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Review

Vector borne viral diseases: An emerging threat and their control strategies in Bangladesh perspectives

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ABSTRACT

Of the vector-borne viral diseases (VBVDs), dengue and chikungunya viral fever appearing almost every year since last two decades but recent report indicates that Japanese encephalitis, West Nile and Zika viral fever has also entered into Bangladesh as these diseases are endemic in India, Myanmar and other South-East Asia countries. Bangladesh have the experiences of several outbreak of dengue (first report in the year 1964 then from 2000 till 2019), chikungunya viral fever (first report in the year 2008 and then from 2014 to 2017), JE (reported once in 1977), Zika (reported once in 2015) and WN (reported first time in 2019) from different region of the country. Different species of vector mosquitoes, *Aedes* and *Culex* spps and their population are very high during pre-monsoon and monsoon seasons in this country. As vector control strategies are very poor (killing of adult mosquitoes by fogging and spraying during outbreak seasons only); so they are very active from dawn to dusk and are responsible for frequent outbreak of dengue and chikungunya every year. Proposed strategies could easily be adapted to reduce prevalence of most of the VBVDs by screening of travelers during in and out from Bangladesh through rapid screening kit tests, social mobilization, behavioral changes, community engagement, vectors control by adapting modern techniques like, predators, parasitoids, pathogens, Classical Sterile Insect Technique (CSIT), genetically modified mosquito (GMS), Gamma Irradiated sterile mosquito (GISM), Oil drip, predator fish culture to kill larva and also using available effective vaccines against important VBVDs before facing serious catastrophe. This review considers existing and proposed strategies for vector and disease control as well as discussing some of the novel approaches how to improve worsening of public health issue against most of the VBVDs and their endemicity in Bangladesh.

Keywords: Vector-borne viral diseases, Dengue, Chikungunya, JE, WN, Zika, CIST, GMS, GISM.

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INTRODUCTION

Vector-borne viral diseases are those which are transmitted to humans and other animals by blood-feeding arthropods, such as mosquitoes, ticks, and fleas (WHO, 2017). Most common vector-borne viral diseases for human include Dengue fever (DF), Chikungunya viral fever (CHIKVF), Japanese encephalitis (JE), West Nile viral fever (WN), Zika viral fever (ZIKVF), Yellow fever (YF), Ross river disease (RRD) and Burma forest disease (BFD) are transmitted by different species of mosquitoes vectors (Gubler, 2009). Dengue viral fever is a mosquito-borne tropical and sub-tropical viral disease of human caused by the five sero-types (DENV-1, 2, 3, 4 & 5) of positive sense, single stranded RNA virus of the family *Flaviviridae* (Kularatne, 2015; Mustafa et al., 2015; WHO, 2016). The new sero-type (DENV-5) is still considered as a sylvatic strain of dengue viruses. Dengue is spread by several species of female mosquitoes of the genus *Aedes* type (principally by *Aedes aegypti* and *Aedes albopictus*). Symptoms typically begin three to fourteen days after bitten by

infected female *Aedes* mosquitoe (Kularatne, 2015) during dawn and dusk. Symptoms of dengue viral fever may include a high fever, headache, vomiting, muscle and joint pain and a characteristic skin rash. It takes generally ten days to two weeks to recover from the disease completely (WHO, 2016). Chikungunya viral fever (CHIKVF) is an infection caused by the CHIK virus, a single stranded positive sense envelope RNA virus of the family *Togaviridae* (WHO, 2016). The virus is spread among people by two types of mosquitos, *Aedes albopictus* and *Aedes aegypti* (WHO, 2016). In Bangladesh, there were three outbreak of CHIK viral fever in the year 2008, 2011 and 2017 (Islam et al., 2017). Japanese encephalitis is a type of infectious encephalitis caused by Japanese encephalitis virus (JEV) also a member of the family *Flaviviridae* (Lobigs and Diamond, 2012). The virus is found in pigs and birds and is transmitted by *Culex* spps. of mosquitoes which breed in water pools and flooded rice fields; they bite mainly during the night or just after sunset. The virus cannot be transmitted directly from person-to-person (WHO, 2015). West Nile fever is an infection caused by the West Nile virus is also a member of the family *Flaviviridae* (WHO, 2011) which is spread by the bite of the mosquitoes of the *Culex* spps (Hayes et al., 2005). Around 80% of the people those who have bitten by the mosquitoes develop mild symptoms and only 20% of people develop high fever, headache, vomiting, or a rash on the other hand less than 1% people develop encephalitis or meningitis associated with the neck stiffness, confusion, or seizures (CDC, 2017). Zika viral fever (ZIKVF) is a disease caused by the virus of the family *Flaviviridae*. It is spread by *Aedes* mosquitoes (*A. aegypti* and *A. albopictus*). As the mosquitos are very active at day time so they bite people during dawn and dusk. The infection, known as Zika fever or Zika virus disease, often causes no or only mild symptoms, similar to a very mild form of classical dengue fever (Malone et al., 2016; Mehrjardi, 2017). Zika can spread from a pregnant woman to her baby. This can result in microcephaly, severe brain malformations, and other birth defects (CDC, 2016). Zika infections in adults may result rarely in Guillain–Barré syndrome (WHO, 2016). Blood feeding infected mosquitoes of different species are serving as primary vectors for the transmission of Dengue viral fever, West Nile viral fever, Japanese encephalitis and Zika viruses of the family *Flaviviridae* and on the other hand Chikungunya viral fever are transmitted by the viruses of the family *Togaviridae* (Gubler, 2009). Although most of the vector-borne viral diseases of the family *Flaviviridae* of human has been originated from Africa but now a days many of them has spread almost 128 countries of the world. Around 4 billion people of the world and around 400 million people of Asia are in serious threat of dengue viral fever only (WHO, 2017).There are more than 350 different species of vector mosquitoes in the world. Mosquitoes (alternate spelling *mosquitos*) are a group of about 3,500 species of small insects that are flies (order-*Diptera*). Within *Diptera* they constitute the family *Culicidae* (from the Latin *culex* meaning "gnat"). The word "mosquito" (formed by *mosca* and diminutive *–ito*) is Spanish for "little fly" (Brown, 1993). Mosquitoes have a slender segmented body, one pair of wings, three pairs of long hair-like legs, feathery antennae, and elongated mouthparts. Of the world total species of mosquitoes around 123 species had been recorded in Bangladesh too and the most common species are *Aedes, Anopheles* and *Culex* (Irish et al., 2016) (Figure 1).

