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Factors, Transmission and Control of Dengue Fever and Dengue Haemorrhagic Fever

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Abstract: Dengue fever is a viral infection, which is common throughout the tropical regions of the world. The disease is caused by the day biting mosquito's *Aedes aegypti* and *Aedes albopictus.* Dengue hemorrhagic fever is second more severe form in which bleeding and occasionally shock occur, leading to death. Dengue virus belongs to the family *Flaviviridae* & genus *Flavivirus*. There are a closely related group of viruses, which share the same structure, genome arrangements and protein types. The main factors influencing dengue virus transmission are increased vector density, shorter incubation period in the mosquito, increase movement of mosquito vectors & viruses and increased density of susceptible human hosts. Dengue is transmitted by the bite of an infected female, *Aedes aegypti* mosquito, which has got the dengue virus by taking a blood meal on a person who is ill with dengue. The main dengue control strategies are source reduction, chemical sparing, chemical larviciding, health promotion, law enforcement and biological control. This work is mainly based on the information from secondary sources.

Key words: Dengue, Fever, Mosquito, *Aedes*

INTRODUCTION

Dengue Fever (DF) is a severe, flue-like illness that affects older children and adults but rarely causes death. Dengue Hemorrhage Fever (DHF) is a second more severe form in which bleeding and occasionally shock occur, leading to death; it is most serious in children. [1,13] Dengue fever is a viral infection, which is common throughout the tropical regions of the world. Among the areas most affected recently are Bangladesh, India, Myanmar and Thailand. The Disease is caused by the day-biting mosquitoes *Aedes acgypti* and *Aedes albopictus*. It is estimated that there are between 50 and 100 million cases of dengue fever and about 5,00,000 cases of dengue haemorrhagic fever each year, which require hospitalization. Over the last 10-15 years DF/DHF has become a leading cause of hospitalization and death with a case fatality rate of 0.3% to 5% among children in South-East Asian region.[2,14]

Dengue Virus: Dengue virus belongs to the family *Flaviviridae* and genous *Flavivirus*. They are a closely related group of viruses, which share the same structure, genome arrangements and protein types. The Flavivirus virion is a spherical structure approximately 50 nm in diameter consisting of a single strand, positive sense RNA genome Located inside a nucleocapsid, which is in turn surrounded by a protein and lipid envelope. The virus has four flavors, called serotypes, which are creatively named DEN 1,2,3 and 4. Getting infected with one serotype does not protect anybody against the other serotypes; in fact, getting a second dengue infection, particularly with type 2, leads to an even worse situation.[2,14]

Grading the Severity of Dengue Infection: To decide about where to treat the patient, it is important to classify the severity of dengue infection. The severity of dengue infection is classified into the grades described in Table: 1 below

Dengue Syndrome: The symptomatic manifestations for all practical purpose are overlapping in nature and not differentiable at the beginning. Some time appears progressing from one category to another. So they are grouped into 'Dengue Syndrome'. Dengue syndrome will encompass the following.[5]

- Dengue Fever (DF)
- Dengue Hemorrhagic Fever (DHF)
- Dengue Shock Syndrome (DSS)

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Table 1: Grading the Severity of Dengue Infection.[3,4]

DF/DHF	Grade*	Symptoms	Laboratory
DF		Fever with two or more of the following signs: headache, retro-orbital pain, myalgia, arthralgia.	Leukopenia occasionally. Thrombocytopenia, may be present, no evidence of plasma loss.
DHF	I	Above signs plus positive tourniquet test.	Thrombocytopenia <100,000, Hct rise $\geq$ 20%
DHF	II	Above signs plus spontaneous beeding	Thrombocytopenia <100,000, Hct rise $\geq$ 20%
DHF	III	Above signs plus circulatory failure (weak pulse, hypotensin, restlessness)	Thrombocytopenia <100,000, Hct rise $\geq$ 20%
DHF	IV	Profound shock with undetectable blood pressure and pulse	Thrombocytopenia <100,000, Hct rise $\geq$ 20%

* DHF Grade III and IV are also called as Dengue Shock Syndrome (DSS)

Dengue Fever: Dengue fever is an acute febrile illness of 2-7 days duration sometimes with two peaks having the following manifestations: [12]

- Sudden onset continuous fever.
- Two or more of the following features:
  Severe headache
  Retro-orbital pain
  Severe myalgia/arthralagia/back pain
  Hemorrhagic manifestations
  Nausea/vomiting/abdominal pain
  Leucopenia
- High index of suspicion based on Period, Population and Place,
- Absence of convincing evidence of any other febrile illness

Dengue Hemorrhagic Fever: Dengue Hemorrhagic Fever is a probable manifestation of dengue syndrome with hemorrhagic manifestations having the following features:[5,6]

- Features of dengue fever at initial stage and
- Hemorrhagic manifestations evidenced through one or more of the following.
  Positive tourniquet test
  Petechiae/ecchymosis/purpura
  Mucosal bleeding: Epistaxis, gum bleeding
  Bleeding from injection or other site
  Hematemesis, melena, hematuria, PV bleeding
  Thrombocytopenia with platelets 100,000 / mm^3 or less
- Any evidence of plasma leakage due to increased capillary permeability manifested by one or more of the following :
  A $\geq$20% rise in henatocrit for age or sex.
  A $\geq$20% drop in henatocrit following treatment with fluids as compared to base line.
  Pleural effusion/ ascitis/ hypoproteinemia.

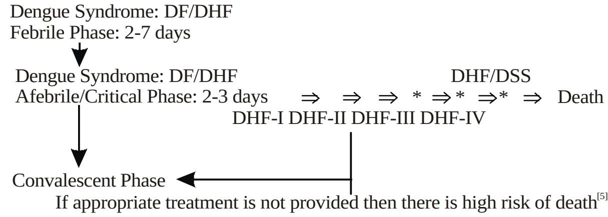
Dengue Shock Syndrome: Dengue Shock Syndrome is a presentation of Dengue Syndrome when a case of DHF manifests circulatory failure with one or more of the following features:[5]

- Hypotension for age
- Cold clammy skin, restlessness, rapid weak pulse
- Narrow pulse pressure (< 20 mm of Hg)
- Profound shock

Disease Course of Dengue Syndrome:
The disease course in dengue syndrome has the following characteristics:

- Phases : There are two phases form the beginning.[5,8]
  Febrile phase: Which lasts form 2-7 days duration. Various categories of presentation cannot be differentiated at this stage.
  Afebrile/Critical Phase: This phase follows the febrile phase and lasts for 2-3 days. The patient is afebrile. In DF cases this phase may be called afebrile phase and usually marks the beginning of convalescence. But in DHF cases at this stage all critical features begin and is called the critical phase.
- Progression: The natural course of progression of dengue syndrome is a continuum, uphill, stationary or downhill mostly not distinguishable at the initial stage. it has to be remembered that DHF per see begins as DHF and not converting from or a complication of DF, but indistinguishable from DF at the beginning. [5.10]

Progression chart for DF/DHF: [5]

