# Global Strategies for Combating Dengue Virus: A Review on the Control Methods

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A thesis submitted to the Department of Mathematics and Natural Science in partial fulfillment of the requirements for the degree of

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## Declaration

It is hereby declared that

1. The thesis submitted is my/our original work while completing a degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material that has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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## Approval

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## Dedication (Optional)

Dedication is the expression of a friendly connection or thanks by the author towards another person. It can occupy one or multiple lines depending on its importance.

## Abstract

Dengue fever, a mosquito-borne disease, has become a significant global public health concern. This study explores various methods for preventing and controlling dengue, including biological, chemical, and community-based approaches. These different methods, even though they have the same purpose, can be differentiated based on their efficacy, sustainability, and the practical aspects of life. We tried delving into the methods and finding out the most suitable and efficacious method based on our country setting and compared it with the various international methods that have been useful. The biological methods mainly utilize natural organisms and environmental components to control the mosquito population. Examples include the use of fish species that prey on mosquito larvae, the bacterium *Bacillus thuringiensis* israelensis (Bti) that kills mosquito larvae, and *Wolbachia* bacteria that reduce mosquito lifespan and ability to transmit dengue. While effective in controlling mosquito populations, chemical methods may raise concerns due to their potential harm to the environment and the development of mosquito resistance. Common practices of chemical control include fogging with insecticides, larvicides applied to water, and insect growth regulators that prevent mosquitoes from reaching adulthood. The community-based methods focus on raising public awareness and promoting individual and collective actions to prevent mosquito breeding and bites. This includes public education campaigns, community clean-up efforts to eliminate mosquito breeding grounds, and the use of personal protective measures like mosquito repellents and bed nets. The increasing prevalence of dengue highlights the need for a comprehensive approach that combines various prevention and control methods while prioritizing environmental sustainability and community engagement. The study concludes by emphasizing the importance of ongoing research and development of novel and sustainable strategies to combat this growing global threat.

**Keywords :** Dengue, Control methods,*Wolbachia* ,Prevention methods,Fogging,Larvivorous fish , Pyrethroids,KAP

## Table of Contents

## Introduction

In the last two decades, dengue fever has significantly increased in prevalence across the globe, posing a grave threat to public health. From 2001 to 2020, the number of cases reported worldwide increased by a factor of ten, according to the World Health Organisation (WHO), from 500,000 to 5.8 million. In 2019, a record number of cases were documented across 129 distinct nations. The decline in dengue cases from 2021 to 2022 can be attributed to the decreased reporting rate and the COVID-19 pandemic. Conversely, a worldwide epidemic of dengue cases occurred in 2022, marked by a substantial escalation in the quantity, magnitude, and concurrent manifestation of numerous outbreaks that infiltrated hitherto unaffected areas. Cycles of dengue transmission are observed, whereby notable epidemics are anticipated every few years (Bhaat et al., 2008). During the COVID-19 pandemic, researchers observed minimal transmission in some regions and moderate transmission in others; consequently, there was an accumulation of individuals who lacked immunity to particular dengue virus serotypes.

Since 2021, nearly 92 nations and territories and 6 WHO regions have documented dengue-related fatalities exceeding 7000. Approximately 76% of the total number of documented cases, or 4.2 million, have occurred in Asia and South America (Yoon et al., 2021). These figures are close to an all-time high, and the outbreak is attributed to the combination of ongoing transmission and an unforeseen surge in cases. This report will dive deep into the study of dengue. In the exponential study of dengue, different methods used to prevent dengue will be analyzed carefully. At this time, comparisons will be made among these types of methods to find out which methods will be most effective in the long run. This thesis will also dive into the conditions of dengue with different types of statistics and graphical visual data to depict the condition of dengue in various countries and in various demographics. On the whole, this thesis shows proper guidance on the steps that should be taken so that dengue can be completely nullified and ultimately make this world free from this malicious and contagious disease.

## Methods of Biological Prevention and Control

To combat the prevalence and spread of dengue disease, biological methods are the most environmentally favorable and sustainable options. Various natural and environmental components, including components of flora and fauna, function biologically to protect against

the virus. It is extremely widespread in many nations across the globe, especially those that are considered less developed. Despite being an extremely primordial method, its success rate is exceptionally high.

An extremely common biological technique involves the consumption of *Aedes* mosquito eggs and larvae by various species of fish such as the use of guppies, tilapia, mosquito fishes, etc. varying from country to country. This occurs frequently in Brazil, India, and Bangladesh. Moreover, Southeast Asian nations such as the Philippines and Indonesia also employ it (Ooi et al., 2018). Initially, a subset of fish is captured and released into bodies of water and ponds where mosquitoes and mosquito larvae are abundant. These fish then consume the mosquitoes' eggs and young, thereby preventing the eventual spread of dengue. Up to 60% is the efficacy rate of this particular type of mechanism.

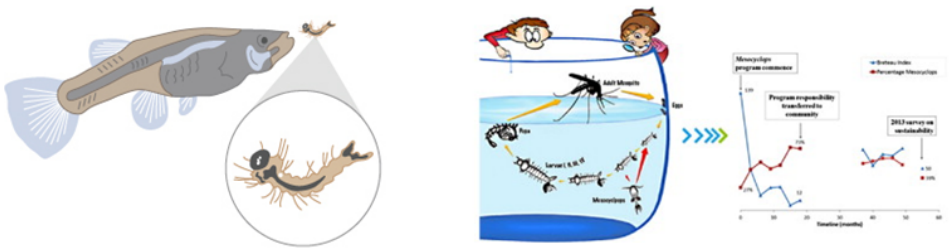

Figure 1: Biological dengue prevention by using fish. Source: (World Peace, 2017)

Using microorganisms in water is an additional biological method of dengue prevention. One of these bacterial strains, *Bacillus thuringiensis* israelensis (Bti), is incorporated into water for dengue prevention. It is a strain of bacteria that is disseminated and diluted with water to render the dengue virus ineffective. This is a prevalent technique in Thailand and Singapore. This particular strain of bacteria contains a toxin that is lethal to mosquito larvae. The beneficial aspect of this bacteria is that it is non-pathogenic and harmless to plants and living organisms, except mosquitoes. *Bacillus thuringiensis israelensis* has a 72% success rate, according to research conducted in Singapore (Guzman et al., 2019).

An additional category of biological systems utilized for dengue prevention is *Wolbachia coli.* This strain of bacteria is widely used in both Indonesia and Australia. Furthermore, its utilization is on the rise in Bangladesh, specifically in the southern sectors of the nation. *Wolbachia coli* is administered directly and dispersed in various locations using this technique to prevent the

growth of mosquitoes and other dengue-causing microorganisms. It is an extremely straightforward and user-friendly approach (Shephard et al., 2012). However, its unavailability in numerous countries makes its cost quite high in these regions. An Australian study conducted in 2011 found that the implementation of *Wolbachia* bacteria in a specific region of Queensland led to a reduction of dengue cases by 50–70%.

