



A comprehensive review on control strategy of Mosquito-Borne Disease (MBD).

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Abstract

Mosquitoes are considered the most fatal and lethal organisms in the world, causing millions of deaths annually around the world. Mosquitoes transmit many types of disease-causing pathogens, such as malaria, dengue, Zika virus, and many more caused the deaths of millions of people. Many types of harmful diseases are spread by mosquitoes; the important ones are Dengue Fever, Malaria, Lymphatic filariasis, Yellow Fever, West Nile Virus, Rift Valley Fever, Chikungunya, Japanese Encephalitis, and some others. MBDs are transmitted in many ways, along with a wide selection of favourable hosts in the form of humans, cattle, and rodents. MBDs are spreading a global threat with many hazardous infections among people, so their control for the elimination of major burden of MBDs from public health is a must. The number of mosquito species has been increasing currently due to climate change and deforestation, and many domestic activities lead to habitat and sites for mosquito breeding. The current scenario highlights the need to reduce the breeding sites of these mosquito vectors through different controlling methods. Many types of controlling approaches are available for the elimination of MBDs, such as chemical, biological control, source reduction, public health awareness, etc. The current study tries to highlight the major common burden of MBDs and focus on the MBDs controlling strategy, including all maximum approaches to control the mosquito fauna.

Keywords: Mosquito-borne diseases, Vector, Control, Biological

Introduction

Mosquitoes (Diptera: Culicidae) have significant public health importance due to their ability to transmit various serious and hazardous diseases, and are considered the world's most deadly arthropods. Climate change and many other factors lead to an increase in the population of mosquitoes. Mosquito-borne diseases are spread through the female bites on the host at the time of blood sucking for oviposition. The main mosquito-borne diseases include malaria, Chikungunya, Zika, Dengue, West Nile, yellow fever, Rift Valley fever, *Lymphatic filariasis*, and tick-borne encephalitis (Sanfelice, V, 2022) [31]. Important vectors of the pathogens causing these diseases are mosquitoes belonging to the genera *Aedes*, *Culex*, and *Anopheles*, widely distributed in Africa, Asia, South America, and Europe (Kraemer, M.U.G., 2015) [24]. Mosquito-borne diseases are a serious threat to public health due to, causing morbidity and mortality at globally. Different mosquito species, such as *Anopheles*, *Culex*, and *Aedes*, carry different disease-causing pathogens of many diseases (Cella, W., 2019) [8].

In mosquito diversity, mostly 3563 species belong to three genera (*Anopheles*, *Aedes*, and *Culex*) within two subfamilies (Anophelinae and Culicinae) are the most important disease-transmitting vectors. The *Anopheles* mosquito vectors can transmit malaria and filariasis, while the *Aedes* can transmit dengue virus (DENV), chikungunya virus (CHIKV), Zika virus (ZIKV), yellow fever virus (YFV), and the *Culex* genus can transmit filariasis, Japanese encephalitis virus (JEV), West Nile virus (WNV), and Rift Valley Fever (RVF) (Tolle, 2009 & Hartman, A., 2017) [16, 37].

Mosquito-borne diseases pose the greatest threat to public health worldwide and are typically associated with severe economic hardships in the countries they infect. Vector-borne diseases have increased in the last 40 years due to a

variety of causes such as population growth, migration, urbanization, globalization, lack of public health infrastructure, less of knowledge awareness, etc. The Global Vector Control Response (GVCR) 2017–2030 provides the strategic plan for preventing the threat of MBDs. control of vector-borne disease outbreaks. GVCR proposed that improved infrastructure, monitoring systems, and technical capacity are required to reduce the burden of MBDs and maintain human health. (Chandra, G, 2024) [9]. Many environmental factors provide the breeding sites of mosquitoes, such as standing water where mosquitoes lay eggs, poor housing quality, lack of air conditioning, and climatic factors increase the abundance, distribution, and risk of exposure to *Aedes aegypti* (Messina, J. P. 2019) [26]. Mosquito-borne diseases are controlled by reducing the diversity of mosquitoes, so mosquito control approaches have a significant purpose. Mosquito control methods are done by directly or indirectly. Direct interventions such as the removal of breeding sites (egg laying habitat) and Chemical and biological control. Indirect approaches such as public health awareness and education, and suitable and managed infrastructure and source reduction etc, (Dr. Feyera, 2023) [13].

