mosquitoes may find unpleasant, decreasing the area's appeal to them.	
Clothes burning	(i) Chemicals released by burning clothing such as phenols and other aromatic hydrocarbons might be disagreeable to mosquitoes and may hinder their ability to find hosts. (ii) Since mosquitoes are drawn to cooler places, the heat produced by burning can form a thermal barrier that they may avoid. (iii) A variety of gases and particulates found in burning smoke can cover up mosquito-attracting aromas like body odour.	Amadi et al., 2018
Straw including dried leaves, grasses, herbs, or agricultural waste (e.g., rice straw, coconut husks)	(i) Pyrethrins bind to mosquitoes' neurons sodium channels which causes paralysing and killing and act as a contact poison that mosquitoes can inhale. (ii) Certain substances, like linalool have minor neurotoxic effects and prevent mosquitoes from sensing people by blocking their olfactory receptors. (iii) Phenolic compounds and alkaloids interfere with mosquito metabolism or egg-laying behaviour. (iv) The smoke produced by burning straw bothers mosquitoes' delicate respiratory and antennal systems, making them avoid the area	Shankar et al., 2013; Dube et al., 2011
Burning tyres	(i) Toxic substances such as sulphur dioxide, benzene, heavy metals, dioxins and polycyclic aromatic hydrocarbons (PAHs) are released when tires burn which blocking their olfactory receptors. (ii) By causing acute toxicity or upsetting mosquitoes' neurological systems, some of these compounds have the potential to incapacitate or kill mosquitoes.	Rosenau 1901; Liu 2024; Subedi, 2020
Cashew (*Anacardium occidentale*)	(i)Anacardic acids act as neurotoxins, upsetting mosquito neurological systems by blocking enzymes like as acetylcholinesterase (AChE) and harm mosquitoes' cellular membranes, resulting in paralysis or death (ii) Flavonoids and Tannins reduce mosquitoes' capacity to recognise hosts by binding to proteins in their saliva or sensory organs and interfere with the function of neurotransmitters or ion channels (e.g., GABA receptors). (iii) By interfering with mosquitoes' olfactory receptors, limonene and α-pinene cover up human scents (such CO_2 and lactic acid) so that they can't recognise human hosts.	Farias et al., 2009; Nnamani et al. 2011; Kim et al., 2021
Charcoal	(i)Because of Charcoal's high surface area and porosity, activated charcoal absorbs moisture and volatile organic chemicals that are released by people such as ammonia and lactic acid. Since mosquitoes mostly rely on olfactory cues to locate hosts, lowering these	Ariana et al., 2023

	chemical cues makes individuals harder for them to detect. (ii) The smoke produced when charcoal is burned such as in coils or incense serves as a physical barrier and the smoke irritates or blocks mosquitoes' sensory receptors, making them avoid the area. Across civilisations, this mechanism is prevalent in conventional repellent techniques. (iii) The main ways that charcoal works in mosquito repellents are by adsorbing attractants, facilitating smoke-mediated deterrent and improving the delivery of active repellents	
'Dhuna' (Frankincense resin/Sal/Boswellia)	(i) Mosquitoes use olfactory receptors to detect body odours, lactic acid and CO_2 in human hosts. By blocking or confusing these receptors, frankincense's chemicals may lessen host-seeking behaviour. (ii) Some terpenes have been shown to aggravate mosquito sensory systems which causes them to avoid the area. (iii) Burned smoke particles form a physical barrier that block mosquitoes' ability to fly and see their surroundings. (iv) Certain terpenes in frankincense such α-pinene may combine with mosquito neurotransmitters or ion channels to temporarily paralyse or confuse them.	Kumar et al., 2023; Pavela et al., 2021; Lemenith & Teketay, 2003
Camphor	(i) Olfactory receptors are used by mosquitoes and other insects to recognise their hosts. These receptors may get saturated by camphor vapours leading to sensory disorientation and a decrease in host-seeking behaviour. (ii) Camphor causes disorientation or paralysis by interfering with octopamine, a neurotransmitter essential for mosquito flight, alertness and foraging. (iii) Camphor may interfere with nerve signal transmission and cause knockdown effects (temporary incapacitation) via affecting sodium or GABA-gated chloride channels. (iv) Borneol is thought to work by triggering the cytochrome P450 enzyme in neuronal channels which can result in the death of neural cells.	Mitasari et al., 2024; Vainer et al., 2023
Coco-coir	(i) Burning coconut coir (for example, in coils or mats) releases smoke that contains particulate matter and pyrolyzed chemicals (phenols and ketones) that irritate mosquitoes or interfere with their sensory receptors and forms a barrier of protection. (ii) By interfering with insects' chemoreception, lauric acid which is present in coconut (coco-coir) derivatives, has shown repelling properties. Additionally, coir's tannins or other phytochemicals may discourage insects.	Anom & Mamangkey, 2016