In many nations, genetic modifications are implemented to prevent mosquitoes from transmitting dengue. Oxitec, a Brazilian corporation, achieved remarkable success in its attempt to eradicate the virus from *Aedes* mosquitoes through genetic manipulation. By utilizing this technique, the mosquitoes are rendered non-viable before their maturation into adults. Because of this, the potential for dengue transmission is significantly reduced (Endy et al., 2001). A 40-day field trial conducted in Brazil yielded a success rate of 90% when employing this particular mechanism. This technique is expanding incrementally from Brazil to other nations.


Figure 2: Oxitec Product. Source: (Oxitec, 2022)

Diverse species of fungi are frequently employed in numerous South American nations as a preventative measure against dengue transmission. In this particular instance, entomopathogenic fungi are utilized. This fungus (*Metarhizium anisopliae*) is environmentally beneficial and inhibits the proliferation of mosquito embryos and adult mosquitoes. When applied to mosquito breeding sites it works by penetrating the insect's exoskeleton and causing a fatal infection. The fact that this fungus can only destroy mosquitoes is a positive aspect (Khan et al., 2016). As a consequence, dengue is averted and additional beneficial plants and invertebrates remain risk-free. Countries in South Asia, including India, Bangladesh, Pakistan, and Myanmar, utilize this variety of fungus. Using this fungus to eliminate mosquitoes and thus prevent dengue has an

approximate 65% success rate. It's important to note that this method is still in development and may not yet be widely implemented for dengue control programs. Additionally, there are considerations such as safety, effectiveness, and environmental impact that need to be thoroughly addressed before widespread implementation.

An additional biological approach involves the utilization of various species of nematodes. Nematodes and worms consume the embryos and larvae of *Aedes* mosquitoes. This system consists of releasing nematodes into bodies of water where mosquitoes are abundant (Ong et al., 2005). These worms then consume the mosquito embryos, thereby preventing the eventual spread of dengue. 55% is the rate of success for this form of mechanism. This occurs frequently in both India and Bangladesh.

## Methods for Chemical Prevention and Control

Today, dengue is frequently combated using chemical techniques. As ever-more-advanced chemicals are introduced to the market, their application is expanding. Various chemical compounds and varieties of chemicals are employed in chemical methods to eliminate mosquitoes to mitigate the transmission of dengue. In contrast to biological approaches, this chemical method uses synthetic substances and additional compounds intended for dengue prevention.

Fogging, a chemical prevention system, is implemented in numerous countries across Asia and South America. In this chemical dengue prevention system, damp, dark areas are sprayed with chemical vapors to eliminate the disease's presence (Khetarpal et al., 2011). This is prevalent in South Asian nations such as Bangladesh, Pakistan, and India. As per a report by Hindustan Times, the efficacy of employing high-quality fumigation mechanisms for dengue control and prevention exceeds 70%. Usually, chemicals like pyrethroids, IGRs (Insect Growth Regulators), and pyriproxyfen are used in the fogging system. Pyrethroids are synthetic chemicals derived from natural pyrethrins, which are extracted from chrysanthemum flowers. Pyriproxyfen or PPF on the other hand mimics the action of juvenile hormone, a natural hormone in insects that regulates growth and development. When mosquito larvae are exposed to PPF, it interferes with their development by inhibiting the transformation from larvae to pupae and subsequently to

adult mosquitoes. This disrupts the mosquito life cycle, reducing the overall population and limiting their ability to transmit diseases. (Ahmed et al., 2020).

Waterborne chemical insecticides constitute an additional chemical approach to combat dengue. Larvicides are among the chemical substances diluted with water for dengue prevention. It is a chemical compound that is dispersed and diluted in water to eradicate mosquito growth and development. This approach is widely utilized in African nations such as Kenya and Nigeria. A similar phenomenon can be observed in Australia. This particular larvicide contains a toxin capable of causing mosquito larvae's demise. 90% is the effectiveness rate of larvicides as a preventative measure against dengue. Pyriproxyfen can also be mixed with water but the most used waterborne chemical insecticide is temephos. Temephos can be applied to various water sources where these mosquitoes breed, including containers used for drinking water storage, discarded tires, and other potential breeding grounds. Mosquito larvae ingest temephos when they feed on water or other materials contaminated with the larvicide. Thus disrupting the enzyme acetylcholinesterase, which is crucial for proper nerve function in insects including mosquitoes. Without properly functioning acetylcholinesterase, the larvae's nervous system becomes overstimulated, leading to paralysis and eventually death.

Chemicals are used in many developed nations to alter the physical condition of insects. The chemicals in question are referred to as insect growth regulators. This renders those mosquitoes incapable of transmitting dengue. The benefit of employing this method is that the mosquitoes are killed off before their maturation. Because of this, the potential for dengue transmission is significantly reduced (Capeding et al., 2018). Over 85% of applications succeed when this type of mechanism is implemented. It is pretty prevalent in Australia. Additionally, measures are being taken by the Indian government to implement these insect growth regulator compounds in Shillong and Haryana. In recent years, Bangladesh has also begun to implement this practice.

Figure 3: Chemical spray dengue prevention. Source: (Prothom Alo, 2021)

Space spray, a chemical spray, is utilized in numerous nations. This chemical dengue prevention system involves the application of chemical gas sprays onto open areas, roads, highways, and fields. These aerosol chemicals are dispersed throughout urban areas and the atmosphere. Sprays with a greater than 55% success rate are utilized to prevent the development of mosquitoes and the transmission of dengue. This occurs frequently in Bangladesh. This chemical discharge system is utilized by the city corporations of Dhaka to prevent the spread of dengue.

Chemical methods, however, present a variety of complications in stopping the spread of dengue. This is due to the detrimental effects that chemical components have on nature and the environment. In addition to preventing dengue, the chemical components cause severe injury to trees and animals. Consequently, the utilization of chemical components has led to a substantial reduction in the population of vegetation, insects, and trees within the affected ecosystem (Khetarpal et al., 2015). As a result, measures must be implemented to ensure that chemical components employed in dengue prevention are utilized appropriately. To prevent dengue, national administrations should implement measures concerning this and the use of chemical elements.

## Methods of Community-Based Prevention

Strategies that are implemented at the community level are the most productive in the fight against and prevention of dengue and mosquito transmission. An indirect strategy is employed in this type of preventive method to eradicate dengue from society to hinder its spread and

propagation. Community-based prevention methods involve measures to raise public awareness about the necessary systems individuals should implement to prevent dengue infection. This approach significantly benefits society and its citizens, fostering a heightened sense of awareness and responsibility among its members. It is highly effective in the long term for preventing dengue (WHO, 2019).

In many nations, particularly those with highly developed educational systems, such as the United States, Europe, and Australia, collective efforts to preserve the environment are observed. They collaborate to clear filthy areas. Furthermore, dengue can be mitigated as mosquitoes prefer filthy environments. There are a multitude of approaches to executing this step. People sanitize ponds, rivers, lakes, and other bodies of water in numerous nations. Campaigns are initiated by youths and individuals affiliated with diverse voluntary organizations and institutes in North America, including but not limited to the India Youth Peace Movement, the American Federation of Students, and the National Youth Society (Thai et al., 2014). These initiatives involve the members of these organizations collecting and disposing of trash from city streets. This activity significantly reduces dengue cases.