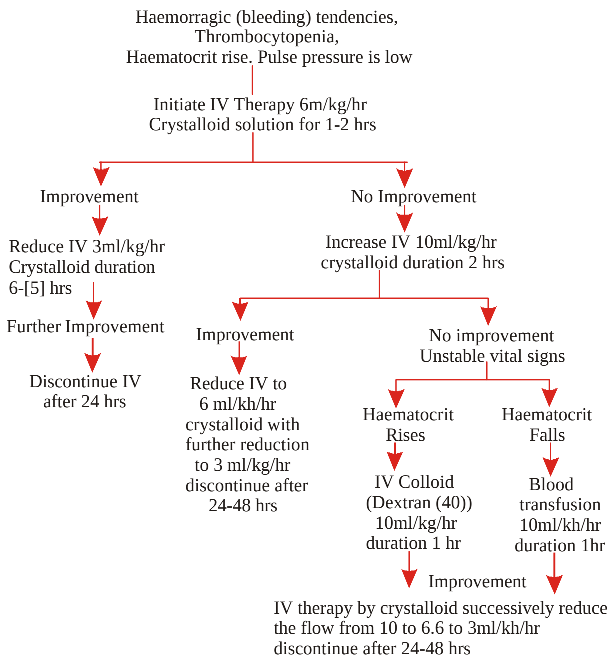


DHF Grades I & II: The only difference between the DF and DHF Grade is the presence of thrombocytopenia and rise in hematocrit (>20%). Patients with DHF Grade I do not usually require intravenous fluid therapy. Intravenous fluid therapy may need to be administered only when the patient is vomiting persistently or severely, or refusing to accept oral fluids. Patients with DHF Grade I who live far away from the hospital or those who are not likely to be able to follow the medical advice should be kept in the hospital for observation.[5,7]

During the febrile phase of DHF Grade II, the complications usually seen, in addition to those observed during DHF Grade I phase, are abnormal pain, black tarry stools, epistaxis, bleeding from the gum, and continued bleeding from the injection sites. Immediately after hospitalization, hematocrit and platelet count must be carried out to assess the condition of the patient. A reduction in platelet count to $\leq$100,000/mm^3 or less than 1-2 platelets/oil field (average of 10 oil field counts) usually precedes a rise in hematocrit. A rise in hematocrit of 20% or more (e.g. increase form 35% to 45%) reflects a significant plasma loss and indicates the need for intravenous fluid therapy. Early volume replacement of lost plasma with crystalloids solution (e.g. isotonic saline solution) can reduce the severity of the disease and prevent shock. Intravenous fluid therapy before leakage is not recommended. But in DHF Grade II depending on the condition IV therapy may be given for 5-24 hours. Medical personnel should monitor patients on hourly basis. Based on periodic hematocrit/platelet count determinations and vital signs. The treatment should be reviewed and revised. [5,14]

DHF Grades I and II: Volume Replacement Flow Chart: [5, 14]

Haemorragic (bleeding) tendencies,
Thrombocytopenia,
Haematocrit rise. Pulse pressure is low



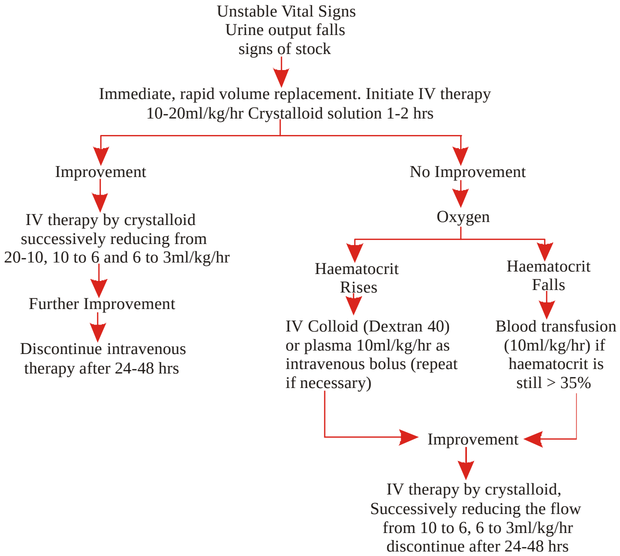
Improvement : Hematocrit falls. pulse rate and blood pressure stable, urine output rises.

No improvement : Hemantocrit/pulse rate rises, pulse pressure falls below 20 mm Hg, urine output falls Unstable vital signs: Signs of shock, urine output falls.[5,14]

DHF grades III & IV: Common signs of complications observed during the afebrile phase of DHF Grade III include circulatory failure manifested by rapid and weak pulse, narrowing of the pulse pressure and hypotension, characterized by high diastolic pressure relative to systolic pressure (eg 90/80mm of Hg) and the presence of cold clammy skin and restlessness. These complications occur because of thrombocytopenia, abnormal hemostasis and plasma leakage, or also from substantial blood loss. Immmediately after hospitalization, the hematocrit, platelet count and vital signs should be examined to assess condition of the patient, and intravenous fluid therapy should be started. The patient requires regular and sustained monitoring. If the patient has already received about 1000 ml of intravenous fluids and the vital signs are still not stable, hematocrit should be repeated and: (a) if the hematocrit is increasing intravenous fluid should be changed to colloidal s olution preferably Dextran, or (b) if hematocrit is decreasing, fresh whole blood trasfusion 10 ml/kg/dose should be given.[5,14] During the afebrile phase of DHF Grade IV vital sings are unstable. The patient, in the early stage of shock, has acute abdominal pain, restlessness, cold and clammy skin, rapid and weak pulse. The patient should be administered intravenous fluid therapy immediately. In case of continued or profound shock when pulse and blood pressure are undetectable, the patient should be given colloidal fluid following the initial fluid bolus.[5,14]

However, in the case of persistent shock when, after initial fluid replacement and resuscitation with plasma expanders, the hematocrit continues to decline, internal bleeding should be suspected. It may be difficult to recognize and estimate the degree of internal blood loss in the presence of hemoconcentration. It is thus recommended to give fresh whole blood in small voumes of 10 ml/kg body weight at one time. Blood grouping and matching should be done for all patients in shock as a routine precaution. Oxygen should be given to all patients in shock.[13]

DHF Grades III & IV: Volume Replacement Flow Chart [5,17]



Special Clinical Situations: DF and DHF may develop in a patient with some other clinical situations besides leading to others. Some common situations are as follows:[5, 14]

- Pregnancy and labor
- Emergency surgical condition eg Acute appendicitis
- Associated medical conditions eg Diabetes mellitus, Myocardial infarction
- Conditions where patients are on maintenance therapies which are contraindicated for DF/DHF eg Nephrotic syndrome case on high dose of steriod
- Patient is on some procedure which may be complicated by DF/DHF eg Maintenance hemodialysis where heparin is used to increase clotting time.
- Hypersensitivity or anaphylaxis due to fluid therapy in DF/DHF

Factors and Transmission of Dengue and Dengue Haemorrhagic Fever:

Factors of DF/DHF: Dengue virus transmission is enhanced by the following factors:[18]

- Increased vector density: In many tropical countries, seasonal increases in rainfall contribute to an increased density of mosquitoes.
- Shorter incubation periods in the mosquito: The length of the incubation time in the mosquito, known as the extrinsic incubation period, is inversely associated with the ambient temperature.
- Increased movement of mosquito vectors and viruses :Air, land and water transportation of mosquitoes or viremic humans facilitate the dissemination or dengue viruses.
- Increased density of susceptible human hosts: Crowded conditions probably increase the potential for virus transmission.

