



**DENGUE FEVER: EPIDEMIOLOGY, PREVENTION AND CONTROL STRATEGIES,
AND THERAPEUTIC POTENTIAL OF HERBAL MEDICINES**

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ABSTRACT

Dengue fever is one of the most rapidly spreading mosquito-borne viral diseases worldwide, posing a significant public health challenge in tropical and subtropical regions. The disease is caused by the dengue virus (DENV) and is primarily transmitted through the bites of infected *Aedes aegypti* and *Aedes albopictus* mosquitoes. Increasing urbanization, climate change, globalization, and inadequate vector control measures have contributed to the growing incidence of dengue infections. This review highlights the global burden of dengue fever and provides a comprehensive overview of current prevention and control strategies, including physical, biological, and chemical approaches. Physical control methods such as GIS mapping, surveillance programs, community participation, and public health education play a crucial role in reducing disease transmission. Biological strategies involving *Wolbachia*-based interventions, genetic modification of vectors, sterile insect techniques, and larvivorous organisms have shown promising outcomes in vector suppression. Chemical control methods, including insecticides, insect growth regulators, and attract-and-kill technologies, remain important components of integrated vector management. Furthermore, the review summarizes medicinal plants and herbal remedies reported to possess anti-dengue activity, platelet-enhancing effects, or immunomodulatory properties. Several plant species, including *Carica papaya*, *Azadirachta indica*, *Euphorbia hirta*, *Phyllanthus* spp., and *Curcuma longa*, have demonstrated potential therapeutic benefits in experimental studies. Although herbal medicines offer promising alternatives, further preclinical and clinical investigations are required to establish their safety, efficacy, and mechanisms of action. An integrated approach combining vector control, public awareness, vaccination, and scientifically validated herbal therapies may contribute significantly to reducing the global burden of dengue fever.

Keywords: Dengue Fever; Dengue Virus; *Aedes aegypti*; Vector Control; Prevention Strategies; Biological Control; Chemical Control; Herbal Medicine; Medicinal Plants; Antiviral Activity; Public Health; Integrated Vector Management.

INTRODUCTION

Dengue fever (break-bone fever) is a viral disease transmitted by a species of *Aedes* mosquitoes (CDC, 2023). It occurs more frequently in tropical and subtropical areas.

According to the WHO report, majority of dengue patients are asymptomatic. Yet, those who experience a high temperature, headache, body aches, nausea, and rash are the most typical symptoms. Most people recover within

1 to 2 weeks. Some dengue patients get severe illness and require hospitalization (WHO, 2023).

Dengue was widespread in more than 120 countries as of 2019. According to the study conducted by Shepard *et al.*, over 60 million symptomatic infections were reported in 2013; 18% of these led to hospital admissions, and 13,600 people died as a result. Dengue cases are predicted to cost \$9 billion globally (Shepard *et al.*, 2016).

The majority of infections are contracted from urban settings (Gubler, 2010). With growth of villages, towns, and cities in locations where it is frequent, as well as greater movement of people, has increased the number of outbreaks and circulation of viruses in recent decades. Dengue, which was once exclusive to Southeast Asia, has now expanded to southern China in East Asia, Pacific Ocean countries, and the Americas according to Gubler. Reiter noted that this could be a danger to Europe.

The WHO Territories of Africa, the Americas, the Eastern Mediterranean, South-East Asia, and the Western Pacific are now home to more than 100 nations where the illness is endemic. With Asia accounting for roughly 70% of the global illness load, the Americas, South-East Asia, and Western Pacific are the areas most severely impacted (Reiter, 2010). While serologic evidence showing Dengue infections are widespread in various countries across Africa, the burden of dengue is still relatively poorly reported (Udoh *et al.*, 2019). According to recent findings, dengue may be a significant contributor to acute fevers in Nigeria (Ayukekbong, 2014), despite the fact that many persons who visit medical institutions complaining of fever are

administered with an antimalarial drug without further testing.

Prevention and control strategies

The prevention and control methods are divided into three categories, which have been discussed accordingly.

A] Physical control

GIS mapping of dengue foci

Among the advanced techniques used for location of DENV, GIS mapping has been efficient in locating dengue concentrations. By locating dengue sero-positive cases within the study area, dengue transmission can be prevented by locating dengue foci, and then treating them with diverse preventive strategies (Gandhi *et al.*, 2017). Kittayapong *et al.*, showed that GIS mapping not only allowed better surveillance and community-based intervention programs for suppressing dengue; it also determined the rate of successful control in the mapped areas.