Certain countries globally, notably Japan and European nations, possess highly developed educational systems. The educational system imparts knowledge to students regarding preventive measures against dengue and environmentally sustainable practices that mitigate the disease's adverse effects. Concurrently, educational institutions, including schools, organize campaigns where students actively participate to repel the pervasive mosquito population. Such campaigns are also extremely effective in preventing dengue. Recently, numerous schools in Bangladesh have also engaged in this type of educational campaign to combat the spread of the dengue pandemic.

In numerous nations, including Brazil, Columbia, and Argentina, council agents are responsible for ensuring that the water in the backyards of residential properties is not obstructed. The primary aim of this inspection category is to ascertain the absence of dengue mosquito reproduction grounds within the residences. Dengue will not be transmitted to dwellings if it can guarantee no obstructed water sources in which mosquito larvae and pupae can ferment and develop (Anders et al., 2012). Studies indicate that 90% of dengue mosquitoes inhabit areas

within three hundred meters of residences. Consequently, community agent inspections may reduce the prevalence and severity of dengue mosquito infestations.

Additionally, implementing digital devices and technology can be a crucial preventative measure against the proliferation of dengue in any nation. People can be educated about dengue by implementing IoT, sensors, and artificial intelligence protocols. Furthermore, it is extremely prevalent in Japan and China as well. Individuals will receive timely notifications regarding dengue via their mobile devices and the Internet. This will deter individuals from visiting the region where they could potentially acquire dengue. A concurrent update will be furnished to the relevant governmental departments regarding the presence of dengue vectors in a specific area (Nagao et al., 2006). The appropriate government agency will subsequently implement measures to eliminate the dengue mosquitoes. Consequently, sensor technology and other data devices can significantly contribute to dengue prevention.

Figure 4: Community-based dengue prevention. Source: (Better Africa, 2018)

Religious leaders, political leaders, and celebrities may also participate in community-based dengue prevention strategies. This is because individuals of this nature have significant sway over the populace. Therefore, these individuals can utilize their influence to educate others regarding preventative measures against dengue. For instance, public figures such as actors, vocalists, or celebrities may share preventative measures against dengue after presenting a film or performing a song. Political leaders can motivate the public regarding preventive measures against dengue through mass communication strategies (Anderson et al., 2013). Religious leaders

may recommend that individuals maintain their dwellings devoid of stagnant water and moist areas, as these factors are known to contribute to the transmission of dengue. This is certainly a good and feasible case in Bangladesh, where individuals tend to embrace anything that celebrities and other esteemed individuals recommend.

## Comparison of Various Preventive Methods

As the mosquito-borne disease spreads more widely due to increasingly extreme weather events, more cases of dengue fever were reported in 2022 than in the previous seven years combined. Between March and December 2022, there were about 7 million cases of dengue fever in 23 of the worst-affected nations. This was a 29% rise in cases throughout 2021 and 17% over the numbers from 2020, the year of the world's most recent significant outbreak. Dengue killed at least 5,652 individuals in the 25 nations, up 14.50% from 2018 and 39% from 2021. Because many cases go unreported, the actual number of deaths and cases is probably far higher (Endy et al., 2012). Children are more susceptible to the disease than adults because of their weakened immune systems and propensity to play outside where there is less mosquito protection, even if data on kid mortality was unavailable for many nations. Children are most affected if their parents or other carers are incapacitated or die from dengue. Children under the age of four are particularly vulnerable to dehydration and shock from the sickness.

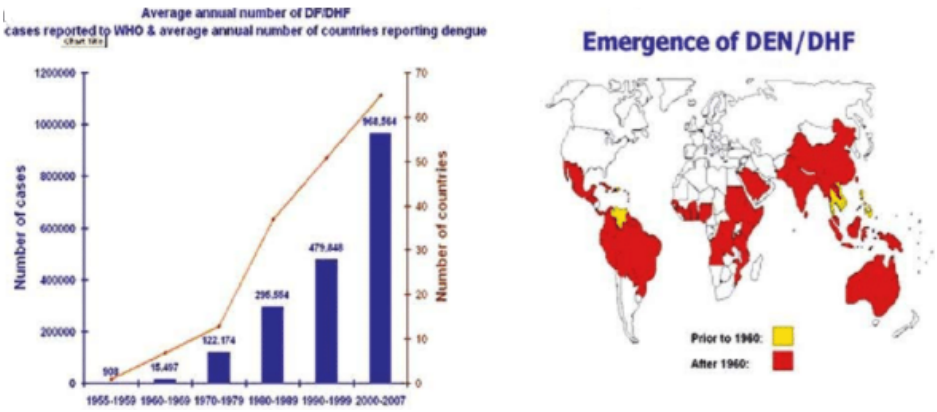


Figure 5: Global dengue cases. Source: (Adroit, 2023)

Bangladesh, the country with the highest recorded mortality toll worldwide, saw the most extraordinary dengue fever outbreak in 2022, with over 338,000 cases reported since May—a sharp increase from the 78,500 cases reported in 2021. The outbreak claimed 1,635 lives, most of

them under the age of eight. In 2022, the number of deaths from the disease exceeded seven times that in 2021. In Peru, the biggest epidemic of the sickness the nation has experienced in over a decade resulted in at least 63 children dying and 88900 more contracting the fatal virus this year. In 2022, the country reported over 275,000 cases of dengue, about six times the 78,500 cases reported in 2018 (Shepherd et al., 2019). The outbreak's primary cause, climate change, which has brought heavy rains, flooding, and a rise in temperature to the northern areas of Samaria and Pohiyan, prompted Peru to proclaim a state of emergency in 23 of its 26 provinces in April. This year, 528 dengue deaths were reported in West Africa, a significant increase over the 17 and 21 reported in 2018 and 2017, the last two years for which data are available. Nearly 61,000 cases are considered probable, according to the Ministry of Health. It is believed that the dengue fever outbreak has been made worse by this year's climate change event and the climate catastrophe. While natural and cyclical, climate change events are made worse by the climate crisis.