Factors contributing to the Reemergence of Dengue and Dengue Haemorrhagic Fever: The emergence of DHF as a public health problem has largely been a result of human behaviours including:[14, 21]

- Population growth
- Poorly planned urbanization, associated with overcrowding, poor water distribution and poor sanitation.
- Changing lifestyles, such as increased reliance on plastic containers and tires, standing water can easily collect in these.
- Modern transportation, with increased movement of viruses, mosquitoes and susceptible humans.
- Lack of effective mosquito control.

Nagao Y. *et al*. tested for correlations of three indices of *Aedes* larval abundance (housing index, container index and Breteau index) against 38 socio-economic and four climatic variables. Availability of public water wells, existence of transport services and proportion of tin houses were positively associated with larval indices. Private water wells, health education, health insurance coverage, thatched houses and use of firewood for cooking were negatively associated. These probably represent both direct effects on breeding sites (private vs. public wells decrease necessity to store water, and health education may encourage breeding site removal), and more general effects of health-related attitudes, housing quality and remoteness from urban areas. Indices were positively associated with daily minimum temperature, an increase in precipitation from the previous month (reflecting the onset of the rainy season) and daily maximum temperatures of approximately 33-34 degrees C.[27, 15]

Yi B *et al*. experimented the influence of climate factor on vector *Aedes* density is complicated. But its primary influence factors are lowest average air temperature, rainfall and relative humidity. The primary influence factors of dengue episode are breteau index.[28] Hales S. *et al*. showed that the current geographical limits of dengue fever transmission can be modelled with 89% accuracy on the basis of long-term average vapour pressure. In 1990, almost 30% of the world population, 1.5 billion people, lived in regions where the estimated risk of dengue transmission was greater than 50%. With population and climate change projections for 2085, we estimate that about 5-6 billion people (50-60% of the projected global population) would be at risk of dengue transmission, compared with 3.5 billion people, or 35% of the population, if climate change did not happen.[29]

Libraty DH *et al*. showed that the following factors on admission were significantly associated with the combined end-point of death or a severe neurological deficit: depressed level of consciousness, elevated concentration of cerebrospinal fluid (CSF) protein, low levels of serum and CSF IgG antibody against Japanese encephalitis virus (JEV), low level of serum IgM antibody against JEV, and a serological response consistent with primary flavivirus infection. On multivariate analysis, an initial serum anti-JEV IgM < 150 U and the absence of a prior flavivirus infection, presumably dengue, remained independent risk factors for death or a severe neurological deficit.[30]

Lum LC *et al*. identified the early indicators of hemorrhage in severe dengue infections in 114 patients; 24 patients had severe hemorrhage and 92 had no hemorrhage. The platelet counts were not predictive of bleeding. The duration of shock (OR, 2.11; 95% CI, 1.13 to 3.92; P =.019) and low-normal hematocrit at the time of shock (OR, 0.72; 95% CI, 0.55 to 0.95; P =.020) were risk factors of severe hemorrhage.[31]

Transmission of Dengue: Dengue is spread by the bite of an infected female, *Aedes aegypti* mosquito, which has got the dengue virus by taking a blood meal on a person who is ill with dengue. The infected mosquito then transmits the disease through its bite to other people who in trun becomes ill and the chain countinues.[13]

Vector of Disease Transmission: The man vector of dengue *Aedes aegypti* mosquito, flourishing in mankind's urban to suburban environments, has spread the disease to many parts of the world. Another mosquito, *Aedes albopictus*, a less important urban vector, has played an important role to spread the disease in Asian regions. *Aedes aegypti* is the most important vector of dengue. The spread of dengue throughout the world can be directly attributed to the proliferation and adaptation of this mosquito. The insect originated in Africa as a "tree-hole" mosqito, breeding in any temporary puddles of water left by recent rains. The "original" mosquito, it is believed, proliferated only during high humidity and rain. Only the eggs survived when the rain stopped and the puddles evaporated. However, *Aedes* eggs do need water to hatch. Thus, adult preponderance declines as the rains cease. In short, the incidence of adult mosquito bites occurs mainly during the rainy during the rainy season.[19]

Patterns of Dengue Virus Transmission: Dengue virus transmission follows two general but not mutually exclusive patterns, with different implications for disease risk in both the local population and travelers.

- Epidemic dengue: Epidemic dengue transmission occurs when the introduction of dengue virus into a region is an isolated event involving a single virus strain. If sufficiently large populations of susceptible hosts and mosquitoes are present, transmission of dengue is explosive, leading to a recognizable epidemic. The incidence of infection among susceptible individuals often reaches 25 to 50 percent, and can be considerably higher. Herd immunity, changes in weather, and mosquito control efforts can contribute to the termination of the epidemic. Epidemic activity is currently the predominant pattern of dengue virus transmission in smaller island nations, certain areas of South America and Africa and in the areas of Asia where dengue virus transmission has recently re-emerged.[14]
- Hyperendemic dengue: Hyperendemic transmission refers to the continuous circulation of multiple dengue virus serotypes in the same area. This requires the year round presence of competent vector mosquitoes and either a large population base or steady movement of individuals into the area to maintain a pool of susceptible individuals. Seasonal variation in virus transmission is common. The incidence of infection also varies from year to year, with increased dengue transmission at intervals of three to four years, but this variation is not as dramatic as in areas where transmission predominantly follows the epidemic pattern. Areas with hyperendemic dengue virus transmission contribute the vast majority of cases of dengue virus infection globally.[14]

Dengue control program:
Area of focus:

Dengue control forms part of the national Vector-Borne Disease Control Programme which encompasses malaria, dengue, Japanese encephalitis, filariasis, typhus, yellow fever and other new emerging vector borne diseases. The dengue control programme comprises the following aspects:[7]

- Disease surveillance and control
- Vector surveillance and control
- Public education
- Inter-agency collaboration and community participation
- Quality assurance
- Research and training.

Table 2: Effect of source reduction of *Aedes sp*. to the ovitrap index (OI) of *Aedes aegypti* (1) and *Aedes albopictus* in Perumnas, Condong Catur, Yogyakarta, Indonesia. [5]

				1		2		1 & 2		Total	
Area	Weeks	Season	N	+	OI(%)	+	OI(%)	+	OI(%)	+	OI(%)
Experimental	0*	D	97	43	44.3	2	2.1	5	2.1	47	48.5
	6	D	86	20	23.3	0	0.0	0	0.0	20	23.3
	[5]	R	85	24	28.2	0	0.0	0	0.0	24	28.2
Control	0	D	90	26	28.9	2	2.2	3	3.3	31	34.4
	6	D	86	28	29.2	4	4.7	0	0.0	32	37.2
	[5]	R	77	23	29.9	0	0.0	0	0.0	23	29.9

29.9*=Pre-test; N=Number of ovitrap examined; D=Dry season; R=Rainy season

Source: *Aedes* Control Programme by source reduction in Perumas, Condong Catur, Indonesia, 2003[5].