Most Common Mosquito-Borne Diseases (MBDs): -

Malaria: - Malaria is a global burden caused by plasmodium parasites and transmitted by *Anopheles* mosquitoes, specifically in sub-Saharan Africa, as 90% of the total mortality and 85% of the total malarial cases mainly occur here (Trujillano *et al.*, 2023) [38]. The malaria parasite life cycle is a complex process involving an *Anopheles* mosquito (sexual) and a vertebrate host (asexual) (Siciliano G, 2015) [33]. For malaria treatment, WHO recommends the use of combination therapy for all types of malaria, involving at least two effective antimalarial agents with different mechanisms of action (WHO, 2022).

Dengue fever: Dengue fever is death causing serious health impacts. The pathogen is dengue virus (DENV), including four different types of serotypes (Agha *et al.*, 2017) [1]. DENV enters the human body by the bite of *Aedes aegypti* and *Aedes albopictus* mosquitoes, mainly in the rainy season. Approximately 2.5 billion individuals are susceptible to dengue annually (Bal and Sodoudi, 2020) [4].

Japanese encephalitis virus (JEV): - JEV is an endemic disease of Asia and parts of the western Pacific and is the leading cause of viral encephalitis in Asia, causing almost 100,000 cases and 25,000 deaths per year. JEV is a zoonotic flavivirus transmitted by the bite of *Culex* mosquitoes in an enzootic cycle involving pigs; humans are considered incidental hosts (Quan TM, 2020) [29].

Lymphatic Filariasis: - LF is a helminthic disease caused by the nematodes *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori*, transmitted to humans by several mosquito species, depending on species-specific specific such as *Anopheles*, *Aedes*, *Culex*, and *Mansoni*. LF has been documented throughout Africa, Southeast Asia, and the Pacific, and in focal areas in the Caribbean, South America, and the Middle East. LF is noticed by long-term infection in lymphatic infections, and includes chronic limb lymphedema to scrotal lymphoedema (hydrocele) (Silvestri, V, 2024) [34].

Chikungunya: - CHIKV is a mosquito-borne alphavirus (family *Togaviridae*) transmitted in humans by the bite of

Aedes (Stegomyia) aegypti and *Ae. (Stegomyia) albopictus* mosquitoes, these vectors also carry pathogens of dengue (DENV) and Zika (ZIKV), and yellow fever viruses. Chikungunya has acute and chronic manifestations, including fever and polyarthralgia. Chikungunya in serious conditions leads to severe manifestations, neurological complications, and death (Weaver,2015) [39].

Zika virus (ZIKV): - ZIKV is a Flavivirus. *Aedes* infected female mosquitoes transmit the pathogen to the host upon blood sucking. In ZIKV infections, many mild symptoms arise, and many infrequent neurological diseases occur in older children and adults. During pregnancy, ZIKV infections lead to congenital malformations and neurodevelopmental deficits (Rabe IB, *et al.*, 2025) [30]. ZIKV is also transmitted from mother to foetus during pregnancy or around the time of birth, and also from laboratory exposure, transfusion of infected blood products (Giménez-Richarte, 2022) [15].

Yellow fever (YF): - YF is caused by an arbovirus (Flaviviridae), a single-stranded RNA virus. The pathogen was first isolated in 1927. Infection is spread by the bite of infected female *Aedes* mosquitoes (Litvoc, 2018) [25]. Yellow fever commonly causes many serious health impacts threat to millions of people residing in tropical and subtropical regions of Africa, South and Central America, and to international travellers who visit these at-risk regions (E Reno,2020) [14].