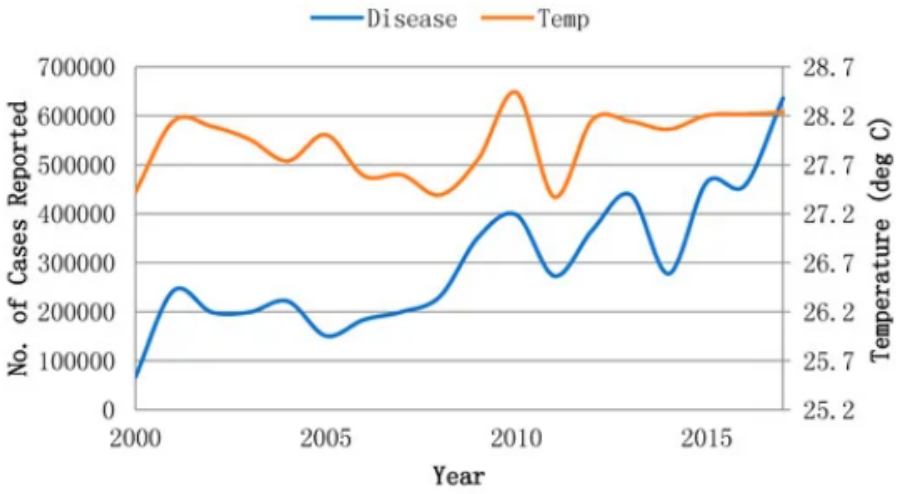


Figure 6: Rise in dengue cases. Source: (Health News, 2023)

Dengue, which strikes the Americas every six years, is the most widespread arbovirus and the leading cause of arboviral disease cases due to its cyclical nature. Additionally, there have been reports of indigenous dengue clusters in the WHO European Region. However, given that the majority of primary infections are asymptomatic and that in many countries, dengue reporting is not mandatory, these numbers likely underestimate the actual disease burden. Several factors contribute to the heightened risk of the dengue epidemic spreading. These include the shifting

distribution of vectors (primarily *Aedes aegypti* and *Aedes albopictus*), especially in countries with no prior experience of dengue; the impacts of El Nino in 2022 and climate change, which will lead to increased temperatures, precipitation, and humidity; the vulnerability of health systems during the COVID-19 pandemic; and the political and economic instability in the region (Nagao et al., 2023). Additionally, these factors raise skepticism regarding the efficacy of the response to the pandemic and its capacity to propagate to other countries. The potential for more severe dengue cases exists due to delayed reporting and response, failure to diagnose symptoms, and inadequate monitoring systems in several affected countries.

Management of mosquito populations is the primary preventative measure against dengue infections. Because mosquitoes are essential for dengue transmission, reducing their populations can halt the disease's spread. Environmental management is facilitated by eliminating unnecessary container habitats (such as plastic jars, bottles, cans, tires, and buckets) where *Aedes aegypti* can deposit their eggs. This strategy is known as "source reduction." Removing container habitats and lining water storage containers with fine mesh to prevent mosquito ingress reduces the likelihood of mosquitoes depositing eggs, and they cannot successfully complete their aquatic life cycles (Huy et al., 2015). It can be advantageous to consistently implement source reduction, especially when community members are involved and well-informed regarding vector management.

Environmental management activities include significant community modifications, such as replacing water storage containers and wells, which can serve as breeding grounds for mosquitoes, and installing water systems with direct connections to residences. Minor modifications to the environment may also yield advantageous outcomes. Mosquito populations can be reduced, for instance, when every community member clears clogged gutters and street sewers and keeps their yards free of standing water containers. Empty and sanitize any open containers once per week to eliminate mosquito larvae and eggs. These initiatives can potentially reduce the mosquito population in a specific area (Yoon et al., 2021). Community-based strategies and education programmes that inform individuals about mosquito vectors and the hazards of having breeding grounds near their homes must coexist. Public education initiatives have the potential to inspire and encourage individuals to engage in source reduction efforts.

People can decrease the likelihood of mosquitoes penetrating their homes by employing window and door screens, maintaining closed windows and doors, and operating air conditioning to keep a cool temperature. As *Aedes aegypti* attacks predominantly during the day, long sleeves and trousers protect against mosquito bites when spending time outdoors. To mitigate the likelihood of mosquito attacks, one may also apply repellents to exposed skin and clothing (Beatty et al., 2009). The Centers for Disease Control and Prevention recommend mosquito repellents containing actual DEET, picaridin, lemon eucalyptus oil, or IR3535. An additional precaution to prevent mosquito bites is to sleep beneath a mosquito net, particularly in households with young children or locations frequented during afternoon naps.

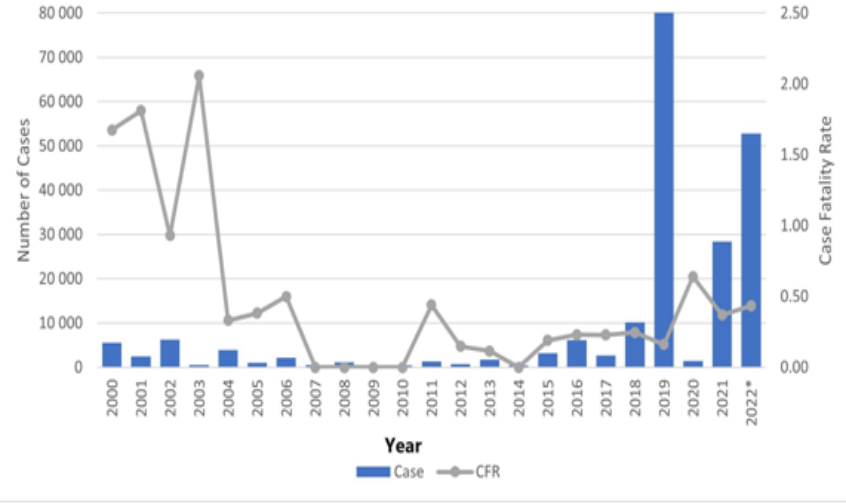


Figure 7: Dengue fatality case. Source: (Info-Graphic, 2022)

Ovum traps are an additional method for reducing *Aedes aegypt*i populations. These are water-containing cylindrical black receptacles. A circular wire lattice and a flotation ring that floats on the water's surface within the container are affixed to the ovitrap's upper portion. Two paddles have been affixed above the lattice. Ovitraps appear to be the optimal nesting grounds for *Aedes aegypti.* The female lays the embryos onto the paddles. The mosquitoes then divide into juvenile larvae and pupae after the eggs have fallen beneath the mesh. Upon their emergence, adult mosquitoes are confined within the ovitrap due to the mesh's immobilizing effect. Certain ovitraps have undergone modifications to incorporate adhesive surfaces capable of capturing mature mosquitoes, whereas others have been treated with an insecticide (Suwandono et al., 2005). The utilization of ovitraps can also be employed for mosquito

surveillance. Reducing the vector population requires consistently maintaining and applying an adequate quantity of ovitraps. An example of the successful application of ovitraps to eliminate mosquitoes at an international airport is observed in Singapore. Precautions must be taken to prevent traps from transforming into productive reproductive grounds; this requires constant monitoring and supervision.

Chemical control can be an effective method of managing mosquito populations. For instance, adult mosquitoes and their larvae are susceptible to insecticide destruction. When circumstances require immediate attention, such as during dengue outbreaks or signs of an impending epidemic, insecticide use is recommended. Conversely, there is a preference for decreasing dependence on chemical methods of mosquito control and favoring community-based, coordinated, and sustainable environmental alternatives over the routine application of chemical treatments. One possible explanation is that mosquitoes can develop resistance to pesticides. Moreover, insecticides are costly and, in excess concentrations, can harm humans and other animals. Hence, exercising prudence is advised when utilizing these substances (Yoon et al., 2019).