Control strategies:
The main control strategies are:

- Source reduction (elimination of breeding source)
- Chemical spraying
- Chemical larviciding
- Health promotion
- Law enforcement and
- Biological control
- These are described below:

Source reduction (elimination of breeding source): Umniyati S. *et al* (1993), conducted experiment on Evaluation of community based *Aedes* control programme by source reduction in Perumnas, Condong Catur. Data were collected by.

(I) Emptying and scrubbing of positive containers, i.e. wash basins, earthen pitchers, animal drinking pans, and flower vases; (ii) covering earthen pitchers and drums with lids, and (iii) eliminating discarded articles. No other control activities were carried out in the experimental areas.[5]

The effects of source reduction for[5] weeks on the OI indoors are presented in Table-2. It revealed that the OI of *Aedes aegypti*, *Aedes albopictus* and both (mixed) species indoors in the experimental area at pre-test were 44.3%, 2.1% and 2.1 respectively, whereas the OI of *Aedes aegypti*, *Aedes albopictus* and both (mixed) species indoors in the control area were 28.9%, 2.2% and 3.3% respectively, although control areas had been fogged indoors and outdoors with malathion a week before the research study. The total OI (*Aedes spp*) indoors at pre-test between experimental and control areas did not differ significantly (X^2=3.7225; p>0.05). Table-2 also revealed that the total OI decreased from 48.5% to 23.3% in the experimental area but it increased from 34.4% to 37.2% in the control group.[5]

The effect of source reduction to the OI outdoors is given in table-3. It revealed that the OI of *Aedes aegypti*, *Aedes albopictus* and both (mixed) species outdoors in the experimental area at pre-test was 32.17%, 17.3% and 4.1% respectively, whereas the OI of *Aedes aegypti*, *Aedes albopictus* and both species outdoors in the control group were 28.4%,4.5% and 2.3% respectively.The total OI outdoors decreased significantly from 54.1% to 32.1% in the experimental group, meanwhile it did not decrease significantly in the control areas.[25]

Effect of source reduction of *Aedes* for 18 weeks on the BI are given in Table. It showed that the BI in experimental area at pre-test and six weeks later in the dry season were 41.2 and 20.7 respectively, whereas the BI in control area were 16.7 and 7.0. Otherwise the BI in experimental area decreased to 1.0 in early rainy season (the [5]th week) meanwhile it increased to 21.1 in the control area. According to WHO (1994), BI >20 poses a risk of dengue transmission.[5]

Chemical spraying: Malathion ULV for focal spraying during epidemics only to reduce adult density. Aqua resigen for peri-focal sprays of case locations and area within 400 metres of case location.[8]

Chemical larviciding: Temephos (Abate) for ground pools and water storage receptacles.[8]

Health promotion: Dengue control demands household-level interventions and behavioural modifications that require high levels of community participation and support to remove refuse or carefully protect essential water containers and other household items that can provide ideal breeding sites for *Aedes aegypti*. During dengue outbreaks, control programmes must convince people of the need to reduce their own, and particularly their children's, chances of being bitten by day-biting mosquitoes. Inter-island and inter-country travel also needs to be reduced during outbreaks.[8]

Dengue education messages are generally based on biomedical explanations of the disease and scientific observations of dengue mosquitoes, but these are often too abstract for people to be able to relate them, to their own knowledge and immediate surroundings. Continued anti-dengue campaigns with community participation and involvement are essential to prevent outbreaks.[9]

Law enforcement (backing for effective implementation of the programme): The penalty for offences related to

Table 3: Effect of source reduction of *Aedes sp*. to the ovitrap index (OI) of *Aedes* aegypti (1) and *Aedes albopictus* (2) outdoors in Perumnas, Condong Catur, Yogyakarta, Indonesia.[5]

				1		2		1 & 2		Total	
Area	Weeks	Season	N	+	OI(%)	+	OI(%)	+	OI(%)	+	OI(%)
Experimental	0	D	98	32	32.7	17	17.3	4	4.1	53	54.1
	6	D	84	20	31.0	0	1.2	0	0.0	27	32.1
	[5]	R	86	22	25.6	0	0.0	1	1.0	23	26.7
Control	0	D	88	25	28.4	4	4.5	2	2.3	31	35.2
	6	D	86	20	23.3	6	7.0	0	0.0	26	30.2
	[5]	R	75	22	29.3	0	0.0	0	0.0	22	29.3

Source: *Aedes* Control Programme by source reduction in Perumas, Condong Catur, Indonesia, 2003[5].

mosquito breeding is very minimal. The Public Health Act of Fiji is under review to address this issue.[8.9]

Biological control:

- Fish *Pocelia reticulata* (Guppy) Talapia – Control in pools, drains, rice fields, etc.
- *Toxorhynchites amboinensis* (A predatory mosquito) – Control in tree holes, tyres, drums etc.
- *Bacillus thuringiensis* var. *Israelensis* (Bactarium) – Control in ground pools with brackish water –coastal areas.
- *Tolypocladium cylindrosporum* (Fungus) lab trials and field trials-Nukui, Rewa.

Predatory capacity of Mesocyclops to *Aedes* aegypti larvae: Nam Vu *et al*. (1999) tested six species to control *Aedes aegypti* larvae. They were *M. woutersi, M. pehpeiensis, M. aspericornis, M. thermocyclopoides, M. affinis and M. ogunnus.* The results showed that *Mesocyclops* had not only eaten but also killed the *Aedes* larvae. Different species had different eating and killing capacities. During the same period of time, a *M. pehpeiensis* ate less (11.7) but killed more (29.9) larvae than other species, resulting in the highest predatory capacity, followed by *M. aspericornis* and *M. woutersi*. Experiments showed that a population of primary 10 *Mesocyclops*, after one month, could kill at least 350 first instar *Aedes aegypti* larvae per day during 10 days (every day 350 larvae had been added, and no one could survive after 24 hours. The results are shown in Table-5.[2 3]

Other Biological Control: In view of the sporadic nature of dengue outbreaks, vector control programmes that are specifically devoted for eliminating or controlling *Aedes aegypti* or *Aedes albopictus*. Vector suppression activities are undertaken only in the case of outbreaks, which are mostly limited to ground or aerial application of pesticides.[6]

The *Aedes* mosquito populations are, to some extent, kept suppressed through national malaria control programmes, or, in some malaria-free countries, by disease vector/pest control programmes, as they use chemical pesticides (a wide range of organochlorines, organophosphates, carbonates and pyrethroids are used). Some countries also use biocides. Trials with *Bacillus thuringiensis* H-14 and *Bacillus sphaericus* have been carried out in some countries. Recently, in response to a regional initiative on integrated vector control, considerable effort will be invested in making full use of this method. The integrated vector control approach utilizes the most suitable combination of environmental, chemical and biological control. Biological control of vector mosquitoes is mainly by the use of larvivorous fish. At least, 15 out of 22 countries are using or have used larvivorous fish, such as *Gambusia affinis, Tilapia mozambica, Aphanius dispar* and *Oreochromis* species, for mosquito larval control. But this method is still far from perfect. [6]