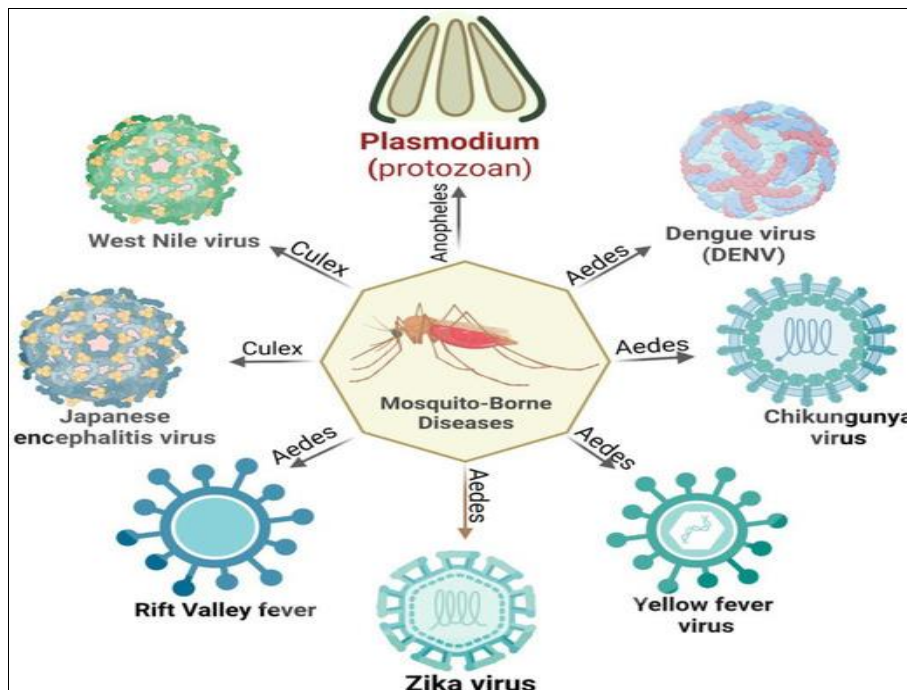


Fig 1: Common Mosquito-Borne Diseases. (Swagato Bhattacharjee, 2023) [36].

Control Methods of Mosquito-Borne Diseases: - Currently, different mosquito control methods are used to prevent MBDs, such as chemical control by insecticides, environmental management for reducing the breeding sites of mosquitoes, biological control by fishes, fungal agents and genetic modification in mosquitoes and personal protection can be important path to reduce the MBDs., and personal protection methods (Kathleen, 2002) [23]. Vector control is a more common method to prevent all vector-

borne diseases, such as mosquito-borne, tick, and mite-borne diseases etc. Inhibiting the contact between the vector and the human host is an important factor for reducing the transmission of MBDs. Vector control methods have different tools in including chemical- and non-chemical-based tools. Chemical and biological control mostly target the immature stage of mosquito vector and removing the breeding sites and many repellent works on same approach, adult vectors are controlled by indoor residual spraying

(IRS), space spraying) and reducing vector contact with human and/or animal reservoir hosts (e.g., topical repellents, house screening, insecticide-treated bed nets [ITNs], insecticide-treated dog collars). Genetic modification in mosquitoes and different bacterial and fungal agents is used to control the mosquitoes. (Wilson AL,2020)^[41].

The chemical methods have many approaches, such as long-lasting insecticide-treated nets (LLINs), indoor residual

spraying (IRS), space spraying, also the implementation of mosquito repellents. Long-lasting insecticide-treated nets are manufactured using a fabric treated with pyrethroids and others. LLINs work as a physical barrier to vectors and hosts; mosquitoes are killed after coming into contact with these nets. LLINs help in protection as an individual and are also applicable in the community for a long time (Pryce, J, 2018)^[28].