Neem leaves extract (*Azadirachta indica*)	(i) Azadirachtin interferes with mosquitoes' regular behaviours such as feeding, moulting, mating and egg laying. (ii) Azadirachtin disrupts hormone systems which hinders mosquito development and egg laying. (iii) Azadirachtin impairs the survival of larvae by delaying development during the pupae-to-adult and larva-to-pupa transitions (Kamilu et al. 2024; Nour et al. 2012).	Kamilu et al., 2024; Nour et al., 2012
Cinnamon	(i) Strong smells and substances like cinnamon aldehyde interfere with mosquitoes' sensory perception and upset the nervous system, killing mosquito larvae and discouraging adult mosquitoes. (ii) Eugenol, which has a strong smell and a spicy taste repels mosquitoes (iii) Safrole in cinnamon may have additional repellent qualities (iv) Tannin and calcium oxalates in cinnamon prevent mosquito larvae from growing	Kurniawan 2022; Mahran et al., 2023
Peppermint oil	(i) By interfering with mosquitoes' sensory receptors, Menthol and Menthone discourage them from approaching. (ii) By hiding attractants, interfering with sensory perception and establishing an environment that mosquitoes find less alluring, the chemicals serve as a natural deterrent	Al Parvez et al., 2023
Citronella oil	(i) Geraniol and Citronellal disrupt mosquitoes' sensory receptors, making it harder for them to identify possible hosts. (ii) Because active compounds are irritating, they harm mosquitoes' integuments making it harder for them to attack hosts.	Kumar et al., 2021; Higuchi et al., 2023
Clove oil	(i) The respiratory system of mosquitoes may be impacted by Eugenol exposure. Suffocation may result from eugenol's ability to obstruct the spiracle which are the apertures through which insects breathe. (ii) Mosquitoes are poisoned by Eugenol. By interfering with neurotransmitters' regular activity, it affects their neurological system, causing paralysis and eventually death. (iii) Mosquitoes may become confused by the presence Eugenol. Their longevity may be shortened as a result of this disorientation which may keep them from locating mates or food sources.	Nentwig et al., 2017
'Makhiyoti' (*Flemingia strobilifera*)	(i) By interfering with mosquitoes' olfactory receptors, Flavonoids and Terpenoids may prevent them from landing or biting.	Iraqui et al., 2022
Orange peel	(i) Insects may be mildly neurotoxically affected by Limonene and other Terpenes which would disturb their nervous systems and make them repelled. (ii) The mosquito's olfactory receptors are disrupted by	Boanyah & Brenyah, 2022

	the potent Citrus aroma of orange peel components. Mosquitoes use their sense of smell to identify human body odours and carbon dioxide (CO_2). These attractants are hidden by the volatile molecules in orange peel which makes it more difficult for mosquitoes to find their prey.	

3.7. DISCUSSION

The study on traditional mosquito repellent strategies in Northeast India offers valuable insights into the interplay between folk wisdom and modern vector control needs. Conducted across eight states, the research documents a variety of traditional methods, such as burning egg trays (32.2%), using 'Dhuna' (30.4%) and employing natural materials like citronella, peppermint, clove oils and neem leaves (24%). These practices reflect the region's rich cultural heritage and resourcefulness, utilizing locally available materials to combat mosquito-borne diseases like Malaria, Dengue, Chikungunya and Japanese Encephalitis. The prevalence of these diseases with Malaria at 44% and Dengue at 30%, underscores the region's vulnerability due to its humid climate, dense forests and water bodies which facilitate mosquito breeding. The survey's findings reveal that 57.9% of respondents view these traditional methods as effective with 14.6% strongly endorsing them, indicating significant community trust. However, the study notes a decline in traditional practices attributed to perceived inefficacy, limited material availability and time constraints. This is concerning as 29.8% of respondents use synthetic liquid repellents and 37.4% rely on coils or incense sticks which may pose environmental and health risks due to chemical exposure. In contrast, traditional methods are environmentally friendly with minimal risk of skin irritation or ecological harm. The use of natural compounds like azadirachtin (neem), citronellal (citronella) and eugenol (clove oil) align with global trends toward sustainable pest control. The study also highlights challenges in rural and tribal areas where healthcare access is limited and government interventions like insecticide-treated nets face logistical barriers due to remote topography and poor infrastructure. This underscores the value of traditional methods as accessible and cost-effective alternatives. The identification of active compounds such as thujone in wormwood and limonene in orange peel suggests potential for developing standardized plant-based repellents. Yet, the lack of standardization and documentation as noted in the study hinders their scalability and integration into modern vector control strategies. The findings advocate for a hybrid approach, combining traditional knowledge with scientific validation to create novel formulations. For instance, neem and citronella-based products could be refined for broader application, reducing reliance on synthetic chemicals. The study's emphasis on community acceptance (72.5% positive response) supports the feasibility of this approach though the 22.8% uncertainty and 4.7% disagreement indicate a need for awareness campaigns to bolster confidence. By addressing these gaps, traditional methods could complement existing interventions, enhancing mosquito control in Northeast India's unique socio-ecological context.

4. CONCLUSIONS

The study on traditional mosquito repellent strategies in Northeast India underscores the potential of folk wisdom in addressing the region's significant mosquito-borne disease burden including Malaria (44%), Dengue (30%), Chikungunya (13%) and Japanese Encephalitis (11%). Conducted in 2024 across 50 districts, it reveals that methods like burning egg trays (32.2%), using "Dhuna" (30.4%) and natural materials such as neem and citronella (24%) are culturally significant and environmentally sustainable. These practices, rooted in local traditions offer affordable alternatives to synthetic repellents which 29.8% of respondents use despite their potential health and environmental risks. The survey's finding that 57.9% of respondents find traditional methods effective with 14.6% strongly agreeing, highlights their practical value particularly in rural and tribal areas with limited healthcare access. However, challenges such as declining use due to perceived inefficacy, material scarcity and lack of standardization threaten their sustainability. Climate change exacerbates mosquito proliferation, making innovative solutions urgent. The study advocates integrating traditional knowledge with modern science to develop eco-friendly repellent formulations, leveraging active compounds like azadirachtin and citronellal. Such an approach could reduce reliance on chemical interventions, aligning with global sustainability goals. The limited effectiveness of government measures, hindered by infrastructural issues further emphasizes the need for community-driven solutions. By standardizing and promoting these traditional methods, Northeast India could enhance its vector control strategies, addressing the 46.8% outbreak frequency reported. Future research should focus on validating these methods scientifically and improving their accessibility, ensuring that cultural heritage contributes to public health resilience in the face of environmental and epidemiological challenges.

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