Focused and effective surveillance

Surveillance provides fundamental information on the assessment of risk, outbreak reaction, program evaluation and guidance, as well as delivers timely responses to prevent and control dengue (Wilder-Smith *et al.*, 2012). Surveillance enables the understanding of spatiotemporal distribution of dengue cases, and provides entomological and epidemiological links for better planning (WHO, 2012; Scarpino *et al.*, 2017). On the other hand, these programs are not focused on the elimination of dengue vector (Abbas *et al.*, 2014). The eruption of dengue in Singapore, after decades of surveillance, indicated unsustainable vector control measures and ineffective surveillance (Ooi *et al.*, 2006) in 2005 (Koh *et al.*, 2008).

Determination of oviposition sites

As determined by Morrison *et al.*, (2004) *Aedes aegypti* females lay eggs above the water in containers or jars and so on for their survival improvement. To detect and reduce the population density of dengue vectors, it is necessary to determine the behavioral pattern of vectors. Wong *et al.*, studied the oviposition pattern of *A. aegypti* and reported that strong intra-specie affinity may be an indication of targeting vector specie. Moreover, once the oviposition sites have been determined, introduction of strategies that eliminate mosquito population at a later developmental stage will increase the efficacy of control strategies (Wong *et al.*, 2011).

Community-based control programs

Community-based control programs are developed with the aim to educate the community about the measures for the extermination of mosquito breeding sites. People in a community are divided into various groups depending upon their level of education and understanding (Abbas *et al.*, 2014). The significance of community-based programs for elimination of dengue mosquitoes in Kerala district (George *et al.*, 2017), Mexico (Tapia-Conyer *et al.*, 2012), and Cuba (Vanlerberghe *et al.*, 2010) has been proven in the form of elevated awareness among the communities.

Education of prevention strategies

It has been noted that the success of community-based strategies depends upon the knowledge, education, and behavior of the people, and strategies involved (Nam *et al.*, 2005). Education serves as a basis for an ability of an individual to identify and deal with vector habitats, and use preventive

measures. Madeira *et al.*, emphasized that distribution of information brings awareness in order to control dengue, and provides necessary measures for the destruction of vector habitats (Madeira *et al.*, 2002).

B] Biological control

Paratransgenesis and use of wolbachia

Nowadays, genetic control of *A. aegypti* has risen as a set of promising techniques, among which paratransgenesis is the popular method (Araujo *et al.*, 2015; Ogaugwu and Durvasula, 2017). This approach utilizes genetically-modified symbiotic bacteria that are reintroduced in the vector to colonize the vector population, hence limiting the transmission of disease (Araujo *et al.*, 2015; Wilke and Marrelli, 2015). As reported in the study by Jeffery *et al.*, the most effective bacterial agents used is *Wolbachia* (Jeffery *et al.*, 2009; Saldana *et al.*, 2017), which is a reproductive parasite interfering with the cellular and reproductive mechanisms of the vector species (Araujo *et al.*, 2015; Kamtchum-Tatuene *et al.*, 2016).

Vector specie genetic modification

The genetic methods for the control of *A. aegypti* aim at suppressing the population and its replacement or transformation. Therefore, the aim is designed to provide an alternate that could be accounted for providing an effector gene for reduction and inhibition of disease transmission (Reis-Castro, 2012; Carvalho *et al.*, 2014; Jupatanakul *et al.*, 2017).

The field release of genetically modified mosquito species in Brazil showed an 85% decline in *A. aegypti* population, indicating that genetically modified vector species are innovative and feasible methods used for

blocking the transmission of mosquito-borne diseases (Fraser, 2012; Favia, 2015).

Use of sterile insect technique (SIT)

As the name indicates, SIT refers to the release of laboratory-sterilized male vectors in the target population. Once released, these male mosquitoes help in suppressing the fecundity rate in female mosquitoes and, consequently control the vector density in urban environments (Dumont and Chiroleu, 2010; Yakob *et al.*, 2017) and transmission of vector-borne diseases (Alphey *et al.*, 2010). According to Oliva *et al.*, SIT is a promising strategy that helps in prevention and control of mosquito-borne diseases.

Use of larvivorous fish and crustacean

Since the larvae of dengue vectors reside in open water bodies, use of larvivorous fish, such as *Poecilia reticulata* (Seng *et al.*, 2008) and *Mesocyclops formosanus* (Kalimuthu *et al.*, 2017) comes as a cost-effective, eco-friendly, and innovate strategy in controlling the population of *A. aegypti* (Warbanski *et al.*, 2017). A successful study in Cambodia was carried out to evaluate the efficacy of introducing larvivorous guppy fish (*Poecilia reticulata*) into heavily infested water containers.