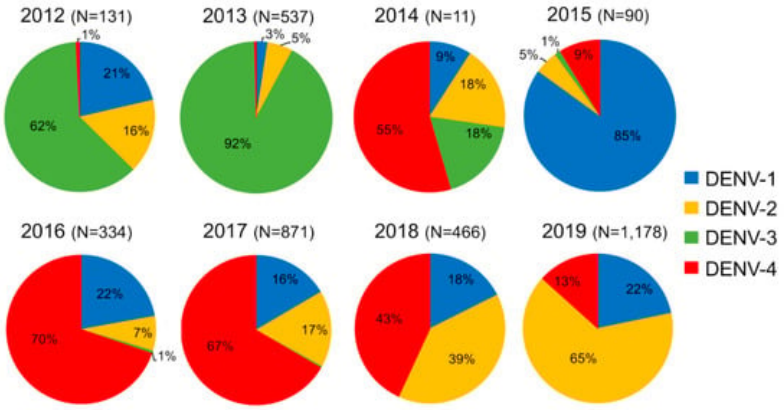


Figure 8: Types of dengue. Source: (Elevate, 2021)

Bioinsecticides are what are referred to as insecticides that incorporate biological controls. An instance of a bioinsecticide is *Bacillus thuringiensis* israelensis (Bti), an indigenous soil bacteria known for effectively eliminating mosquito larvae found in aquatic environments. Small, slow-releasing cylinders called "mosquito dunks" are formulated with the compound Bti, which is extremely specific to mosquitoes. These dunks float on the water's surface and effectively treat deep water. Various *Bacillus thuringiensis* strains exist, each exhibiting distinct toxicity

attributes. As juvenile hormone equivalents, certain bioinsecticides (pyriproxyfen and methoprene, for instance) inhibit the development of mosquito larvae into adults. Researchers have recently implemented insecticides into larval environments through the use of mosquitoes. After consuming blood, female *Aedes aegypti* were found to favor moist, dark environments to rest (Endy et al., 2016). To take advantage of this behavior, the researchers set up moist, gloomy stations dusted with a bioinsecticide targeting larvae. The mosquitoes transported the bioinsecticide to their aquatic breeding grounds via the legs while they were at rest stations. The larvae were effectively eradicated, resulting in a reduction in the population of adult mosquitoes.

Biological approaches are substituted in the management of mosquito populations. For example, mosquito larvae are consumed by a diverse array of fish, including guppy fish larvivorous fish such as Gambusia and Poecilia, and predatory crustaceans referred to as copepods. These organisms inhibit the growth of mosquitoes by consuming their progeny and are, therefore, maintained in aesthetically pleasing ponds, pools, and container habitats. The successful implementation of copepods in large water storage containers in Vietnam reduced the transmission of dengue. Other live predators, such as dragonflies, tiny aquatic turtles, and beetle larvae, have also been effective at eliminating *Aedes aegypti*. Furthermore, innovative genetic approaches are currently under investigation to control mosquito populations.

Researchers from Oxitec and the University of Oxford altered the DNA of female mosquitoes to render them incapable of flight. Flying immobility constitutes a significant hereditary detriment. Due to their inability to pass, female mosquitoes are unable to use their wing oscillation "song" to initiate sexual relations with male mosquitoes. It is simpler for predators to identify flightless female mosquitoes as prey (Ong et al., 2018). According to the researchers ' hypothesis, dengue transmission could potentially be reduced, and mosquito populations could be managed with the assistance of these genetically modified insects. Recently, to eradicate dengue fever, an identical group of scientists modified male mosquitoes genetically to render them infertile. They subsequently released these mosquitoes on the Pacific island of La Jolla for an experiment.

Dr Peter Bryan and colleagues from the University of Sydney, Australia, developed an additional innovative approach to control dengue transmission. The parasite employed by these scientists to infect mosquitoes was *Wolbachia pipientis,* which is known to reduce the lifespan of fruit flies. They hypothesized that *Wolbachia* might be responsible for the shortened lifespan of

dengue-infected insects. The scientists' objective was not to eradicate mosquitoes but rather to alter the age distribution of the mosquito population through the use of the bacterium (Yoon et al., 2020). Although mosquitoes would persist, their current lifespan would be significantly shorter. Dengue transmission from an infected mosquito to a healthy individual is restricted to a period of eight to twelve days. The mosquito will then be able to transmit the infection to humans for the duration of its life cycle, which generally spans three to four weeks. A shortened life cycle would create fewer opportunities for an infected mosquito to transmit dengue.

## Most Prevalent Methods in Bangladesh and Other Countries

Since the beginning of 2023-2024, the number of cases of dengue fever in Bangladesh has been steadily climbing at an alarming rate. A national death toll of 298 individuals was attributed to dengue in 2022, according to the Directorate General of Health Services (DGHS). This figure is an all-time high for the deadly disease. The number of dengue cases in the final half-year of 2023 has been seven times higher than the number of cases that occurred during the same period in 2022. This is before the formal beginning of dengue season in 2023.

The situation has become even more dire in June as a result of the arrival of the monsoon, which is a time when Aedes mosquitoes are at their most abundant. Two of the 856 patients who were hospitalized with dengue between February 15 and July 15, 2022, passed away as a result of their illnesses, according to the data provided by the Department of Health and Social Services (DGHS). Despite this, between the 30th of June and the 30th of June, 2023, a total of 302572 people were admitted to hospitals, and 43 of them passed away as a result of dengue fever. The problem is getting worse daily as a result of the failure of the local government and health ministries to implement comprehensive steps to control the number of *Aedes* mosquitoes (Bhaat et al., 2018). There is no restriction on the locations of *Aedes larvae*, including flower containers, standing water on rooftops, or even within homes. In public areas, particularly within buildings and structures that are still being constructed, they can survive in contaminated water that has been abandoned in containers, bottles, packages, cans, abandoned tyres, and brick pits. This is especially true in public spaces where structures are still being constructed. According to a survey conducted by the Department of Health and Human Services (DGHS), the three most common places for *Aedes* mosquitoes to nest are plastic containers, moist floors (whether in the

basement or elsewhere), and abandoned tyres. Just 4.18 percent of the breeding sources were comprised of flower containers and trays.

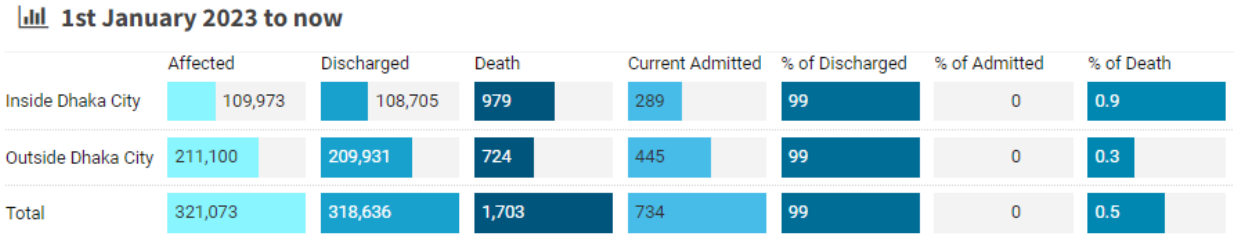


Figure 9: Bangladesh dengue case data. Source: (Dengue Prevention Committee Bangladesh, 2024)

Construction sites are one of the critical sources of *Aedes* mosquitoes, according to statements made by senior entomologist Ramon Sethi of the World Health Organisation during his visit to Dhaka in 2020. Using measures to prevent mosquito reproduction at building sites, dengue transmission could be lowered by as much as 48 percent (Ong et al., 2018). Furthermore, it is the responsibility of the relevant government ministries and departments, including municipal corporations, to make certain that construction sites and abandoned tyres do not serve as breeding grounds for Aedes mosquitoes.