Strategies for sustainability: The goal of the strategy, for anti-dengu vector preventive and control work in Fiji is to prevent the recurrence of dengue epidemic as a public health problem. It has nine components as key areas of concentration.[8]

- Develop diagnostic procedures to enable confirmatory tests of dengue fever cases.
- Develop cilinical management of dengue cases both for use by the general public in rudimentary early case management and importantly at clinics, hospitals, and for outpatients and also for inpatients.
- Vector surveillance and control: This includes consistent mosquito surveillance and anti-mosquito work focusing first in cities, towns, neighbouring settlements and villages. It also includes designs and management of control programme that are practical and economical.
- Mobilization of communities for source reduction from church groups, women and youth groups, scouts and girl guides, schools, villages and similar types of groups.To be effective in source reduction, any

attempts to address mosquito-breeding sites must include a strong and effective mobilization programme.
- Development and wide distributation of effective health promotion materials to the general public and government and non-government institutions. Evaluation of these materials must be an ongoing exercise to be responsive to public attitudes and behavioural patterns.
- Capacity –building and training in the entomological, surveillance and vector control aspects of the programme of divisional, district and area health inspectors, including those who are employed in city and town councils.
- Periodical exercise to alert key workers of the importance of emergency preparedness and coordination in vector mosquito surveillance and control work.
- Information and management training of key environmental health officers and other cadres of key health workers who are involved in surveillance and control work, source reduction, resource management and health promotion.
- Develop and improved anti-mosquito surveillance and control programme in each of the major cities, towns and each rural local authority. The plan will include zoning of each area to facilitate proper coverage and consistence in mosquito surveillance and control work.

Table 4: Effect of Source Reduction of *Aedes sp* to the Breteau Index (BI) of *Aedes sp*. in Perumnas, Condong Catur, Yogyakarta.

		Breteau Indesx (BI)	
Weeks	Season	Expeimental	Control
0	D	41.20	16.7
6	D	20.70	07.0
[5]	R	01.00	21.1
18	R	09.80	27.9

Source: *Aedes* Control Programme by source reduction in Perumas, Condong Catur, Indonesia, 2003[5].

Other Control Strategies: Other control strategies include:

- Use of Legislation
- Community-based control project
- Awareness of the population
- Epidemic plan
- Partnerships
- Use of ovitraps
- Treatment of curtains
- Applying space sprays
- Functions of the Environmental master team
- Housewives' behaviour towards control of DHF

These are described below:

Use of legislation: The purpose of legislation is to ensure compliance with advices/messages to speed up behavioural changes. However, it alone is not the solution. The message should be internalized and people motivated to act in the desired way by themselves, instead of through the fear of enforcement. To illustrate this point, Singapore uses the case of the Infectious Diseases Act (IDA), which requires doctors to notify ministry of the Environment on any DF/DHF case. To comply strictly with the law, the doctor would need to take blood sample from any febrile patient and send it for diagnosis in a laboratory to confirm if the patient is infected with DF/DHF. However, doctors are not prepared to take blood samples from patients because of the cost that will be passed on to the patients, until the symptoms are quite obviously DF/DHF. By this time much precious time has already been lost for control measures to be taken to prevent the transmission of the disease.[9]

Seng T.A. (2001) showed the achievement of law enforcement by states for the year the year 2000. A total of 3,956,344 premises were examined, out of which 21,117 (0.53%) premises were found to be positive for *Aedes* breeding. A total of 8,601 warning notices, 15,209 compounds, 506 court prosecutions and 16 stop-work or closure orders were issued. [10]

Community-based control project: Talco George *et al*. utilizes community involvement in removing breeding sites. This community-based project, inaugurated in 1999, is supported and supervised by the Ministry of Health through the Vector-Borne Disease Control (VBDC) office. The purpose of this project is to both educate the people in the Manples area (in a suburb of Port Vila) on vector-borne diseases and mosquito control and to use this knowledge to reduce mosquito breeding sites by community participation.[2]

The Manples project evolved from the routine larval collection team who noticed that a lot of tins, drums and tyres accumulated in this area because there was no established disposal facility. Once every three months the staff of the (VBDC) office distributes one plastic bag to each household in the Manples area. Each plastic bag costs 100 vatu (US$ 0.71). All tins and water containers are collected in this bag by people living in that household. Every three months the Malaria and other VBDC office collect the bags and distributes new ones. Financial expenses are low, even when including the cost of petrol to reach the Manples area, and are charged to the recurrent budget of the Ministry of Health. [2]

Awareness of the population: Many kinds of IEC (Information, education and communication) materials about dengue are available and are used in Vanuatu. Educational posters on mosquito control are distributed in hospitals, health centers, dispensaries and communities on a regular basis. In case of suspected cases of dengue, booklets in Bislama, the most common of the three official languages of the country, are copied and distributed in

Table 5: Predatory capacity of *Mesocyclops* to *Aedes aegypti* larvae:[23]

	No. of experiments	No. of *Ae. aegypti* larvae used	Average No. of larvae eaten by *Mesocyclops* in 24 hours	Average No. of larvae killed in 24 hours	Species Total
M. woutersi	75	3750	20.57	16.03	36.60
M. pehpeiensis	40	2000	11.70	29.90	41.30
M. thermocyclopoides	50	2500	09.58	[5].48	22.06
M. affinis	50	2500	11.30	10.42	21.72
M. aspericornis	60	3000	23.75	13.43	37.18
M. ogunnus	50	2500	08.48	07.58	16.02
Control	20	1000	00.00	01.40	01.40

Source: Laboratory evaluation as biological control of *Aedes aegypti*, 2000[23]

Table 6: Enforcement of Destruction of Disease-Bearing Insects Act, 1975 (Amended 2000) by states in Malaysia during 2000.[10]

State	No. of Premises Examined	No. of Premises found	No. of warning notices issued	No. of compounds issued	No. of court cases	No. of premises closed
Perlis	23173	179	19	160	0	0
Kedah	336050	991	1393	819	1	5
P. Pinang	324927	730	11	643	0	0
Perak	715302	3745	799	2624	207	0
Selangor	517010	5700	[5]71	4041	168	9
Wpkl	51913	1490	616	510	96	0
N.Sembilan	151337	5[5]	20	459	20	0
Melaka	189788	610	340	254	8	0
Kjohor	454418	2637	286	2350	0	0
Pahang	208559	881	77	779	3	0
Terengganu	202699	513	1780	505	3	0
Kelantan	281578	719	274	345	0	2
Sabah	257172	945	687	696	0	0
Sarawak	2424[5]	1495	1028	1024	0	0
Total	3956338	21117	8601	15209	506	16