C] Chemical control

Use of insecticides and plant derivatives

The chemical compounds, called insecticides, have been utilized for mosquito control for many decades. These insecticides became the most commonly used integrated strategy; nevertheless, the continuous use developed resistance in the target vector population, and

can induce negative impacts on the environment. These plant-based insecticides can be developed from different plant parts (leaves, stem, roots) and/or herbal extracts, such as, *Cipadessa baccifera* (Ramkumar *et al.*, 2015), *Callistemon rigidus* (Pierre *et al.*, 2014), *Erythrina indica*, and *Asparagus racemosus*.

Use of insect growth regulators (IGRs)

Among other known chemical compounds, insect growth regulators (IGRs) are used for hindering the growth and development in insects. During early stages of development, IGRs induce changes that kills the insect before becoming an adult. There are number of IGRs such as, diflubenzuron, endotoxins, and methoprene that have been used to counter viral infections spread by *A. aegypti* (Abbas *et al.*, 2014).

Use of pheromones as “attract-and-kill” approach

The practical application of pheromones as a part of integrated pest management (IPM) has been well-documented in various fields. In a recent integrated approach using pheromones, also termed attracticides, and IGRs, Nagpal *et al.*, demonstrated the prevention of developmental stages from eggs to adults (Nagpal *et al.*, 2015). In this study, larvae in test containers were found in a greater number than controls containers, which indicated that using attracticides hampers the progression of adulthood in *A. aegypti* and is effective in field conditions.

Table 1: Herbal drugs used for prevention of dengue

S. No.	Plant	Family	Part Used	Mode of Action	Reference
1.	<i>Alternanthera photoperiods</i>	Amaranthaceae	Whole plant	Inhibited DENV-2 replication	Jiang et al., (2005)
2.	<i>Alternanthera sessillis</i>	Amaranthaceae	Leaves	Significant platelet increasing activity	Arollado et al., (2014)
3.	<i>Arrabidaea pulchra</i>	Bignoniaceae	Leaves	Inhibited DENV-2	Brandao et al., (2013)
4.	<i>Cissampelos pareira</i>	Menispermaceae	Aerial part	Increased the platelet counts	Sood et al., (2015)
5.	<i>Curcuma longa</i>	Zingiberaceae	Not stated	Anti-DENV activity in Huh7it-1 cells	Ichsyani et al., (2017)
6.	<i>Cymbopogon citratus</i>	Poaceae	Root	Inhibited DENV-2 replication	Rosmalena et al., (2019)
7.	<i>Euphorbia hirta</i>	Euphorbiaceae	<i>Euphorbia hirta</i>	Significantly reduced the plaque forming capacity of the DENV-1-2	Tayone et al., (2014)
8.	<i>Phyllanthus sp</i>	Phyllanthaceae	Whole plant	Inhibited DENV-2 replication	Lee et al., (2013)
9.	<i>Myristica fragrans</i>	Myristicaceae	Leaves	Inhibited DENV-2 replication	Silva et al., (2011)
10.	<i>Rhizophora apiculata</i>	Rhizophoraceae	Whole plant	Inhibited DENV-2 replication	Klawikkan et al., (2011)
11.	<i>Uncaria tomentosa</i>	Rubiaceae	Stem	Reducing DENV-Ag+ cell rates	Reis et al., (2008)
12.	<i>Catharanthus roseus</i>	Apocynaceae	Leaves	Inhibited DENV-2 replication	Zarina et al., (2020)
13.	<i>Cynometra cauliflora</i>	Fabaceae	Leaves	Inhibited DENV-2 replication	Wahab et al., (2018)

CONCLUSION

Dengue in India has established its roots. Now it is endemic and almost hyperendemic in our population. National level comprehensive studies to estimate the true burden of dengue in India and its geographical mapping are lacking. Through integrated and combined efforts from various sectors and policy makers, prevention of dengue must be

intensified to control further disease transmission.

For herbal remedies, studies on their antiviral properties and ability to modulate the immune response are crucial. Traditional plant-based compounds, such as those derived from *Azadirachta indica* and *Carica papaya*, show promise in laboratory settings for reducing viral load and supporting immune

function. However, these herbal remedies need rigorous clinical trials to assess their safety, proper dosage, and potential interactions with synthetic drugs. Additionally, large-scale epidemiological studies are necessary to determine the real-world efficacy of these remedies when used alongside existing preventive measures like vaccines and vector control strategies.

DECLARATION OF INTEREST

The authors declare no conflicts of interests. The authors alone are responsible for the content and writing of this article.

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