Additionally, government officials must encourage and convince concerned citizens and companies to avoid standing water from gathering inside privately held dwellings. This is necessary to prevent flooding. Regarding this matter, our municipalities can enact measures that are comparable to those that the Delhi Municipal Corporation has taken. The city administration of Delhi adopts techniques to control the Aedes mosquito population throughout the year instead of concentrating its efforts solely on reducing the mosquito population during the monsoon season.

Over the years, the organization continually checks hospital records and keeps track of the accumulation of stagnant water to identify any cases of dengue that have been recorded (Khetarpal et al., 2021). This is done in order to guarantee that a fast reaction is provided. Around 25 to 30 personnel belong to three different groups distributed across the 163 wards that make up Delhi City. The first group is responsible for conducting water investigations. In contrast, the second group is liable for raising awareness about the presence of stagnant water in the regions that they have specified. A fast action unit consisting of fifteen individuals is kept on

standby in each of the eighteen boroughs. Implementation of steps to eradicate reproductive grounds for *Aedes* mosquitoes begins as soon as a dengue outbreak is discovered and identified as having occurred.

It is important to note that Singapore is a noteworthy example of the optimal structure for state institutional measures pertaining to dengue control. The National Environment Agency personnel in Singapore frequently enter residential neighborhoods, construction sites, and public spaces to eliminate breeding grounds for *Aedes* larvae. When inspection procedures are being carried out, hazardous places, such as building sites, are subjected to higher scrutiny.

To impede air circulation and prevent mosquito larvae from multiplying in stagnant water at these locations, the Code of Practice of Environmental Control Officers in Singapore mandates that contractors employ pest control agencies and cleansers as components of vector control (Khetarpal et al., 2020). This is done to prevent the spread of mosquito larvae. It is the responsibility of the staff members to undertake activities related to cleaning the floor every morning and to apply anti-mosquito oil every week. The National Environment Agency conducts monthly inspections of building sites; infractions are penalized by substantial penalties or an order to stop work. An order to cease work may also be issued. It is necessary to identify and eliminate the source of *Aedes* larvae to avoid dengue fever. Additionally, locations affected by the disease should be designated as "dengue clusters," and the local populace should be educated.

In Singapore, residents will be alerted by raising a red or yellow flag corresponding to the cluster status if three or more dengue cases are discovered within a 100-meter radius of a residential block within 15 days. The number of cases will determine whether or not the inhabitants are notified. Moreover, the National Environment Agency website provides the general public with access to up-to-date information regarding dengue clusters. This information is made accessible for the benefit of the public. The National Environment Agency has strategically deployed approximately 75,000 Gravitraps in Singapore to capture mature female *Aedes* mosquitoes ready to lay their eggs. This is done to prevent the spread of the disease. There is a possibility that the National Environment Agency may be able to determine the prevalence of *Aedes* mosquitoes in particular regions by analyzing the data obtained from insects that were captured by its equipment (Guzman et al., 2016). This enables the agency to concentrate on places that produce

the most beneficial results, which is a significant advantage. These gadgets can potentially wipe out a sizeable number of adult *Aedes* mosquitoes, another species that is prone to extinction.

In India, Union Health Minister Mansukh convened a high-level conference in 2022 to assess the situation and public health readiness amid an increase in dengue cases throughout India. He gave states and union territories instructions to follow the Centre for Prevention and Control of Vector-Borne Diseases' guidelines. India gave the government instructions to bolster dengue prevention, containment, and management strategies. India emphasized that screening kits and financial help for fogging and IEC initiatives had been given to states by the Union government. Healthcare personnel have received training as well.

According to India, the federal government has provided sufficient funding to the states under the Programme Implementation Plan (PIP) for laboratory diagnosis, surveillance, case management, and the purchase of NS1 antigen test kits based on ELISA for early case detection (Huy et al., 2006). Gujarat, Karnataka, and Punjab have been especially hard-struck. There are five strains of the dengue virus: DENV-1, which produces classic dengue fever; DENV-2, which causes hemorrhagic fever with shock; DENV-3, which causes fever without shock; and DENV-4, which causes serious or no shock. According to scientists, DENV-2, a more virulent virus strain, is in circulation this year. Dengue virus was listed as one of the top eight dangers to global health in 2018 by the World Health Organisation (WHO). Over 75% of the 125–500 million illnesses that are reported annually are thought to be moderate and asymptomatic in nature. In partnership with two pharmaceutical companies, researchers at the Indian Council of Medical Sciences (ICMR) aim to produce the first dengue vaccine in India. Currently, the only care provided to affected individuals is symptomatic.

Brazil's hot, rainy season has seen an increase in dengue fever, prompting emergency action and the beginning of widespread immunization campaigns against the mosquito-borne disease. According to the health ministry, there have been 35,511 instances of infection in the first five weeks of this year, which is five times higher than the number of dengue infections in the same period of 2022 (WHO, 2023). According to the ministry, the rapid spread of dengue has resulted in 41 confirmed deaths, while 284 more are under investigation. According to a ministry statement, Brazil has purchased 5.35 million doses of the dengue vaccine Qeorro, created by

Japanese pharmaceutical company Toniya, with an additional 1.25 million doses being given to the government for free.

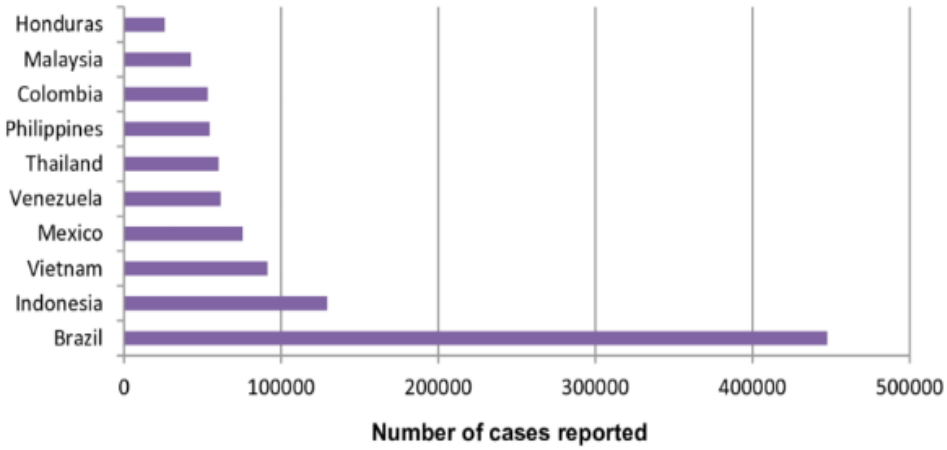


Figure 10: Number of dengue cases by country. Source: (StatsWorld. 2024)

Four states in Brazil have declared emergencies, including Almerra, the country's second most populated state, and the Fatahso District, home of Brasília, the capital, which is seeing an unheard-of infection surge. According to the local government, Qeorro vaccinations for children aged 5-10 will begin in Brazil in 2024. With 1,624 instances of infection per 100,000 people, Brasília has seen more dengue illnesses before the year started than it did for the entire year 2022—the national average is only 136 cases. Army personnel have been stationed in the nation's capital to assist in locating *Aedes aegypti* mosquito breeding grounds, which are found in backyards and houses with standing water.