Source: Vector- borne Disease Barnce,Ministry of Health,Malaysia (2000)[10]

the communities. Each booklet gives very simple and basic information about dengue fever, the main symptoms and the way to prevent the disease .[2] One video in Bislama on mosquito control entitled *"One present long niufala Bede"*, produced by a local theatre group, "The Wan Small Bag Theatre" is broadcast on TV during the wet season. Another Video, in English, "It can't happen here", is focused on dengue disease and is shone on TV when suspected case of dengue are found in the country. Finally, during the "at dengue risk season", messages are displayed at the national radio and TV to remind everyone to clean their gardens and to destroy all potential mosquito breeding sites.[2]

Epidemic plan: In a large-scale dengue outbreak, control efforts shift from treatment of homes in the immediate vicinity of a case to treatment of "hotspots" (e.g. areas with significant numbers of cases), as well as hospitals, airports and seaports. Furthermore, greater emphasis is placed on larval source reduction rather than on indoor space spraying for adult mosquitoes. Manpower to supplement the strength of the workers from the Malarla and Other VBDC Programme comes from 40 previously trained volunteers. The Dengue Early Warning Committee would be responsible for coordinating the provision of additional manpower and transportation. Furthermore, this committee may solicit the Cabinet to organize national clean-up days, thereby enlisting the entire community in the dengue outbreak control effort.[2,12]

Partnerships: At the very least, each of the following sectors or agencies has an important role to play in dengue control: [3]

- Public health ministries: Ministries of public health define the size and impact of dengue as a health problem, provide facilities and manpower for coping with its clinical burden and many provide the manpower and resources to combat *Aedes aegypti*. Instead of sustained mosquito control programmes dengue is controlled through mosquito abatement mounted in response to reported cases, e.g. adulticide sprays. Budgets are often inadequate to support either control or a meaningful research effort.
- City health departments: The modern megacity is often autonomous or semi-autonomous. Its health department may organize dengue vector control programmes that are independent of national authorities.[3]
- Environment ministry. In many countries, environment ministries have assumed responsibility for source reduction and the application of pesticides against *Aedes aegypti*. This is consistent with the reality that environmental programs are needed for dengue control.
- Urban planning: It is not at all clear that past or present generations of urban planners or architects have included as a goal the reduction of breeding sites for

Aedes aegypti in public or private spaces.

- Justice sector: The design and/or enforcement of laws that regulate human behavior are usually the responsibility of the justice sector. Sanctions and fines discouraging the breeding of vector mosquitoes by householders have been the key to historically successful *A. aegypti* control programmes. Such laws continue to be used effectively in modern-day Singapore, Malaysia and Cuba.
- Education sector: A number of countries have designed, implemented and evaluated curricula for school children that teach the biology of *Aedes aegypti* and its control, including laboratory and field work. Universities, envisioned by most national leaders as institutions crucial to national development, have failed to respond to the dengue problem. A recent survey of Asian universities found almost no graduate education in medical entomology, especially on the bionomics and control of *Aedes aegypti*. Little attention is paid by academia to the human behavioural aspects of dengue control.
- Science and technology: Most large dengue-endemic countries offer only limited support to research on vector control and almost none to develop the technical and scientific manpower that such research requires. Large industrialized countries do support modest programmes for basic and vaccine research on dengue, but this is not an effort commensurate with the size of the problem.
- The media: The media everywhere make efforts to educate the public on health issues and to be a part of the solution of public health problems. A dramatic example is Ted Turner's gift to the UN of CNN time dedicated to health and children's issues.
- Private sector: A significant, but largely unmeasured percentage of effective control of adult *Aedes aegypti* can be attributed to the use of commercial products, e.g. aerosol insect sprays. In some developing countries small private vector control firms have come into existence. In the United States there are many large private firms that provide a wide range of control services against nuisance or vector mosquitoes. Private foundations, Rotary clubs and Rotary International have and will continue to support research, training and pilot community-based dengue control programmes.
- People themselves: A number of pilot studies have explored and demonstrated effective ways to interest and educate people on the problem of dengue and *Aedes aegypti* control. Efforts have been made to encourage people to take greater responsibility for mosquito source reduction. Much has been learned, but much remains to be learned.

Each of the above sectors might and can play a different and more constructive role in the control of dengue: [3]

- Public health ministries: Because dengue is an human health problem, health ministries should serve as coordinator when multiple partners are involved in vector control programmes. Health ministries must maintain essential services such as the care of the sick, surveillance on the vector and on dengue infections and promote research on improved treatment, dengue surveillance and better methods of mosquito control. But, dengue transmission is largely an environmental problem. The responsibility for vector control must be shared by appropriate agencies.
- City health departments: Because large cities are a major milieu for the transmission of dengue viruses, city health departments must play a central role in dengue control. But, city and national programmes must be tightly coordinated. For example, cities might design, conduct and evaluate pilot control programmes using laboratory support provided at the national level.
- Environment ministries: Several important responsibilities usually delegated to environment ministries are critical to the control of dengue: solid waste management, drainage, regulation of construction sites, distribution of safe drinking water and the management of rainwater and gray water drainage in underground culverts.
- Urban planning: Urban planners should assume the central responsibility for creating master plans that include comprehensive dengue control. Crucial elements include the distribution of ample and safe drinking water, the construction of buildings and building codes designed to minimize sites for mosquito breeding, the regulation of construction sites to prevent mosquito breeding and the coordination of these components.
- Justice sector: Source reduction requires human behaviour change resembling programmes such as seat belt use or smoking cessation. National legislatures must write laws that provide incentives and disincentives that promote source reduction behaviour; the justice sector should enforce them.[3]
- Education sector: The needed manpower and the intellecutal, scienrtific, research and technical underpinning for dengue control must come form the education sector. In the large dengue endemic countries, universities must adopt affirmative programmes to provide a cohort of leaders in virology, vector bionomics, behavioural sciences, as well as in environmental, legal and architectural fields. As a global problem, major universities in industrialized countries

also should assume a prominent role.

- Science and technology: Science and technology funding for the research enterprise must be forthcoming. Where education and science funding come form separate appropriations, coordination between ministries is crucial to attract high-calibre people to the field and to sustain a quality dengue control effort.
- The media: There are many opportunities for explicit partnerships between the media and agents of change. In Puerto Rico, TV telenovellas have told the dengue story. A Rockefeller Foundation pilot project in Mexico worked with a local television station to commission puppet shows that dramatized the problem of *Aedes* ageypti.
- Private sector: The private sector is perhaps the greatest untapped resource that can help with dengue control efforts. Vector control programmes are frequently planned by government workers who are unknowledgeable or uncomfortable with the private sector. The private sector can provide help at any scale, from neighbourhood mosquito abatement to the national level. If work contracts are written carefully and the rewards for success are sufficient, the private sector is capable of delivering sustained mosquito abatement and source reduction imaginatively and competently.
- People themselves: The biggest lesson of modern history is that effective national development depends upon the strength of a civil society. Authentic participation in decision-making and individual "ownership" of a healthy environment are crucial to bring into existence an informed citizenry who expect much of themselves and make appropriate demands on government. Community-based disease control programmes contribute constructively towards the emergence of civil societies.

Use of ovitraps: Ovitraps are autocidal traps, which attract *Aedes* mosquitoes to breed in them, but the adult mosquitoes are unable to emerge and therefore drown in the traps. It has been used mainly as a monitoring tool so far. Singapore is using ovitraps both as a monitoring tool and a control tool. About 2,000 ovitraps are placed in dengue-prone areas all over Singapore to serve as sentinel or monitoring stations. They are useful as it is unable to check every part of Singapore regularly. About 10 ovitraps are placed in each of the monitored areas, and weekly reading of the number of eggs laid, larval counts and species breeding are recorded. If there is an increase in prevalence or change in the species breeding in the ovitraps from *Aedes albopictus* to *Aedes aegypti*, control operations will be launched in the area immediately.[20]

In some outbreak areas where transmission has started spreading outwards, Singapore uses ovitraps to control the transmission of Dengue virus. They have found that cases tend to spread outwards after they removed or neutralized all potential breeding sites within the initial focus, as the remaining surviving infected adult *Aedes* mosquitoes would fly further out to look for breeding habitats. They now put ovitraps back into the outbreak area to continue providing the mosquitoes a place to breed within the area, and to reduce their population eventually.[20]

Treatments of curtains: Madarieta S.K. *et al*. (1999) conducted an experimental study on the use of permenthrin-treated curtains. The chemical used in the study was Coopex 25% EC which contains 250g/litre of the residual pyrethroid, permethrin. Curtains of the 65 sample households in the experimental barangay were soaked in 25% EC permethrin at a 1:20 dilution (1 litre of the chemical to 20 litres of water). Twenty-one litres of the solution was enough to soak 80-100 pieces of curtains made of light cotton material. Two large basins were used, one for soaking the curtains and the other for catching the excess solution from the soaked curtains. After soaking the curtains for at least 2 minutes, they were allowed to drip in the order basin for a few minutes so that the excess solution from the drippings could still be used. The curtains were then air-dried and were not exposed to direct sunlight.[15]

Applying space sprays:

Thermal fogs: Thermal fogs are produced by equipment in which an insecticide dissolved in oil with a suitably high flash point is vapourized when injected into the high-velocity stream of hot gases. Malathion has been the most commonly used insecticide usually applied by hand-carried Swingfog thermal generators, or for larger areas, by vehicle mounted generators. The hand-carried foggers usually have a pulse-jet engine. Applications should be done early in the morning before thermal convection currents lift the fog from the ground level. Adult mosquito populations will generally recover rapidly unless the foggings are repeated; programme using thermal fogs should repeat applications every four days to maintain *Ae. aegypti* at low levels.[16]

Thermal fogging is widely used by vector control organization throughout the region. These thermal fogs are highly visible and inhabitants of the treated area perceive their application as an effort by the authorities to reduce mosquito populations. Unfortunately, thermal foggings are often applied late in the day (at a time when more people can see them) rather than early in the morning, they are not repeated frequently enough, and their efficacy is not evaluated to determine when retreatments are necessary. Nevertheless, if properly applied, thermal fogging can provide effective, if only short, periods of control. Applications of malathion 4% and fenitrothion 1% resulted in good reductions of natural infestations of mosquitoes in Bangkok; even better results were obtained with thermal fogs of pirimifos-methyl in Malaysia. Use is also being made of pyrethroids such as resigen, permethrin, cypermethrin, and lambdacyhalothrin, which can produce a rapid knock down of adult mosquitoes. [16]

Ultra low volume (ULV) fogs: Also called "cold fogs" as no heat is used to produce them, ULV application equipment uses technical or high concentrations of insecticides which produce large numbers of droplet particles into the air, each of which when of the right diameter, carries a dose lethal to the mosquito upon which it impinges. Mount *et al*. (1968) emphasized that ULV aerosols are advantageous as they have no need of oil solvents or carriers as with thermal fogging, the amount of spray solution or mixture that has to be applied is much smaller than thermal fogs, and ULV applications have no need of mixing. Early field trails carried out in the USA showed ULV applications to be at least as effective or more effective against both caged and free-flying *Ae. taeniorhynchus*.[16]

In order to determine if ULV applications would be effective against *Ae. aegypti* in South-East Asia, trails were carried out in Thailand, first by aerial applications. The largest trial covered 18 Km^2 of the city of Nakhon Sawan with some 9,000 houses which were treated by two applications, four days apart, of 95% malathion as an ULV spary at a concentration of 438 ml/ha by a C47 aircraft. The *Ae. aegypti* landing counts before treatment were 8.6/man hour and premise indices were as high as 94%. The landing rate was reduced by 95% to 99% after the applications and remained low for ten days. The extent of the reduction of the mosquito populations was rapid and quite impressive, however, the aerial applications were expensive and depended on the availability of a large spray aircraft and a highly trained crew. Studies were therefore made on the efficacy of ULV ground application methods. [16]

Functions of the environmental master team: In 1998, an "Environmental Master Team" for control of DHF was constituted in Thailand. After each training sessions, the environmental master team members could go back to their house-block to work with their people. The functions of an environmental team member were to:[17]

- Introduce health education to villagers concerning DHF and preventive methods;
- Manage environmental conditions across the house-block;
- Crate community awareness about *Aedes* larvae in water containers;
- Supply sand abate to villagers and explain application methods, and
- Link with team advisers, especially personnel.

The team members would come to the monthly meeting to report their performance and problems faced by the house-block. During meetings, the team members could solve problems, for example, searching for a public space for dumping garbage (now in use), constructing a receptacle bin for public garbage (in the plan), raising funds for buying a garbage truck (in the plan) and raising a clean-up campaign in the village.

Members of the environmental team felt responsible for the health of other families. Meetings were organiged by themsalves every month, mostly at nighttime after their housework. Four training sessions were conducted mostly in the meeting room of the Sub-district Administrative Organization (SAO). A monthly meeting was organized by school teachers, health officers and the President of the SAO. Social cohesion in the village was a strong tie. Information education and communication (IEC) messages and activities were undertaken to advocate the need for community co-operation, and complete coverage and supervision by almost all families for the benefit of all children.[17]

Housewives' behaviour towards control of DHF: Andajani S. *et al*. (1998) analyzed the Housewives' awareness about DHF and its control. This was assessed through a knowledge, attitude and practice study. Their findings are listed below:

- A significant correlation was found between the household income and the presence of DHF cases with the housewives` knowledge about controlling DHF: (a) every increase of Rp.100,000 in the household income resulted in better knowledge (as much as 1.34 times), and (b) housewives with the presence of cases had 0.28 times less knowledge then housewives without cases.[18]
- A significant correlation was found between the presence of cases with the housewives' attitude towards controlling DHF. Housewives with the presence of cases had 0.5 times lower attitude than housewives' without cases.[18]
- A significant correlation was found between the housewives practice in controlling DHF. Every increase

of 10 years in the age of a housewife resulted in a better practice by 2.88 times.[18]

- A significant correlation was found between the presence of cases with the housewives' behaviour in controlling DHF. Housewives with the presence of cases had a behaviour level 0.41 times lower than the housewives without cases.[18]
- A significant correlation was found between the housewives knowledge with their practice in controlling DHF. Better knowledge had better practice as high as 3.43 items.[18]

RESULTS AND DISCUSSIONS

For decades, the countries affected by dengue fever have been routinely controlling *Aedes aegypti*. This control has been done mainly by applying insecticides to larval habitats, destroying unwanted containers and educating the population. During epidemics, this has been complemented by insecticide space spraying against adults.[19] In recent years, no one has been able to clearly demonstrate that the use of these specific measures prevents or limits dengue epidemics efficiently and on a long-term basis, despite the fact that considerable sums have been invested in the control of dengue vectors.

Larval control is hampered by the multiplicity and inaccessibility of breeding sites, constantly replenished by man. In most cases, space spraying only has a transient and limited impact on adult mosquito and on transmission of the virus. Health education has not had the desired effect. Trying to activate the community only has a limited response and is more effective when there are epidemics when it is usually too late to have any real impact on transmission. This situation, even if there are some exceptions, reflect the reality of the problem confronting the affected countries, whatever their level of economic development.[19]

The International Conference on Mosquito Control organized in Fort-de-France from 28 February to 3 March 2000 recommends: [19]

- That anti-*Aedes* control measures be integrated into a general mosquito control programme with cooperation at regional, national and international levels. This approach best suits the expectations and needs of the population for an improvement in their quality of life. It also corresponds to the expectations of political decision makers concerned about ensuring sustainable development for the populations they represent.
- That the training of staff involved in mosquito control be stressed. Given the limited range of active insecticides, the increase in resistance, the importanceof preserving zones where mosquitoes have been controlled, all mosquito control requires competent and motivated staff, capable of designing, implementing and evaluating the integrated control, that best responds to the circumstances.
- That community participation, often indispensable, is real and based on systematic feedback, the results of which are automatically taken into account in the drawing-up of education campaigns and actions in the field.

The incidence of dengue and its more severe form dengue haemorrhagic fever is increasing in the region of the Americas. After the first significant DHF epidemic in Cuba in 1981 and subsequently in the last decade, we have seen a steady increases in DHF. Unfortunately, the trend reflects that which occurred in Asia 30 years ago.[24] In view of this during the 3rd Direction Council of the Pan American Health Organization (PAHO), in September 2001, the Ministers of Health of all countries in the Americas, unanimously approved a Resolution to address dengue and dengue haemorrhagic fever. The Resolution highlights the need for a long -term change in health management, adopting strongly integrated actions for dengue control and prevention at all levels. The Resolution also urges the incorporation of social communication and community participation in the national programmes, with a focus on both individual and collective behaviour change.

As a result, the Resolution encourages national programmes to move from the traditional vector control approach of actions (using insecticides) to focusing on community actions emphasizing "ownership" of dengue control and prevention. Social communication, health education, environmental management of water supply and disposal, as well as solid waste management, form the basis of the new generation of prevention and control programmes on dengue. PAHO is convinced that strengthening the social element of the programme while maintaining the other components will minimize the threat of an increase of dengue hemorrhagic fever and the reappearance of urban yellow fever in the Americas. PAHO is also conscious that the transition from vertical to horizontal programmes is a long-term process that will affect determinant and / or risk factors along the way, most likely in five to seven years.[24]

Previous dengue control programmes have not proved successful or sustainable because they are expensive, vertically structured, insecticide-based and include community participation or health education only in case of emergency ("epidemic windows"). Implementing the new generation of dengue prevention and control programmes will be an opportunity to change the similar trend that dengue in the Americas shares with the region of South East Asia, where thousands of cases of dengue haemorrhagic fever occur every year.

The Intercountry Consultation of Programme Managers of DF/DHF from endemic countries and scientists/experts from the South-East Asia and Western Pacific Regions, which met at Batam Island, Indonesia reviewed the latest developments with regard to case management, prevention and control of DF/DHF recommended "Revised Regional Strategies for Prevention and Control of DF/DHF- July 2001" and further made recommendations for implementation of different elements.[25]

There are six basic elements of the revised regional strategies:[25]

- Establishing an effective disease and vector surveillance system based on reliable laboratory and health information systems;
- Ensuring early recognition and effective case management of DHF/DSS to prevent case mortality;
- Undertaking disease prevention and control through integrated vector management with community and intersectoral participation;
- Undertaking activities to achieve sustainable behavioural changes and partnerships;
- Establishing emergency response capacity to control outbreaks with appropriate medical services, vector control, communications and logistics and
- Strengthening regional and national capacities to undertake prevention and control of dengue and research related to epidemiology, disease and vector management and behavioural changes.

Dengue fever/dengue haemorrhagic fever (DF/DHF) is gaining an ever-increasing foothold in countries of South East Asia-epidemics of DHF are now recurring in 3-5year cycles in Indonesia, Myanmar and Thailand. This situation is a result of rapid urbanization, population movement and increased commercial activity consequent upon globalization. Whereas all four dengue viruses circulate in all the endemic countries of this region, in some countries no incidence of the disease has yet been reported; these include the Democratic People's Republic of Korea, and Bhutan and Nepal in the Himalayan ranges where vectors of the disease have, however, been detected in towns located in the foothill regions.[1,31]

Research activities in South East Asia have led to great strides in the case management of DHF, including research carried out at Queen Sirikit's Institute of Child Health in Thailand, a WHO Collaborating Centre for Clinical Management of Dengue. Results from studies on pathogenesis and clinical management have been used effectively in referral hospitals to reduce the case fatality rate from 10-15% (40% in some areas) in the early 1950s to less than 0.5% today. In order to detect the severity of dengue early, other research in Thailand emphasized the identification of several critical clinical events during the course of the disease. And research in the area of diagnosis resulted in the development of an improved serological test, the IgM capture ELISA test, which has now become the standard test in laboratories all over the world. This research in Thailand led to the development of WHO guidelines for the clinical diagnosis and management of DHF where facilities are minimal, in small hospitals at district level.[1]

For control of dengue in South East Asia, the different countries have developed various control strategies to reduce the disease burden in their communities. Indonesia, Myanmar, Sri Lanka and Thailand, for instance, have organized formal national level programmes, whereas India, Bangladesh, and Maldives have placed ad hoc arrangements under the responsibility of the national vector borne diseases control programmes. The different approaches to control of dengue are largely community based; they involve control of the vector through source reduction of breeding places. These activities have been found to be particularly successful when carried out by school children and women's organizations backed by inter-sectoral support. Before developing local management methods using environmental interventions however, there is a need for research to identify and map the breeding sites in endemic areas; otherwise, lack of knowledge about the use of preventive actions in the different environmental/epidemiological situations means that vector control strategies may not be optimal. In this respect, WHO's South East Asia Regional Office (WHO/SEARO) has developed guidelines to help strengthen prevention and control, and has organized reviews of the dengue control programs in Indonesia and Thailand with a view to strengthening the national programs.[1]

Another line of research being followed vigorously in Thailand is aimed at developing an effective vaccine against DF/DHF. A tetravalent (effective against all four dengue viruses), live, attenuated dengue vaccine has been successfully developed by Mahidol University with the support of WHO. Phase I and II clinical trials of this vaccine in adults are now taking place.[1, 30]

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