The mosquito's life cycle consists of egg, larva, pupa, and adult stages. Adult female *Aedes and Culex* spp of mosquitoes laid their eggs on the stagnant and clear water surface. The eggs are then hatch out as motile larvae that feed on aquatic algae and organic material. The adult female mosquitoes feed on blood, which contains protein, glucose and iron and are the essential sources of energy to produce eggs. Thousands of mosquito species feed on the blood of various vertebrates-hosts, including mammals, birds, reptiles, amphibians, and some fishes. During blood sucking time most species of mosquitos need to transfer their saliva on the biting site and produces an itchy rash on and around the skin of the individual (Michigan Mosquito Control Organization, 2013). Like this, many species of mosquitoes initially ingest live and virulent viral pathogens from the acute phase patients suffering from any type of vector-borne viral diseases and act either as mechanical or amplifying vectors to transfer the active pathogens from infected to the healthy hosts. In this way, mosquitoes are acting as an important vectors for many viral diseases such as dengue viral fever, chikungunya, Japanese encephalitis, West Nile, Zika, Yellow fever, Rose-river , Burma forest and other important human arboviruses (Gubler, 2009). Through transmitting arboviruses, mosquitoes are responsible for causing deaths more than 700,000 human patient every year globally (BBC, 2016; Wineguard, 2019). More than two serotypes of a either Flaviviridae/Togaviridae or single serotype of vector borne viruses of both the families or multiple serotypes of dengue viruses with chikungunya or dengue-chikungunya-zika viruses can co-circulate simultaneously in a country (Shrivastava et al., 2018; Hisamuddin et al., 2018; Rahman et al., 2019; Rahim et al., 2019; Rico-Mendoza et al., 2019). Because of the spacio-temporal relationship between the dengue and chikungynya viruses their co-existence and concurrent outbreak are very likely for Bangladesh.

METHODOLOGY

Global standard methods of controlling vector mosquitoes and VBVDs

Control strategies of the vector-borne viral diseases are mainly two types, one focused on vector control strategies and another on disease control strategies.

Figure 1. Map of Bangladesh showing distribution of *Aedes, Culex* and *Anopheles* spp. of mosquitoes (the vector mosquitoes are distributed all over Bangladesh).

Mosquito vector control strategies

The aim of vector control strategies is to prevent transmission of arbo-viruses through mosquito vectors and to interrupt human-vector contact. A number of strategies have been developed in several endemic countries of the world. Those strategies have been proven as highly effective means in various situations in many countries of the world. Although each of those methods has been found to control dengue and other vector-borne diseases to a certain extent, in order to eradicate vector-borne viral diseases transmission cycle completely, it is important to envisage the control programme in the way which must integrate a combination of appropriate measures (Malavige et al., 2004).

Integrated vector management approach

Integrated vector management approach (IVMA) is a rational decision-making process for the optimal use of resources for vector control (WHO, 2012). This approach was first promoted in 2004 by the WHO with the aim of making vector control more efficiently, cost-effectively, ecologically sound and sustainable. According to the WHO, planning and implementation of vector control involves analyzing the local determinants of disease, assessing requirements and resources, and designing locally appropriate implementation strategies at a national level (WHO, 2012). The five key elements of an IVMA are: i) advocacy, social mobilization and legislation; ii) collaboration within the health sector and with other sectors; iii) an integrated approach; iv) evidence-based decision making; and v) capacity building (Chanda et al., 2013). Effective dengue and other vector-borne disease control activities require collaboration between agencies involved in strategic planning, project development and operational management, and their productive partnership with other stakeholders in promoting a community-based control programme (Chang et al., 2011).

Environmental management approach

Environmental management seeks to change the environment in order to prevent or minimize vector propagation and human contact with the vector-pathogen by altering, removing, destroying or recycling non-essential containers that provide larval habitats of *Aedes, Culex* and other species of mosquitoes. Such actions should be in the mainstay of viral vector control. Environmental managements are of three types:

- Environmental modification – to reduce vector larval habitats a long-lasting physical transformation may be required such as installation of a reliable piped water supply to the communities and including household connections.
- Environmental manipulation – temporary changes to vector habitats involving frequent emptying and cleaning

water-storage vessels, flower vases, air conditioners, cleaning of gutters, storing tires, recycling or proper disposal of discarded containers and tires.
- Changes to human habitation or behavior to reduce human-vector contact, such as installing mosquito proof wire net on the windows, doors and other entry points and using mosquito nets while sleeping during day and night time.

Improvement of water supply and water-storage systems

Improving water supplies is a fundamental method of controlling *Aedes* vectors, especially *Aedes aegypti*. However, potable water must be supplied reliably so that water-storage containers that serve as larval habitats such as drums, overhead or ground tanks and concrete jars are not necessary. Traditional water storage practices may also persist even when reliable supplies are available.