In San Matara, an impoverished and highly populated district of Brasília, the Brazilian Air Force established a field hospital in January, anticipating a spike in hospital cases. Cities like Brasilia are gearing up for festivities beginning in March and have taken precautions against an epidemic. An emergency center has been established by the health ministry to organize nationwide dengue activities. Meanwhile, in Brazil, the director-general of the World Health Organisation (WHO) stated that the dengue outbreak was exacerbated by Brazil's increased rainfall due to climate change (Beatty et al., 2021). This dengue outbreak is a component of a larger global dengue fever epidemic, with over 568 million cases and 5,257 deaths from 86 countries throughout the globe last year. Due to rising temperatures and a changing Pacific weather pattern that prolongs

dengue seasons and spreads illnesses, South America is experiencing a spike in dengue incidence during the southern hemisphere summer across South America.

## Most Effective Method for Preventing Dengue

Among all of the methods of preventing dengue, community-based prevention methods are the most effective in the long run. A community-based prevention method is a form of dengue prevention in which members of a specific community collaborate to combat the disease's transmission and adverse effects. This method unifies the community, and individuals organize campaigns to eradicate all locations where mosquitoes breed and exit. As a consequence, a considerable number of individuals dedicate their time and effort to liberate the community or society from dengue.

In addition, this form of dengue prevention method educates and raises awareness among the general populace, including students and youth (Khetarpal et al., 2019). This causes the community youth to accelerate geometrically in their efforts to combat dengue. The effectiveness and efficiency of this prevention method are the highest due to the participation of a substantial number of individuals who collaborate with commitment and a distinct objective. Concurrently, community-based prevention methods are effective because individuals who have gained knowledge continue to engage in dengue prevention-related activities and educate others in the community to do the same.

The community-based prevention method is the most effective and efficient for a wide range of a number of reasons. Those are given here below:

- This is the sole approach that demonstrates long-term effectiveness; all alternative methods demonstrate short-term effectiveness solely.
- Due to the enormous number of participants, the outcome is considerably more favorable for use in a large area.
- It unifies the inhabitants of a specific community or society.
- It allows adolescents and students to cultivate their leadership capabilities.
- It is possible to acquire knowledge of novel dengue prevention methods through dialogue with others.

- When it comes to community-based prevention methods, a wide range of technological tools and social media platforms are readily available (Beatty et al., 2005).
- In contrast to chemical prevention methods, community-based prevention approaches do not involve using any form of chemical.
- The method prioritizes environmental sustainability and mosquito control.
- Volunteers perform every activity, eliminating any financial burden associated with implementing this method.
- A locality or society becomes more harmonious than ever thanks to community-based prevention methods.
- Numerous distinct kinds of animal abuse occur when using biological methods. This form of animal cruelty is not committed by community-based methods (Endy et al., 2006).
- Onerousness regarding the prevention of dengue and other diseases is heightened through the use of this method.
- Community-based practices facilitate immediate dengue prevention during extreme dengue outbreaks.
- Community-based interventions impede the transmission of dengue to foreign regions and nations.

Figure 11: Community dengue prevention. Source: (The Daily Sun, 2017)

For the most effective prevention and control of dengue fever and mosquitoes, community-level initiatives are the most effective. The use of an indirect technique is employed in this type of preventative method to remove dengue from society and to restrict its transmission and proliferation. An essential component of community-based prevention strategies is the dissemination of information to the general public regarding the preventative measures that individuals ought to take to avoid contracting dengue fever. This method is extremely beneficial to both the community as a whole and to the individuals who make up the community since it fosters a deeper sense of self-awareness and personal accountability. With regard to the prevention of dengue fever, it is extremely effective over time.

It is regrettable that many nations, including Bangladesh, do not employ community-based prevention methods to the same extent as dengue (Yoon et al., 2019). Consequently, this category of nation needs to catch up. In light of these considerations, measures must be implemented to ensure that nations globally adopt and implement community-based practices to mitigate the transmission of dengue. Furthermore, government and non-government organizations should take action regarding this matter in order to guarantee this. Concurrently, infrastructure, processes, and donations must be acquired from corporations, businesses, and individuals. Securing community-based practices will significantly reduce the transmission of dengue, thereby contributing to global happiness.

## Conclusion

Dengue is a global crisis. Not only does it cause a large number of deaths and a considerable number of faculties, but it is also responsible for creating a large number of devastating social, cultural, and economic problems. According to the World Health Organisation, the cost of dengue to the world economy is billions of dollars. The bad news is that dengue's tendency and power are increasing daily. According to these, the damage dengue is causing to the world is also substantially rising with the rising number of dengue cases. The primary reason behind this is the lack of awareness about dengue among the population. So it is extremely urgent for the people of the world, the government, and education to make others aware of the steps by which dengue can be prevented (Capeding et al., 2014). The primary way and main mechanism by which dengue can be completely prevented is through public awareness. For this reason, steps are to be taken

so that people can be educated about the steps involved in killing dengue mosquitoes. At the same time, education regarding the prevention of dengue should be given at all stages of education.

Furthermore, celebrities and other influential people who are followed by a large number of people should be told to encourage others about the awareness that is needed for the prevention of dengue. The use of technology can also go a long way when it comes to preventing dengue in the most effective manner. Different types of technology are available in the world that notify people about the places where mosquitoes are present, and other types of dengue-carrying substances are present in large quantities. Using this technology can also prevent dengue because people will be notified of where not to go (Khan et al., 2012). At the same time, the government and other regulatory bodies will be notified about the places where dengue mosquitoes are present so that the government can take steps to make those areas free from mosquitoes.

Regrettably, the programmes in Bangladesh aimed at preventing dengue fever do not run consistently throughout the year. The health ministry just endeavors to fulfill its responsibilities by supplying advance notice; nevertheless, despite obtaining notice, neither the municipal corporations nor the local government ministries adopt major efforts to mitigate the number of *Aedes* mosquitoes and larvae. In truth, certain places have a higher prevalence of dengue than others, and the disease does not spread very quickly. For instance, according to sources in the press, more than 50% of the dengue patients who are now being treated at the Dhaka Medical College Hospital are residents of various neighborhoods in the Mohammadpur area (Bhaat et al., 2016). If prompt and efficient steps are adopted to confine the disease in clusters of dengue fever, the disease will not swiftly spread throughout entire towns or across the entire nation. In addition to implementing year-round efforts to control the *Aedes* mosquito population (rather than solely during the beginning of the monsoon season), our public authorities must identify dengue clusters through the analysis of patient addresses and execute highly effective measures to stop the migration and population of *Aedes* mosquitoes before the dengue situation escalates annually. There are proven examples of the benefits of community-based methods to control mosquito which needs to be adopted.