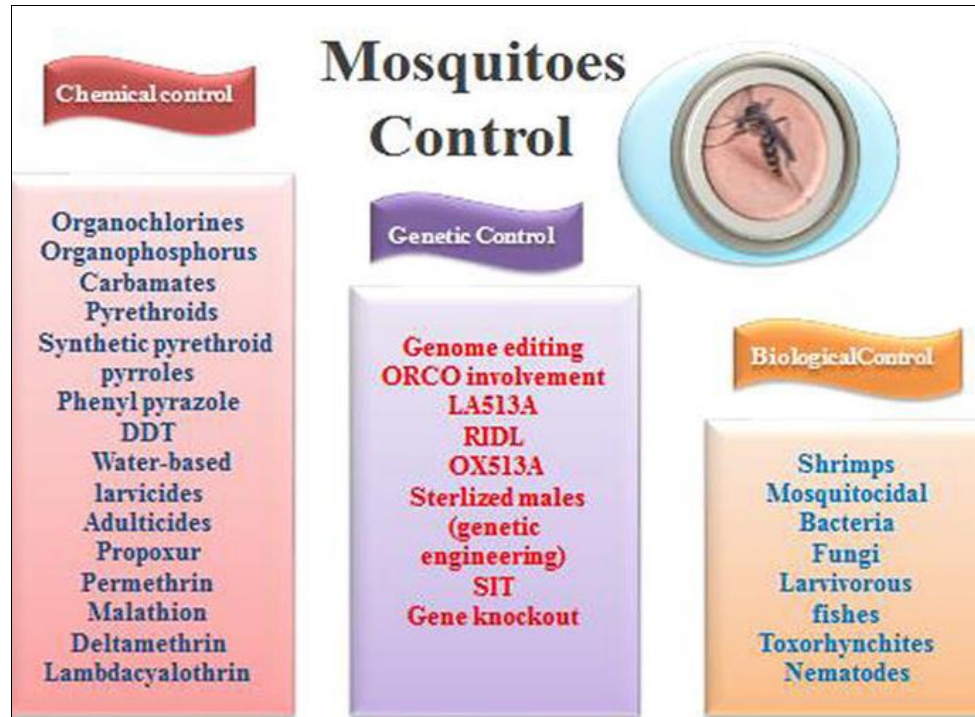


Fig 2: Mosquito control methods. (Zeeshan Javed, 2022)^[22, 44].

Indoor residual spraying (IRS) is an effective method to prevent malaria infections, but IRS is now limited to high-cost and implementation approaches that are cost-effective. Selective spraying is best to target selected and limited areas on dwellings and surfaces (Seth R. Irish, 2024)^[18]. Repellents are mostly used to break the close contact between the host and vectors. Repellents like DEET, Picaridin, and other plant-based products are used to decrease the transmission of MBDs. The development and efficacy of synthetic pyrethroid insecticides like Metofluthrin and transfluthrin are synthetic pyrethroid are used as a repellent for killing the vectors. (J.D. Charlwood, 2025)^[21].

Biological Control: - Introduction of some bacterial and fungal agents as a controlling approach, as biological control is a new lead to prevent the MBDs. Biological control reduces the immature stage of these vectors. Biological control is suitable for many mosquito-borne arboviruses, which lack proper treatment and vaccines (W.H.O, 2006).

Fish as predators are introduced into aquatic bodies to reduce the mosquito community due to these fish's intake of mosquito larvae of mosquitoes as a food source. These fish do not have any negative impact on the environment, so these fish are highly beneficial as a biological control. Showed high advantages as compared to chemical control (Bay, E.C., 1967)^[5]. Development as a biological agent has many important functions and is best used to control the mosquitoes, including *Ae. aegypti*, *Ae. albopictus*, and *Cx.*

quinquefasciatus (Digma, 2019)^[12]. Mosquitoes developed a behaviour to sense the presence of these larvivorous fishes in water bodies. *Culex* mosquitoes can sense the presence of *G. affinis* and deposit eggs on locations where these fish are less or absent (Angelon, K.A., 2013).

The genetically engineered mosquito concept is a milestone, the best tool for biological control. An important fundamental of these genetically engineered mosquitoes is replacing the pathogenic and main vectors from the ecosystem with modified mosquitoes. Genetically engineered mosquitoes in biological control applications approach focuses on directly converting the resistance to arboviruses by "intracellular immunization" with the help of antiviral genes, it doesn't directly decrease the diversity of mosquito vectors like other natural control strategies. transmission decreases by lowering the abundance of competent mosquitoes in the ecosystem. These approaches are pathogen-specific based on the expression of antiviral RNA molecules, and transmission can also be prevented by disrupting the biological cycle of wild mosquitoes through the introduction of genetically engineered mosquitoes. (Nawtaisong, P., 2009 & Isaacs, A.T., 2012)^[19, 20, 27].

Microbial control is also a useful tool for preventing the burden of MBDs, the use of bacterial agents of *Bacillus thuringiensis* subsp. *israelensis* (Bti) and *Bacillus sphaericus* (Bs) as effective mosquito control agents. Research concluded that Bti and Bs are more effective in combination, and alone use is significant for mosquito control, and these approaches are also non-harmful for other

animals (Derua, Y.A., 2018) ^[11]. Fungal agents change the physiology of mosquitoes, so they can be a significant tool for mosquito control. These agents change the physiology of mosquitoes to prevent the diversity of mosquitoes, transmission of mosquitoes. Fungal agents' application is also a best tool for vector control (Darbro, J.M., 2012) ^[10].

Nano pesticides are an eco-friendly approach to control the pest in a few quantities of nonapeptides; these tiny and flimsy particles play role in control the mosquitoes as a penetrate the negatively charged outer biological membrane of mosquito larvae so ultimately these are the helpful for controlling the mosquitoes and not have any negative impact on ecosystem (Sap-Iam N, 2010) ^[32]. In the current era, nanoparticles are also an effective tool for controlling mosquitoes. these nanoparticles are used as a potential insecticide to control mosquitoes, and the application of nanoparticles is safe for the ecosystem and other fauna of living biota. Nanoparticles are used as formulations as adulticides, pupicides, larvicides, ovicides, and repellents for effective mosquito control (Benelli G, 2016) ^[6, 7].

Source reduction is a method to eliminate the breeding sites of the mosquito vector to prevent the burden of vector-borne disease. Anti-larval activities lead to reducing and permanently destroying the breeding habitats of mosquitoes. The basic aims of source reduction are to prevent the metamorphosis of immature stages into adult by destroying their breeding sites, so it can be reducing the diversity of mosquitoes, and ultimately, MBDs prevention can be achieved by source reduction. Source reduction is eco-friendly and not no negative impact and humans and animals, and also requires minimal manpower to perform source reduction. (NVBDCP).

Modify the mosquito vector habitat to decrease larval development or inhibit host and vector contact is considered as environmental management. EM can be applied for long-term prevention of mosquito-borne disease and proper elimination of breeding locations of vectors and proper corrections in human residential areas to minimize the burden of MBDs (WHO, 1980). Proper knowledge of vector biology is required to modify the local environment to decrease the transmission of MBDs, so environmental management is also an important tool for eliminating the mosquito community (Baitharu, I, 2020) ^[3].

Currently, almost all vectors develop a resistance against the chemical insecticide, so it is best to select the eco-friendly green approach to control the mosquitoes. it can be biological control by bacterial and fungal strains, and control by larvivores fishes, and many mechanical control methods are also applicable for reduce the transmission of MBDs (Benelli G, 2016) ^[6, 7].

Sukumar *et al.* (1991) ^[35] observed that many plant products are used as skin repellents and fumigants and insecticides for adult control, and also larvicides for biological control, and can also be used in the formation of any alternative for mosquito control. Pyrethrum, obtained from *Chrysanthemum cinerariaefolium* and piperidine skeleton, found in piperine (chemical agent in pepper, *Piper spp.*) (Kathleen, 2002).

Conclusion: - Mosquito-borne diseases are a major threat at the global level to human health. Mosquitoes transmit many types of viral pathogens and some protozoan and helminth worms. Anopheles mosquitoes transmit the protozoan parasite Plasmodium, and Culex mosquitoes transmit the pathogen of Japanese encephalitis and Lymphatic filariasis;

similarly, Aedes mosquitoes are known for spreading the pathogen of dengue, chikungunya, Zika virus, yellow fever, etc. MBDs can be controlled in many possible ways, but if the strategy is applied to controlling the vector, then this deadly disease will be eliminated. Prevention of MBDs can be achieved by reducing the mosquito diversity because if the transmitting vector is not available, then the infection will be less. The Mosquito Control approach is a suitable application to prevent the threat of MBDs. Vector control methods are commonly chemical control, biological control, source reduction, and public health awareness. Mosquito control is the most suitable approach to reduce the burden of MBDs, so proper knowledge about the control methods of vectors and vector habitat, and vector biology is much needed to reduce the burden the hazardous effects of MBDs.

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