Water-storage containers can be designed in such a way which prevents access of female mosquitoes for oviposition. Containers can be fitted with tight lids or if rain-filled, tightly-fitted mesh screens which can allow rainwater to be harvested from roofs while keeping mosquitoes out. Expanded polystyrene beads used on the surface of water to provide a physical barrier that inhibits oviposition in storage containers from which water is drawn from below via a pipe and from which there is no risk of overflow.

Solid waste management approach

In the context of dengue and other important VBVDs vector control, “solid waste” refers mainly to non-biodegradable items of household, community and industrial waste. The benefits of reducing the amount of solid waste in urban environments extend beyond those of vector control and applying many of the basic principles can contribute substantially of reducing the availability of *Aedes, Culex* and other mosquitos’ larval habitats.

Street cleansing approach

A reliable and regular street cleansing system that removes discarded water-bearing containers and cleaning of drains to ensure that water do not become stagnant and help breeding mosquitoes particularly *Aedes aegypti* and *Culex* spp.

Building structures

During planning and construction of buildings and other infrastructure, including urban renewal schemes and through legislation and regulation, opportunities arise to modify or reduce potential larval habitats of urban disease transmitting vectors, including *Aedes aegypti and Culex* spp.

Chemical method for the control of mosquito vectors

Adulticides

Methods of chemical control that target adult vectors are intended to impact on mosquito densities, longevity and other transmission parameters. Adulticides are used in the wide areas by fogging and spraying.

Insecticides for adult mosquitoes

The insecticides that have been deployed worldwide include organophosphates (e.g. fenitrothion, fenthione malathione) and pyrethroids (e.g. cypermethrin, deltamethrin, permethrin) (Robert et al., 1997). Long lasting insecticidal nets (LLINs) are being used as a cost effective and sustainable method for protection against VBVDs.

Larvicides

Larviciding should be considered as complementary to environmental management and except in emergencies. The difficulty of accessing indoor larval habitats of *A. aegypti* (e.g. water-storage containers, plant vases, saucers) to apply larvicides is a major limitation in many urban contexts. As *A. aegypti* often deposits eggs in water-storage containers, the larvicides should have low toxicity to other host and should not significantly change the taste, odour or colour of the water. The International Programme on Chemical Safety (IPCS) has assessed the toxicity of the active ingredients methoprene, pyriproxyfen and temephos and those in *Bacillus thuringiensis serovar israelensis* (Bti) to determine their safety for use as mosquito larvicides in drinking-water at the dosages that are effective against *Aedes* larvae.

Oil drip method

An oil drip can or oil drip barrel (Kerosene and Diesel) is considered as a common and nontoxic anti-mosquito measure. The thin layer of oil on top of the water prevents mosquito breeding in two ways, mosquito larvae in the water cannot penetrate the oil film with their breathing tube so they die easily and the adult mosquitoes do not lay eggs on the oiled water (Le Prince, 1915).

Biological control methods

Biological control measures exploit the innate behavior of a living creature in order to limit the population size of a targeted vector species of mosquitoes. Such natural enemies of the important vector mosquitoes include predators, parasitoids and pathogens (Sarwar, 2015).

Predators–feed on mosquitoes, e.g. dragonflies and damselflies, frogs, toads and their tadpoles, birds (notably swallows, martins and swifts, ducks and other waterfowl), fish (including tilapia, goldfish, guppies, bass, bluegill and catfish). The most effective fish predator for mosquito larvae is *Gambusia affinis* (commonly called the 'mosquito fish') (Sarwar, 2015).

Parasitoids–are the organisms that live like a juvenile stage of larva of a parasite inside the host mosquito before destroying them. A prime example is the protozoan *Ascogregarina culicis*, a parasite of *A. aegypti* larvae, that adversely affects the mosquito population (Sarwar, 2015). Another bacterial parasite, *Wolbachia pipientis*, has been demonstrated to reduce the life span of *A. aegypti* under laboratory conditions (McMeniman et al., 2009).

Pathogens of mosquitoes include viruses, bacteria, fungi and protozoa. Infection of mosquitoes with these pathogens decreases their rates of growth and feeding on humans, checks their reproduction, and even kill or seriously disable them (Sarwar, 2015). Examples of such pathogens include: spores of entomopathogenic fungi (such as *Beauveria bassiana* and *Metarhizium anisopliae*), which affect larval and adult stages of mosquitoes (Scholte et al., 2004); Csp_P, a bacterium of the genus *Chromobacterium* that resides in the mosquito midgut and helping reducing the survivability of both the larvae and adults (Ramirez et al., 2014); and the bacteria *Bacillus thuringiensis israelensis* H-14 (Bti) another potential mosquito larvicide that is commercially available under a number of trade names (WHO, 1997).

Classical sterile insect technique (SIT)

The sterile insect technique (SIT) is based on the release of sterilized male insects, traditionally by means of irradiation, to suppress vector mosquito populations. SIT induces random lethal dominant mutations in the germ cells, which acts on the eggs in the female to prevent fertilization (Proverbs, 1969). The concept is that sterile males will mate with wild females without producing any offspring of Aedes mosquitoes.

Release of insects with dominant lethality (RIDL)

The technological advancement of emerging vector control tools for large scale deployment and to long-lasting effect progresses continuously. The RNAi-based release of insects carrying a dominant lethality (RIDL) system for mass rearing of male mosquitoes has been developed, a technique which involves injection of a lethal gene into mosquito eggs (Alphey et al., 2008). Integration of the lethal gene into the mosquito genome leads to formation of many toxic metabolites in the larva, causing either its death or sterility. Another pioneering study reported the ωMelPop-CLA strain of *Wolbachia* as an effective agent for preventing dengue transmission by causing cytoplasmic incompatibility, reducing the life span of *A. aegypti* and in so doing interfering with viral transmission (Yeap et al., 2011). Only older mosquitoes transmit the dengue virus, so this is predicted to reduce transmission. Over just a few generations, the bacterium is able to spread, infected mosquitoes replace the wild population and reduce their reproductive capability.

Sterilizing mosquitoes with gamma rays

A strategy of mosquito control by zapping millions of male mosquitoes with gamma rays to sterilize them and stop the spread of the virus linked to thousands of birth defects. Recently, Brazil is scrambling to eradicate the *Aedes* mosquito that has caused an epidemic of dengue and more recently an outbreak of Zika, a virus associated with an alarming surge in cases of babies born with abnormally small heads (Reuters, 2016). The sterile males can be released into the target areas to mate with wild females who will lay sterile eggs that produce no offspring. The sterile insect technique using small doses of radiation was found the safest way to fight the mosquito because nothing toxic gets released into the environment. It was found more cost-effective than using transgenic mosquitoes (Reuters, 2016).

RESULTS

Vector-borne viral diseases in Bangladesh

Bangladesh is one of the sub-tropical countries in the world and is located in the South Asia, bordered on the north, east and west by India, southeast by Myanmar and south by Bay of Bengal. Dengue infection in Bangladesh was first detected when a febrile illness called "Dacca Fever" occurred in the capital (now Dhaka) during the late summer of 1964 (Sharmin et al., 2015). The number of dengue patients identified across Bangladesh in the year 2019 so far was nearly double of the total diagnosed mosquito-borne disease recorded in the past 19 years. Between 2000 and 2019, around 131,723 dengue patients were identified in the country. Between 2000 and 2019, case fatality rate of dengue fever was recorded as 9.29% across the country (Table1).

The CHIKVF was first reported in Bangladesh in the year 2008 (ICDDRB, 2009; Islam et al., 2017).

Table 1. Year wise outbreak report on dengue from 2000 to 2019 in Bangladesh.

Year	Cases	Death	CFR%	Maximum temperature	Humidity	Rainfall (mm)
2000	5551	93	1.6	30.2	80	2571
2001	2430	44	1.81	30.7	80	2460
2002	6132	58	0.95	30.3	80	2611
2003	486	10	2.05	30.2	80	2285
2004	3934	13	0.33	30.3	80	2690
2005	1048	4	0.38	30.6	80	2506
2006	2200	11	0.5	31.8	80	2127
2007	466	0	0	30.4	80	2746
2008	1153	0	0	30.3	81	2397
2009	474	0	0	31.3	79	2232
2010	409	0	0	31.2	79	2154
2011	1362	6	0.44	30.5	80	2495
2012	671	1	0.1	31.2	79	2303
2013	1749	2	0.11	36.3	81	2449
2014	375	0	0	38.1	83	2456
2015	3162	6	0.18	34.5	82	2529
2016	6060	14	0.23	37.2	78	2503
2017	2766	8	0.28	36.1	79	2522
2018	6040	15	0.24	34.9	76	2613
2019	85255	81	0.09	34.7	82	2590

CFR = Case fatality rate.

Subsequently the disease re-emerged in the year 2011 and 2017 in a fulminating form at Dhaka city and other parts of Bangladesh. Only in the year 2017 the number of chikungunya affected patients in and around Dhaka city of Bangladesh during outbreak was 18,000,000. Between the year 2008 and 2019, total number of chikungunya affected patients identified in the country were around 18,000,235 (Table 2). Zika virus affected single patient of 65 years old was detected in the year 2015 in Bangladesh (Muraduzzaman et al., 2017). JE was reported for the first time in 1977 in Bangladesh after that the disease has been appearing in the sporadic form all over the country (Hussain et al., 2004).

In Bangladesh, a single case of WN fever has been reported by ICDDR, B Dhaka in the year 2019 (Table 3) (reported by the daily Prothom Alo of 25th September 2019, Bangladesh).

Currently practicing methods of controlling adult mosquitoes in Bangladesh

The indoor methods of controlling adult mosquitoes are using mosquito net, aerosol, goodnight, mosquito bat, mosquito coil, mosquito repellant in Bangladesh. For outdoor methods of controlling adult mosquitoes are fogging and spraying in and around Dhaka and other cities of Bangladesh during outbreak season only particularly in the monsoon.

DISCUSSION

All the neighboring countries reported different clinical form of dengue viral fever (DF, DHF and DSS), CHIKVF, ZIKVF, JE and WN before they appears in the form of epidemic, endemic and sporadic diseases in Bangladesh. As Bangladeshi economy is growing up and the status of the country has been upgraded from LDC to developing countries by developing friendship with many countries of Asia, Europe, America and Africa through trade, academic and technology exchanges many new diseases are also introducing in this country since past two decades. Meanwhile people of both the urban and rural areas of this country have the experiences of several kinds of vector-borne viral diseases like dengue viral fever, chikungunya viral fever, Japanese encephalitis, Zika viral fever and West Nile viral fever since past two decades. Among the neighboring countries DF had been detected in the year 1946 in India (Karamchandani, 1946). In Myanmar, DF appeared for the first time in 1970 (Thu et al., 2004).

The disease chikungunya first recorded of in the form of outbreak at Kolkata in the year 1963 and re-emerges subsequently in the year, 1964, 1975 and 2005 (Yergolkar et al., 2006; Chhabra et al., 2008), and also appeared subsequently in Thailand in 1958, Sri Lanka in 1969, Vietnam in 1975 and Myanmar in 1975. Whereas Zika virus has been reported at Ahmedabad, Gujarat, Krishnagiri, Tamilnadu, Jaypur of India 2017 (WHO, 2017)

Table 2. Year wise outbreak report on Chikungunya from 2008 to 2019 in Bangladesh.

Year	Cases	Death	CFR%	Maximum temperature	Humidity	Rainfall (mm)
2008	39	-	-	30.3	81	2397
2009	-	-	-	31.3	79	2232
2010	-	-	-	31.2	79	2154
2011	196	-	-	30.5	80	2495
2012	-	-	-	31.2	79	2303
2013	-	-	-	36.3	81	2449
2014	-	-	-	38.1	83	2456
2015	-	-	-	34.5	82	2529
2016	-	-	-	37.2	78	2503
2017	18,000,000	-	-	36.1	79	2522
2018	-	-	-	34.9	76	2613
2019	-	-	-	34.7	82	2590

CFR = Case fatality rate.

Table 3. Reporting and outbreak status of important vector-borne viral diseases (VBVDs) in Bangladesh.

Vector-borne viral diseases	Vectors	Reporting and outbreak status
Dengue Fever	*Aedes aegypti* and *Aedes albopictus*	First case reported in 1964 Massive outbreak reported in 2000, 2019
Chikungunya Viral fever	*Aedes aegypti* and *Aedes albopictus*	First case reported in 2008 Massive outbreak reported in 2017
Zika Viral disease	*Aedes aegypti* and *Aedes albopictus*	First case reported in 2015
Japanese Encephalitis	*Culex tritaeniorhynchus*	First case reported in 1977
West Nile viral fever	*Culex pipiens, Culex trasalis* and *Culex quinquefesciatus*	First case reported in 2019

in three people who had no history of travels outside India (DON, 2017). First case of JE was reported in India in 1955 (Webb and Pereira, 1956), JE is an endemic now in India. Serologically confirmed cases of West Nile virus infection were reported from Vellore and Kolar districts of India (National Health Portal of India, 2017).

Though there is no report of Yellow fever, Ross River viral fever and Barmah Forest viral fever in Bangladesh yet but due to the era of globalization a strong trade exchange and human mobilization these three diseases can also enter in this country at any time like the other five vector-borne viral diseases. Yellow fever is a vector-borne viral disease of typically short duration (WHO, 2013). In cities, it is spread primarily by *Aedes aegypti*, a type of mosquito found throughout the tropics and subtropics (WHO, 2013). This is also a virus of the family *Flaviviridae* (Lindenbach et al., 2007). This disease is mostly confined in different countries of African continent. Many Bangladeshi army and NGOs people are working in different countries of Africa under UN peace treaty. A strong possibility of migration of the YF from Africa to Bangladesh through those people. Ross River fever is a mosquito-borne infectious viral disease of human caused by the virus of the family *Togaviridae* (Harley et al., 2001) and the disease is spread by the biting of infected mosquitos of the genus *Aedes* species (Russell and Doggett, 2008). This is an endemic and sporadic disease of Australia, New Zealand and Asia Pacific countries. Many Bangladeshi people are also living in those countries too. As the mosquito vectors are prevalent in this country so the disease can enter into the country at any time. Barmah Forest fever is another vector-borne viral disease caused by a virus of the family *Togaviridae* and the disease is spread by the bite of infected mosquitos of the genus *Aedes* species. This disease was named after the Barmah Forest in the northern Victoria region of Australia where it was first isolated in 1974 (Smith et al., 2011; Cashman, 2008). There is also a high chance of migration of the disease from far Australia and New Zealand to Bangladesh.

Proposed strategies for the control of vector mosquitos for Bangladesh

All the modern techniques that are being practiced

globally such as environmental modification, environmental manipulation, changes to human habitation or behavior, improvement of water supply and water-storage systems, mosquito-proofing of water-storage containers, solid waste management, street cleansing, building structures, chemical control method, insecticides for adult mosquitoes, larvicides, oil drip method, biological control methods, predators, parasitoids, pathogens, Classical Sterile Insect Technique (SIT), release of insects with dominant lethality (RIDL), sterilizing mosquitoes with gamma rays should be introduced in Bangladesh on an urgent basis to inhibit increasing population of adult and larval stages of *Aedes* and other species of mosquitoes who are the potential vector of important vector-borne diseases.

Advice to use mosquito repellent, wear protective clothing, use window screens or insecticide treated bed nets and plug-in insecticide vaporizers where possible within the home. Spatial repellents designed for indoor use (typically plug-in emanation devices containing synthetic pyrethroids such as d-allethrin) should be encouraged for use in rooms where infected people are resident. Infected people should not donate blood until four weeks after complete recovery from VBVDs.

Screening and quarantine methods to stop spreading vector-borne diseases

A dengue affected member in the family increases responsibility of the rest who must ensure the patient remains quarantined for at least 5-7 days so that the disease does not spread. People with less immunity, such as children or elderly are more vulnerable to catching infection. Families of migratory dengue patients as well as those diagnosed with dengue in the city have to ensure infection does not spread to neighbors and natives. Special attention should be given to the airport, land port and seaport through which travellers are entering into the country easily. Traveller's movement should be restricted when primary screening by using NS-1 kit test are positive. Infected people notified should be strongly advised not to travel to the regions where there is the potential for dengue transmission during the period they are likely to be viraemic stage (while they are symptomatic, usually 3-5 days). Infected people in receptive areas should be advised to avoid being bitten by mosquitoes for up to 12 days from onset of illness to avoid passing dengue virus onto mosquitoes, which can facilitate further transmission to humans.

Alternative control strategies of VBVDs for Bangladesh

Vaccination

Dengue viral fever: As of 2019, there is only one clinically available vaccine to prevent dengue fever in humans, CYT-TDV, brand name Dengvaxia. Dengvaxia became commercially available in 2016 in 11 countries: Mexico, the Philippines, Indonesia, Brazil, El Salvador, Costa Rica, Paraguay, Guatemala, Peru, Thailand and Singapore (Reuters, 2016). In Indonesia, it costs about US$207 for the recommended three doses. The value of this vaccine is limited by the fact that it may worsen outcomes in those who have not previously been infected. Several other vaccine candidates are in development including live attenuated, inactivated, DNA and subunit vaccines. Live attenuated vaccine candidates are the furthest along in development (McArthur et al., 2013).

Chikungunya viral fever: Though effective vaccine against chikungunya viral fever is not available yet but as of 2015, a phase 2 trial has been planned using 400 adults of 18 to 60 years old in the Caribbean (Al Idrus et al., 2015). Hope effective vaccine against chikungunya viral fever will appear soon. Even with the vaccine, mosquito population control and bite prevention will be necessary to control chikungunya viral fever in a country (Morens and Fauci, 2014).

Zika virus disease: For Zika virus disease effective vaccine is not available but American scientists are trying day and night to produce effective vaccine against Zika soon. The goal of a Zika virus vaccine is to elicit protective antibodies against the Zika virus to prevent infection and severe disease. Additionally, as dengue virus is closely related to Zika virus, the vaccine needs to minimize the possibility of antibody-dependent enhancement of dengue virus infection globally (Ghaffar et al., 2018).

As different species of mosquito vectors (especially *Aedes* and *Culex* spp) are present all over Bangladesh and getting resistance against commonly used insecticides which have been used to kill the adult mosquitoes only. Meanwhile, five important vector-borne viral diseases (Dengue, CHIKVF, ZIKVD, JE and WNVF) are circulating among the population of Bangladesh; so at any time a serious catastrophe can happen by any of these VBVDs.

CONCLUSIONS

To arrest the upsurge of dengue, chikungunya, zika, JE, WN and other vector-borne viral diseases in Bangladesh, idea must be changed from focusing primarily on patient-centered like curative and medicine-intensive disease management to give priority by improving environmental health and vector habitats management. In Bangladesh, Ministry of Health has implemented only adult vector control strategy over the past two decade as yet there has not been a follow-up survey to assess the relative success of its implementation. It would be worthwhile to

conduct such studies in order to determine the current status of adult vector mosquitoes and their larval habitats and also to identify challenges for implementation in the urban and rural areas of the country. Monitoring and evaluation are integral to every aspect of the programme and critical to its success. As Bangladeshi economy is growing very fast because of increasing trade with VBVDs epidemic and endemic countries of the world; so any time a serious catastrophe can be caused by any member of the VBVDs.

Taking a holistic perspective, for effective management of dengue, chikungunya, zika, Japanese encephalitis and West Nile viral fever and other vector-borne and zoonotic diseases, the coordinated and multidisciplinary efforts of different governmental departments with regard to sanitation, urban development and education are essential. Moreover, local communities must be engaged to take active responsibility for their own protection by supporting elimination of *Aedes* and *Culex* species of mosquitoes and their breeding sites, and take personal measures towards prevention of infection using mosquito repellents as well. To reduce the frequency of outbreak of the important vector-borne viral diseases in Bangladesh, it is important to implement vector control (adult and larva) programme round the year as well as strengthening quarantine and restricted movement of the infected and suspected groups of people (local and foreigner) at different cities and entry/exit points of the country. Despite adapting all the precautionary measures as addressed for majority groups (age and sex) of total population of the country, people should be brought under effective vaccination programme with the vaccines that are available in the world market against the important and deadly VBVDs.

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REFERENCES

Al Idrus A, **2015**. NIAID to bring Chikungunya vaccine into Phase II. Infectious Diseases. http://www.fiercevaccines.com/story/niaid-bring-chikungunya-vaccinephase-ii.

Alphey L, Nimmo D, O'Connell S, Alphey N, **2008**. Insect population suppression using engineered insects. In Transgenesis and the management of vector-borne disease. Springer, New York, NY. pp. 93-103.

BBC, **2016**. Zika virus triggers pregnancy delay calls. https://www.bbc.com/news/world-latin-america-35388842.

Brown L, **1993**. New shorter Oxford English dictionary on historical principles. Clarendon.

Cashman P, Hueston L, Durrheim D, Massey P, Doggett S, Russell RC, **2008**. Barmah Forest virus serology: implications for diagnosis and public health action. Commun Dis Intell Q Rep, 32(2): 263-266.

CDC, **2016**. Symptoms, Diagnosis & Treatment. Zika virus. Centers for Disease Control and Prevention. https://www.cdc.gov/zika/symptoms/index.html (Accessed on March 4, 2016).

CDC, **2017**. West Nile Virus. Centers for Disease Control and Prevention. https://www.cdc.gov/westnile/ index.html (Accessed on October 26, 2017).

Chanda E, Govere JM, Macdonald MB, Lako RL, Haque U, Baba SP, Mnzava A, **2013**. Integrated vector management: a critical strategy for combating vector-borne diseases in South Sudan. Malar J, 12(1): 369.

Chang MS, Christophel EM, Gopinath D, Abdur RM, **2011**. Challenges and future perspective for dengue vector control in the Western Pacific Region. WPSAR, 2: 9.

Chhabra M, Mittal V, Bhattacharya D, Rana UV, Lal S, **2008**. Chikungunya fever: A re-emerging viral infection. Indian J Med Microbiol, 26: 5-12.

DON, **2017**. Zika Virus Infection. Disease Outbreak News, India. http://www.who.int/csr/don/26-may2017-zika-ind/en (Accessed on May 26, 2017).

Ghaffar KA, Ng LF, Renia L, **2018**. Fast tracks and roadblocks for Zika vaccines. Vaccines, 6:77.

Gubler DJ, **2009**. Vector-borne diseases. Revue scientifique et technique, 28: 583.

Harley D, Sleigh A, Ritchie S, **2001**. Ross River virus transmission, infection, and disease: a cross-disciplinary review. Clin Microbiol Rev, 14: 909-932.

Hayes EB, Komar N, Nasci RS, Montgomery SP, O'Leary DR, Campbell GL, **2005**. Epidemiology and transmission dynamics of West Nile virus disease. Emerg Infect Dis, 11: 1167–1173.

Hisamuddin M, Tazeen A, Abdullah M, Islamuddin M, Parveen N, Islam A, Faizan MI, Hamza A, Naqvi, HI, Verma HN, Malik A, Ahmed A , Parveen S, **2018**. Co-circulation of Chikungunya and Dengue viruses in Dengue endemic region of New Delhi, India during 2016. Epidemiol Infect, 146(13): 1642-1653.

Hussain SM, Ekram AS, Hossain MJ, Gurley E, Lubey S, **2004**. Japanese encephalitis: Bangladesh perspective: A review. J Teacher Assoc, 17: 57-70.

ICDDRB, **2009**. First identified outbreak of chikungunya in Bangladesh. Health Sci Bull, 7:1-6.

Irish SR, Al-Amin HM, Alam MS, Harbach RE, **2016**. A review of the mosquito species (Diptera: Culicidae) of Bangladesh. Parasit Vectors, 9: 559.

Islam QT, Amin R, Islam MR, **2017**. Chikungunya - An emerging threat for Bangladesh. Bangladesh J Med, 28: 54-56.

Karamchandani PV, **1946**. Dengue group of fevers in India. Lancet 1946, 247:92-93.

Kularatne SA. Dengue fever. BMJ, 351: h4661.

Le Prince JA, **1915**. Control of Malaria: Oiling as an Antimosquito Measure. Public Health Rep, 26: 599-608.

Lindenbach BD, Thiel HJ, Rice CM, **2007**. Flaviviridae: the viruses and their replication. In: Knipe DM, Howley PM, Griffin DE, Lamb RA, Martin MA, Roizman B, Straus SE, editors. Fields Virology. Philadelphia: Lippincott Williams & Wilkins, pp. 1101–1152.

Lobigs M, **Diamond** MS, **2012**. Feasibility of cross-protective vaccination against flaviviruses of the Japanese encephalitis serocomplex. Expert Rev Vaccines, 11: 177-187.

Malavige GN, Fernando S, Fernando DJ, Seneviratne SL, **2004**. Dengue viral infections. Postgrad Med J, 80: 588-601.

Malone RW, Homan J, Callahan MV, Glasspool-Malone J, Damodaran L, Schneider AD, Zimler R, Talton J, Cobb RR, Ruzic I, Smith-Gagen J, **2016**. Zika virus: medical countermeasure development challenges. PLOS Negl Trop Dis, 10(3): e0004530.

McArthur MA, Sztein MB, Edelman R, **2013**. Dengue vaccines: recent developments, ongoing challenges and current candidates. Expert Rev Vaccines, 12(8): 933-953.

McMeniman CJ, Lane RV, Cass BN, Fong AW, Sidhu M, Wang YF, O'Neill SL, **2009**. Stable introduction of a life-shortening Wolbachia

infection into the mosquito Aedes aegypti. Science, 323(5910): 141-144.
Mehrjardi MZ, **2017**. Is Zika virus an emerging TORCH agent? An invited commentary. Virology, 8:1178122X17708993.
Michigan Mosquito Control Organization (MMCO), **2013**. Mosquitoes of Michigan -Their Biology and Control. https://www.michigan mosquito.org/control.html (Accessed on March 30, 2013).
Morens DM, **Fauci** AS, **2014**. Chikungunya at the door—deja vu all over again? N Engl J Med, 371: 885-887.
Muraduzzaman AK, Sultana S, Shirin T, Khatun S, Islam M, Rahman M, **2017**. Introduction of Zika virus in Bangladesh: an impending public health threat. Asian Pac J Trop Med, 10(9):925-928.
Mustafa MS, Rasotgi V, Jain S, Gupta V, **2015**. Discovery of fifth serotype of dengue virus (DENV-5): A new public health dilemma in dengue control. Med J. Armed Forces India, 71(1): 67-70.
National Health Portal (NHP), **2017**. West Nile fever. National Health Portal of India. https://www.nhp.gov.in/disease/communicable-disease/west-nile-fever (Accessed on May 31, 2017).
Proverbs MD, **1969**. Induced sterilization and control of insects. Annu Rev Entomol, 14:81-102.
Rahim MA, Zaman S, Uddin KN **2019**. Chikungunya-Dengue co-infection: Reports of two cases from Bangladesh. J Bang Coll Phys Surg, 37: 86-88.
Rahman M, Rahim R, Hasan A, Murad AS, Biswas M, **2019**. Co-circulation of three dengue virus serotypes in 2017 in Dhaka city: First report from Bangladesh. Biores Comm, 5(1): 637-641.
Ramirez JL, Short SM, Bahia AC, Saraiva RG, Dong Y, Kang S, Tripathi A, Mlambo G, Dimopoulos G, **2014**. Chromobacterium Csp_P reduces malaria and dengue infection in vector mosquitoes and has entomopathogenic and in vitro anti-pathogen activities. PLoS pathogens, 10(10): e1004398.
Reuters, **2016**. Brazil to fight Zika by sterilizing mosquitoes with gamma rays. https://www.thedailystar.net/health/disease/brazil-fight-zika-sterilizing-mosquitoes-gamma-rays-659470 (Accessed on October 8, 2019)
Reuters, 2016. Sanofi's dengue vaccine approved in 11 countries. https://www.reuters.com/article/us-sanofi-vacccine/sanofis-dengue-vaccine-approved-in-11-countries-idUSKCN1240C5 (Accessed on October 8, 2016).
Rico-Mendoza A, Porras-Ramirez A, Chang A, Encinales L, Lynch R, **2019**. Co-circulation of dengue, chikungunya and Zika viruses in Colombia from 2008 to 2018. Pan Am J Pub Health, 43:1- 4.
Robert LL, Perich MJ, Schlein Y, Jacobson RL, Wirtz RA, Lawyer PG, Githure JI, **1997**. Phlebotomine sand fly control using bait-fed adults to carry the larvicide Bacillus sphaericus to the larval habitat. J Am Mosquito Contr, 13(2):140-144.
Russell RC, **Doggett** SL, **2008**. Ross River & Barmah Forest. Department of Medical Entomology, University of Sydney.
Sarwar M, **2015**. Reducing dengue fever through biological control of disease carrier Aedes mosquitoes (Diptera: Culicidae). Int J Prev Med, 1: 161-166.
Scholte EJ, Knols BG, Samson RA, Takken W, **2004**. Entomopathogenic fungi for mosquito control: A review. J Insect Sci, 4(1): 19.
Sharmin S, Viennet E, Glass K, Harley D, **2015**. The emergence of dengue in Bangladesh: epidemiology, challenges and future disease risk. Trans R Soc Trop Med Hyg, 109:619-627.
Shrivastava S, Tiraki D, Diwan A, Lalwani SK, Modak M, Mishra AC, Arankalle VA, **2018**. Co-circulation of all the four dengue virus serotypes and detection of a novel clade of DENV-4 (genotype I) virus in Pune, India during 2016 season. PLoS ONE, 13(2): 1-19.
Smith DW, Speers DJ, Mackenzie JS, **2011**. The viruses of Australia and the risk to tourists. Travel Med Infect Dis, 9: 113-125.
Thu HM, Lowry K, Myint TT, Shwe TN, Han AM, Khin KK, Thant KZ, Thein S, Aaskov J, **2004**. Myanmar dengue outbreak associated with displacement of serotypes 2, 3, and 4 by dengue 1. Emerg Infect Dis, 10(4): 593–597.
Webb JK, **Pereira** S, **1956**. Clinical diagnosis of an arthropod borne type of virus encephalitis in children of North Arcot District, Madras State, India. Indian J Med Sci, 10: 573-581.
WHO, **1997**. Dengue haemorrhagic fever: diagnosis, treatment, prevention and control. World Health Organization. 2nd ed. Genava.
WHO, **2011**. World Health Organization. West Nile virus. http://www.euro.who.int/__data/assets/pdf_file/0020/246170/Fact-sheet-West-Nile-virus-Eng.pdf?ua=1 (Accessed on October 28, 2017).
WHO, **2012**. Handbook for Integrated Vector Management. World Health Organization. https://apps.who.int/iris/bitstream/10665/ 44768 /1/9789241502801_eng.pdf?ua=1 (Accessed on September 8, 2016)
WHO, **2013**. Yellow fever Fact sheet N°100. World Health Organization. https://www.who.int/immunization/diseases/yellow_fever/en/ (Accessed on February 23, 2014).
WHO, **2015**. Japanese encephalitis. World Health Organization. https://www.who.int/immunization/monitoringurveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_10_JE_R2.pdf?ua=1 (Accessed on October 29, 2017).
WHO, **2016**. Chikungunya Fact sheet. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/chikungunya (Accessed on September 8, 2016).
WHO, **2016**. Dengue and severe dengue Fact sheet N°117. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue (Accessed on February 3, 2016).
WHO, **2016**. Zika Virus Microcephaly and Guillain–Barré Syndrome Situation Report. World Health Organization. http://apps.who.int/iris/bitstream/10665/204961/1/zikasitrep_7Apr2016_eng.pdf?ua=1 (Accessed on April 8, 2016).
WHO, **2017**. Vector-borne diseases. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases (Accessed on October 31, 2017).
WHO, **2017**. Zika Virus Infection-India. World Health Organization. http://www.who.int/csr/don/26-may-2017-zika-ind/en/ (Accessed on June 16, 2017).
Wineguard D, **2019**. The mosquito: A human history of our deadliest predator. Nature, 572: 310-311.
Yeap HL, Mee P, Walker T, Weeks AR, O'Neill SL, Johnson P, Ritchie SA, Richardson KM, Doig C, Endersby NM, Hoffmann AA, **2011**. Dynamics of the “popcorn” Wolbachia infection in outbred Aedes aegypti informs prospects for mosquito vector control. Genetics, 187(2):583-595.
Yergolkar PN, Tandale BV, Arankalle VA, Sathe PS, AB S, Gandhe SS, Gokhle MD, Jacob GP, Hundekar SL, Mishra AC, **2006**. Chikungunya outbreaks caused by African genotype, India. Emerg Infect Dis, 12(10): 1580-1583.

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