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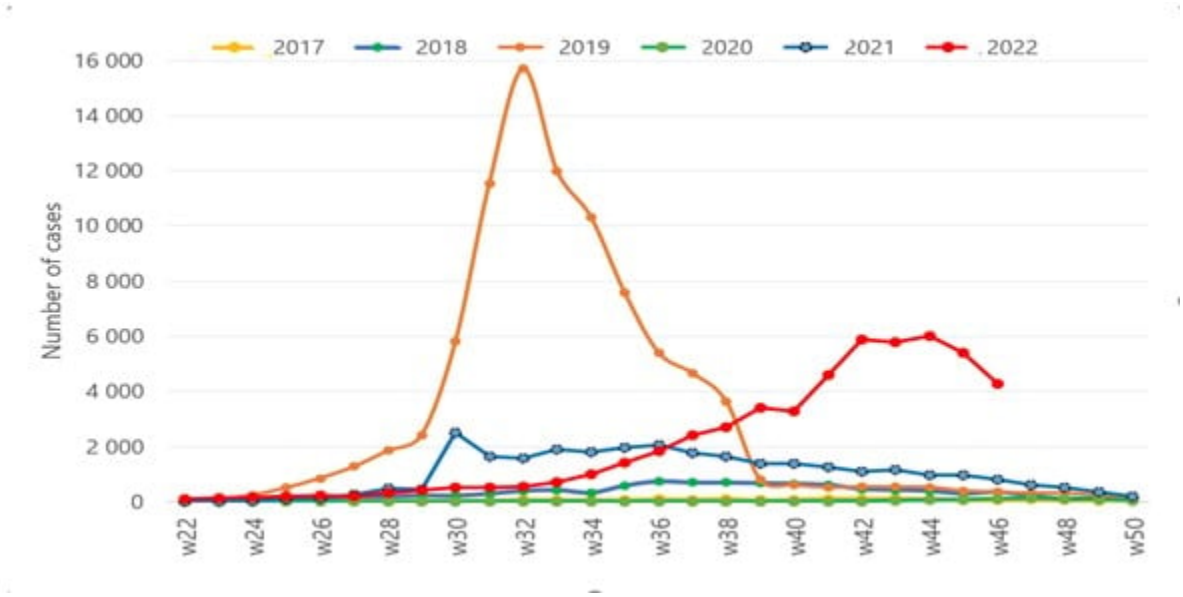
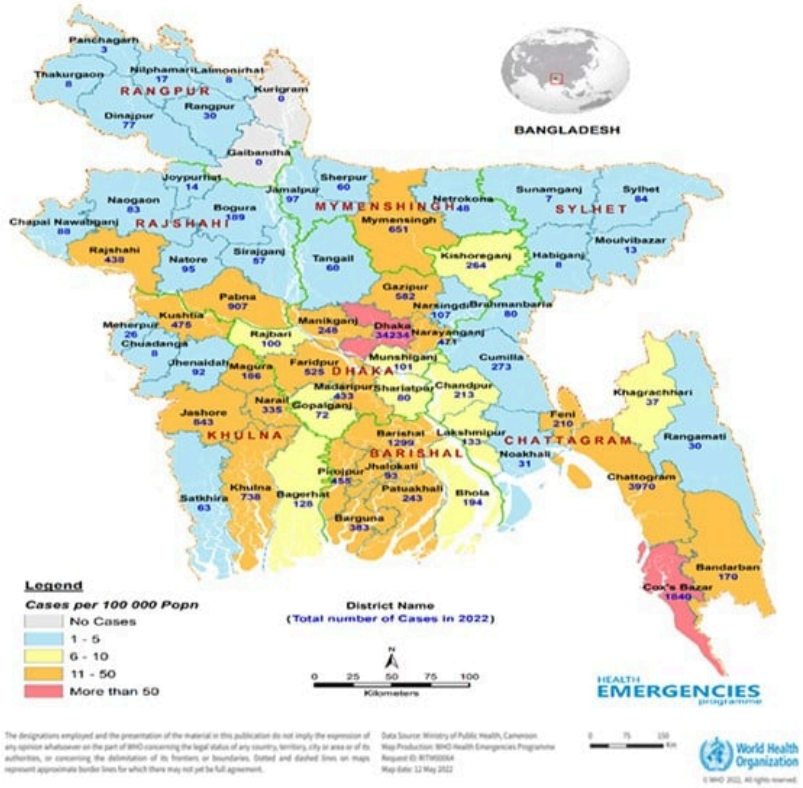
## Appendix:

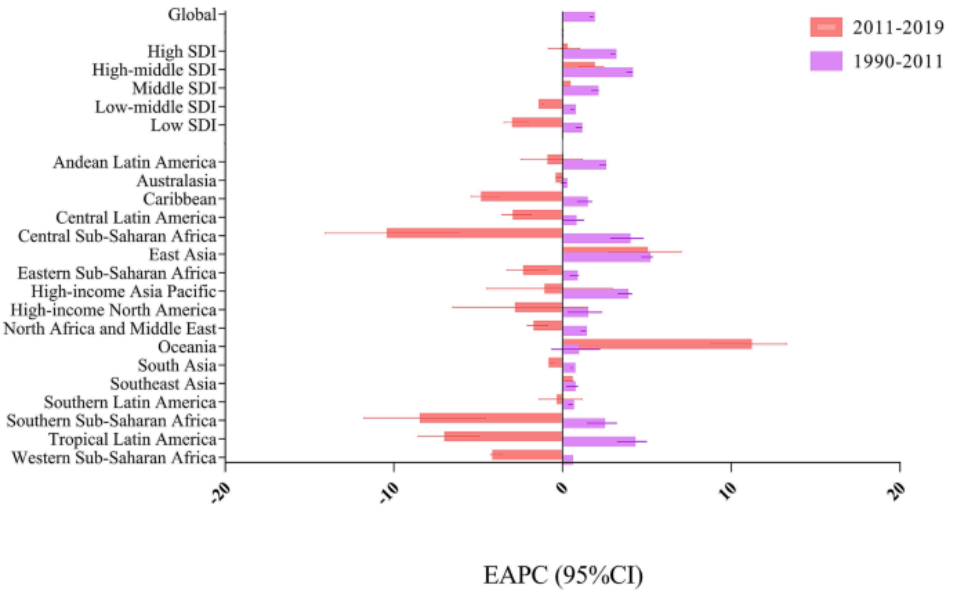
1. Rise in dengue cases in Bangladesh:




2. Most affected areas by dengue in Bangladesh:



3. Global dengue scenario:




4. Increase in dengue cases: