







2012–2020

GLOBAL STRATEGY FOR DENGUE PREVENTION AND CONTROL

World Health Organization

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FOREWORD

In just the past decade, the significance of dengue as a threat to health and a burden on health services and economies has increased substantially. Compared with the situation 50 years ago, the worldwide incidence of dengue has risen 30-fold. More countries are reporting their first outbreaks. More outbreaks are explosive in ways that severely disrupt societies and drain economies. Today, dengue ranks as the most important mosquito-borne viral disease in the world. Everywhere, the human and economic costs are staggering.

In a sense, this neglected tropical disease has taken the world by surprise, with few coherent and coordinated efforts, at national or international levels, undertaken to hold dengue at bay and reverse these alarming trends. The Global strategy for dengue prevention and control, 2012–2020, aims to correct this situation. It answers requests, by multiple WHO Member States, for advice on how to move from a reactive response to an emergency situation to proactive risk assessment, early warning systems, and preventive measures, guided by entomological as well as epidemiological surveillance.

Above all, the Global strategy emphasizes the many new opportunities, opened by country experiences and recent research, also on vaccines, that can be seized to reduce morbidity and mortality, rationalize the disease response, and build capacities that increase resilience to future outbreaks. To this end, the document also serves as an investment case, spelling out the steps that can be taken to improve risk assessment and mapping, stockpiling and logistics, surveillance and diagnostic capacity, behavioural and social interventions, and risk communication.

A complex disease like dengue demands a multi-pronged response that engages government ministries well beyond the health sector. The Global strategy promotes coordinated action among multisectoral partners, an integrated approach to vector management, and sustained control measures at all levels. Its guiding principle is to harmonize prevention, entomological and epidemiological surveillance, and case management with existing health systems, ensuring that efforts are coherent, sustainable, cost-effective and ecologically sound.

This is a global strategy for a global threat. As we have learned, dengue and its vectors travel well internationally. I challenge all partners to study the strategy, define their role, and engage with a fully justified sense of urgency. As the strategy demonstrates, doing so will be highly rewarding. The overall message is upbeat and encouraging. Despite the complex clinical manifestations of this disease, its management is relatively simple, inexpensive and highly effective in saving lives, provided correct and timely interventions are instituted. When these interventions are in place, mortality from dengue can be reduced to zero. Let us make this our overarching – and broadly shared – goal.

Dr Margaret Chan
Director-General
World Health Organization

EXECUTIVE SUMMARY

Dengue is a major public-health concern throughout tropical and sub-tropical regions of the world. It is the most rapidly spreading mosquito-borne viral disease, with a 30-fold increase in global incidence over the past 50 years. The World Health Organization (WHO) estimates that 50–100 million dengue infections occur each year and that almost half the world's population lives in countries where dengue is endemic. While dengue is a global concern, with a steady increase in the number of countries reporting the disease, currently close to 75% of the global population exposed to dengue are in the Asia-Pacific region.

Epidemics of dengue result in human suffering, strained health services and massive economic losses. In some countries, the burden of dengue is comparable to that of tuberculosis and other communicable diseases with high disease burdens; unexpected surges in cases and the challenge to health systems of triaging thousands of cases without knowing which severe cases will require hospital care are additional challenges. There has not, however, been concerted action against dengue, and the 1995 WHO strategy[1] warrants revision in the light of new advances. This *Global strategy for dengue prevention and control, 2012–2020* aims to address this need.

The goal of the global strategy is to reduce the burden of dengue. The specific objectives are to reduce mortality and morbidity from dengue by 2020 by at least 50% and 25% respectively (using 2010 as the baseline). These objectives can be achieved by applying existing knowledge.

Dengue mortality can be reduced by implementing early case detection and appropriate management of severe cases; reorienting health services to identify early cases and manage dengue outbreaks effectively; and training health personnel, along with appropriate referral systems, at primary health-care levels.

Dengue morbidity can be reduced by implementing improved outbreak prediction and detection through coordinated epidemiological and entomological surveillance; promoting the principles of integrated vector management and deploying locally-adapted vector control measures including effective urban and household water management. Effective communication can achieve behavioural outcomes that augment prevention programmes.

Research will continue to play an important role in reversing the trend in dengue, a neglected tropical disease, by improving methods and systems for surveillance, prevention and control.

Reversing the trend requires commitments and obligations from partners, organizations and countries, as well as leadership by WHO and increased funding. Fund-raising is probably best addressed by a combined effort, with consideration for dengue as a public health problem in countries with substantial local and national funding resources that must be effectively channelled through sound technical support. Dengue prevention and management can now exploit opportunities presented by promising advances in vector control technology interventions, diagnostics, prognostic systems for triage, evidence-based clinical interventions and candidate vaccine developments. In order to realize these opportunities, we need to ensure they are implemented, coordinated and adequately resourced.

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[1] WHO (1996). *Report of the consultation on key issues in dengue vector control towards the operationalization of a global strategy, WHO, Geneva, 6–10 June 1995*. Geneva, World Health Organization (CTD/FIL(DEN)/IC/96.1).

1. DENGUE: A GLOBAL THREAT – GLOBAL ANSWERS

1.1 BURDEN OF THE DISEASE

In 2012, dengue ranks as the most important mosquito-borne viral disease in the world. Outbreaks exert a huge burden on populations, health systems and economies in most tropical countries of the world. The emergence and spread of all four dengue viruses ("serotypes") from Asia to the Americas, Africa and the Eastern Mediterranean regions represent a global pandemic threat. Although the full global burden of the disease is still uncertain, the patterns are alarming for both human health and the economy.

During the past five decades, the incidence of dengue has increased 30-fold (*Figure 1*). Some 50–100 million new infections are estimated to occur annually in more than 100 endemic countries (WHO, 2012a; *Figure 2*), with a documented further spread to previously unaffected areas (CDC, 2010; La Ruche G et al, 2010); every year hundreds of thousands of severe cases arise, including 20 000 deaths (Gubler DJ, Meltzer MI, 1999); 264 disability-adjusted life years per million population per year are lost (Cattand P et al, 2006), at an estimated cost for ambulatory and hospitalized cases of US$ 514–1394 (Suaya J et al, 2009), often affecting very poor populations. The true numbers are probably far worse, since severe underreporting and misclassification of dengue cases have been documented (Suaya J et al., 2007; Beatty ME et al. 2011).

Compared with other diseases and their respective burdens, dengue can cause as much or greater human suffering than other communicable diseases in some of the most affected regions. In Latin America and the Caribbean, for example, by the 1990s dengue was causing a similar burden of disease as meningitis, hepatitis, malaria, the childhood cluster of diseases (polio, measles, pertussis, diphtheria and tetanus) or tuberculosis (Meltzer et al., 1998). For South-East Asia, the burden of the disease was comparable with that of meningitis, having twice the burden of hepatitis and one third of the burden of HIV/AIDS (Shepard DS et al, 2004). For Africa, there are insufficient data from endemic countries to make even rough estimates of burden. In a recent publication 22 countries in Africa have reported sporadic cases or outbreaks of dengue from 1960-2010 (Amarasinghe A et al, 2011).

For individual countries, the importance of dengue as disease and public health problem cannot be overestimated, as seen in the recent explosive outbreaks of dengue in Brazil and Pakistan. In 2008, in Rio de Janeiro State alone, an outbreak caused more than 158 000 reported cases, over 9000 hospital admissions and 230 deaths between January and April (Barreto, 2008). This situation led to the military being deployed to help in the massive response, mostly involving improved health-care and vector control operations. A call for international aid was later formulated (Lancet editorial, 2008) – although it is estimated that

Figure 1. Average number of dengue and severe dengue cases reported to WHO annually in 1955–2007 and number of cases reported in recent years, 2008–2010

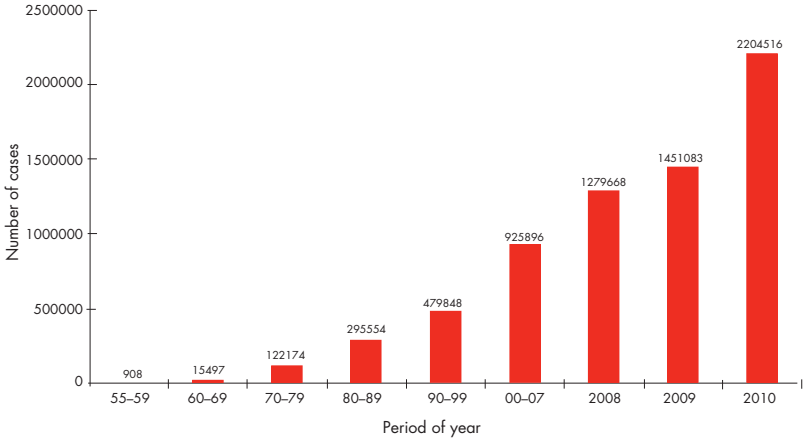
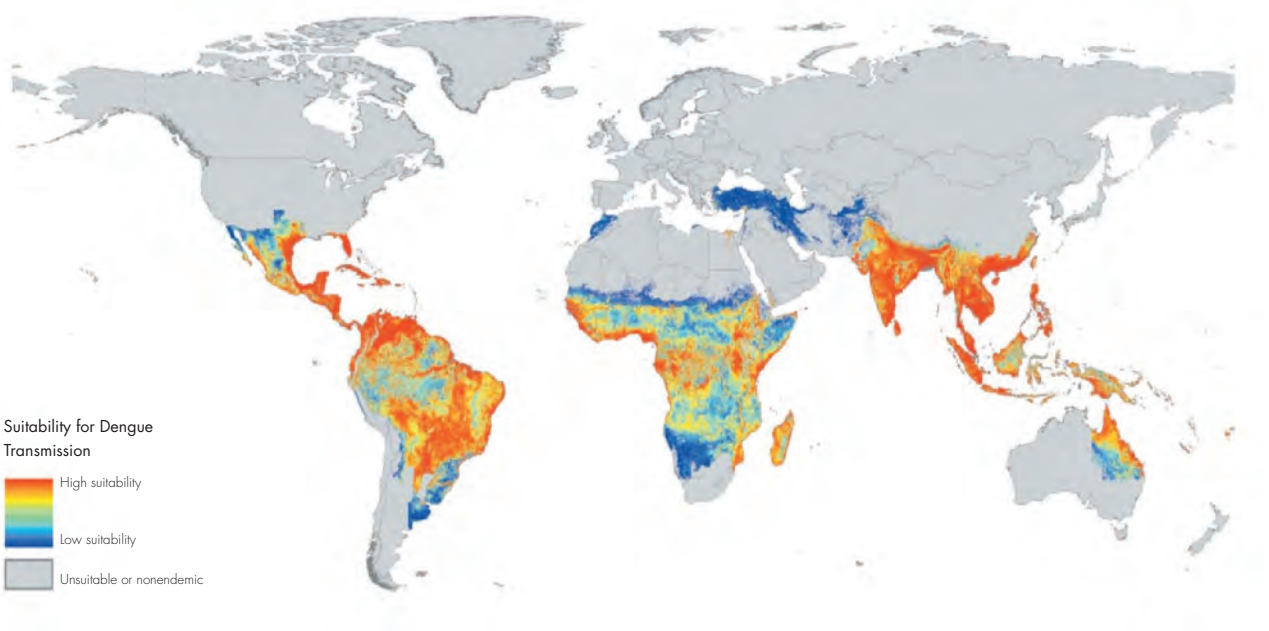


Figure 2. Distribution of global dengue risk (determination of risk status based on combined reports from WHO, the United States Centers for Disease Control and Prevention, Gideon online, ProMED, DengueMap, Eurosurveillance and published literature (Simmons CP et al, 2012).



US$1 billion was already being spent at the national level on dengue prevention and control. Despite these control efforts, in 2010 there were more than 1.2 million reported dengue cases in Brazil (CONASS, 2011), which is only one country cited as an example of the worsening global situation (*Figure 3*). *Annex 2* describes this worsening situation in five of WHO's six regions; Annex 3 details its underlying causes.

Given the importance of the global dengue epidemic, with its staggering human and economic costs, an international effort to reduce morbidity and mortality is long overdue. As a neglected tropical disease, little or no globally coordinated efforts have been undertaken. New opportunities to overcome the disease now make such an effort feasible.

The 2005 revision of the International Health Regulations (IHR) (WHO, 2005a), adopted by the Fifty-eighth World Health Assembly (resolution WHA58.3), includes dengue as an example of a disease that may constitute a public health emergency of international concern, with implications for health security due to disruption and rapid epidemic spread beyond national borders. Implementation of the IHR (2005) obliges countries to take routine and specific actions to build resilience against such epidemic-prone diseases. Such actions require investment in surveillance and preparedness capacity for early detection and reporting of disease outbreaks, and carrying out robust and timely public health responses for their containment and mitigation, including cross-border and wider international information sharing and collaboration. Hence, national commitments to dengue control are consistent with the aims and requirements of the IHR (2005). *Annex 3* highlights the global commitment to dengue prevention and control, as articulated in resolutions of the World Health Assembly and related resolutions.

This global strategy addresses the necessary steps and opportunities for investment in order to achieve the objective of reducing mortality and morbidity caused by dengue.

1.2 REVERSING THE TREND

This global strategy provides the technical elements and enabling factors for implementation that are necessary to reverse the growing trend in the number of dengue cases. Applying existing knowledge for dengue prevention and control will require collaboration among partners, organizations and countries, leadership by WHO and increased funding.

Dengue mortality can be reduced by implementing early case detection and referral systems for patients; managing severe cases with appropriate treatment; reorienting health services to cope with dengue outbreaks; and training health personnel at all levels of the health system.

Dengue morbidity can be reduced by implementing improved outbreak prediction and detection through coordinated epidemiological and entomological surveillance; promoting the principles of integrated vector management; deploying locally-adapted vector control measures, including effective urban and household water management; and through communication to achieve behavioural outcomes in prevention programmes.

Because dengue infection can cause a spectrum of disease manifestations, more accurate estimates of its true burden are essential to assess the progress of prevention measures. The enhanced surveillance systems and dedicated studies necessary for estimating true burden will not be possible in all endemic countries without additional investment.

Reversing the trend of the disease could be further supported by the anticipated availability of a dengue vaccine within the next few years. Drawing on the experiences of other vaccine-preventable vector-borne diseases, effective surveillance, prevention and outbreak response tools (vector control and vaccines) must continue to complement each other in reducing the burden of the disease. The main question for planning for dengue prevention and control is therefore how to integrate a vaccine with other prevention and control interventions. Increased research will play an important role in any strategy to reduce dengue incidence because, as a neglected tropical disease, dengue research has received relatively little support.

A hospitalized child with severe dengue

1.3 OPPORTUNITIES FOR INVESTMENT

Mortality from dengue can often be reduced to zero if severely ill patients access health services in time and receive appropriate clinical care. The technical knowledge for achieving this objective is available: implementation depends on capacity-building. Training in all affected countries must reach those health personnel involved in prevention and case management of dengue. The development and use of locally adapted public information materials can help families recognize the early warning signs of severe dengue so they seek medical care promptly. Countries with greater experience than others could be requested to participate in a South–South collaboration. It might also be necessary to assess how to reorganize a health-care services to better cope with dengue outbreaks.

With more countries experiencing recurrent and, in-some cases, large-scale dengue outbreaks, effective dengue outbreak prevention and control depends on a coherent approach. Intersectoral collaboration and coordination can formalize emergency response planning with stakeholders from diverse government ministries (health, environment, interior, education, etc.), municipal and local authorities, public and private sectors, and professional, religious and community representatives.

Dengue outbreaks are also of international concern and require global coordination of response efforts across national borders. Special needs for support include when countries are experiencing epidemics, when the

viruses appear in previously non-endemic regions and when a new serotype enters an endemic area.

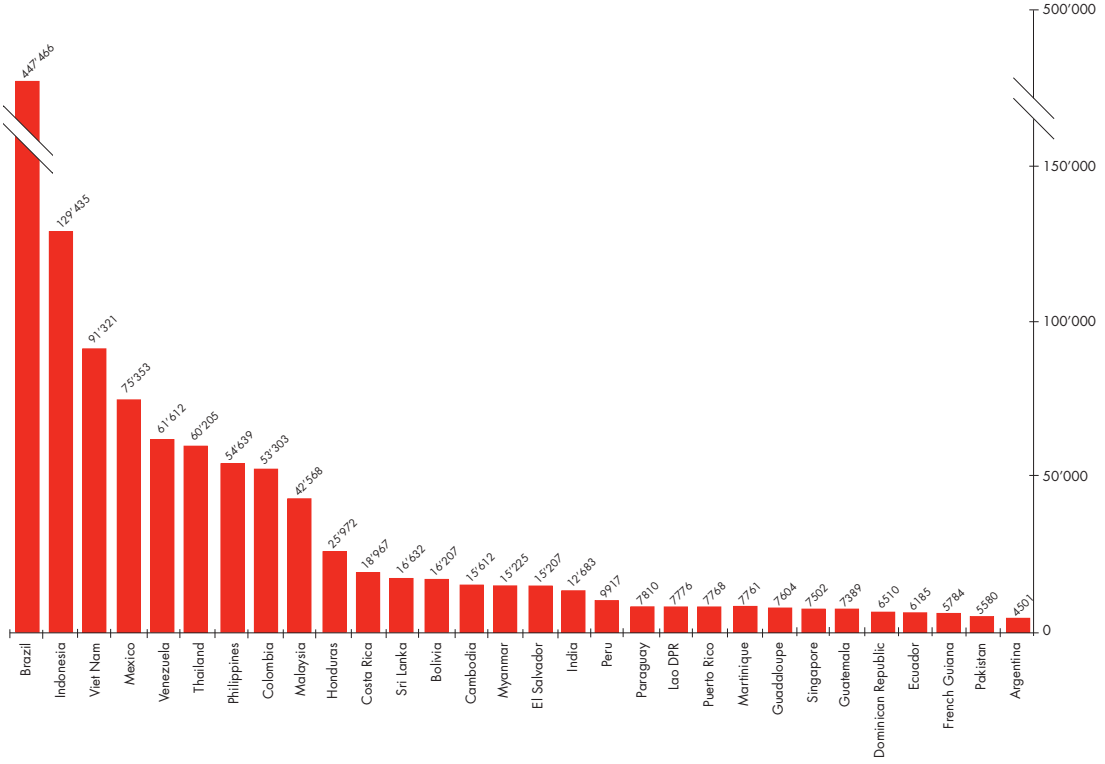
Investment in dengue preparedness and response, including risk assessment and mapping, stockpiling and logistics, surveillance and diagnostic capacity, behavioural and social interventions, and risk communication are all essential not only for early outbreak detection and rapid response, but also for implementing the IHR (2005) requirements to manage acute public health events.

A better estimate of the true burden of the disease needs to be addressed as a priority. Improved surveillance and the training to support it should be supported by national governments and coordinated by WHO.

Dengue research offers a unique opportunity for investment. Both basic and operational research are opportunities for international organizations and funding sources. Networks for research cooperation could offer opportunities to rapidly advance research with limited funding. To raise awareness and funds, an international effort led and supported by WHO is recommended.

Advocacy, fundraising, international collaboration and harmonization of regional efforts can be addressed by strong leadership from WHO and its regional and country offices. This should include an effort to measure the cost of implementing the global strategy at regional and national levels.

Figure 3. Average number of dengue cases in 30 most highly endemic countries/territories as reported to WHO, 2004–2010



2. THE GLOBAL STRATEGY FOR DENGUE PREVENTION AND CONTROL

2.1 GOAL AND OBJECTIVES

The goal of the global strategy is to reduce the burden of dengue. Its specific objectives are:

- to reduce dengue mortality by at least 50% by 2020;
- to reduce dengue morbidity by at least 25% by 2020;[1] and
- to estimate the true burden of the disease by 2015.

The target audience of the strategy is leaders in national control programmes, research and funding organizations and other stakeholders involved in dengue prevention and control (e.g. urban planners, water resources managers): Dengue is a global threat that requires a global response involving all possible partners.

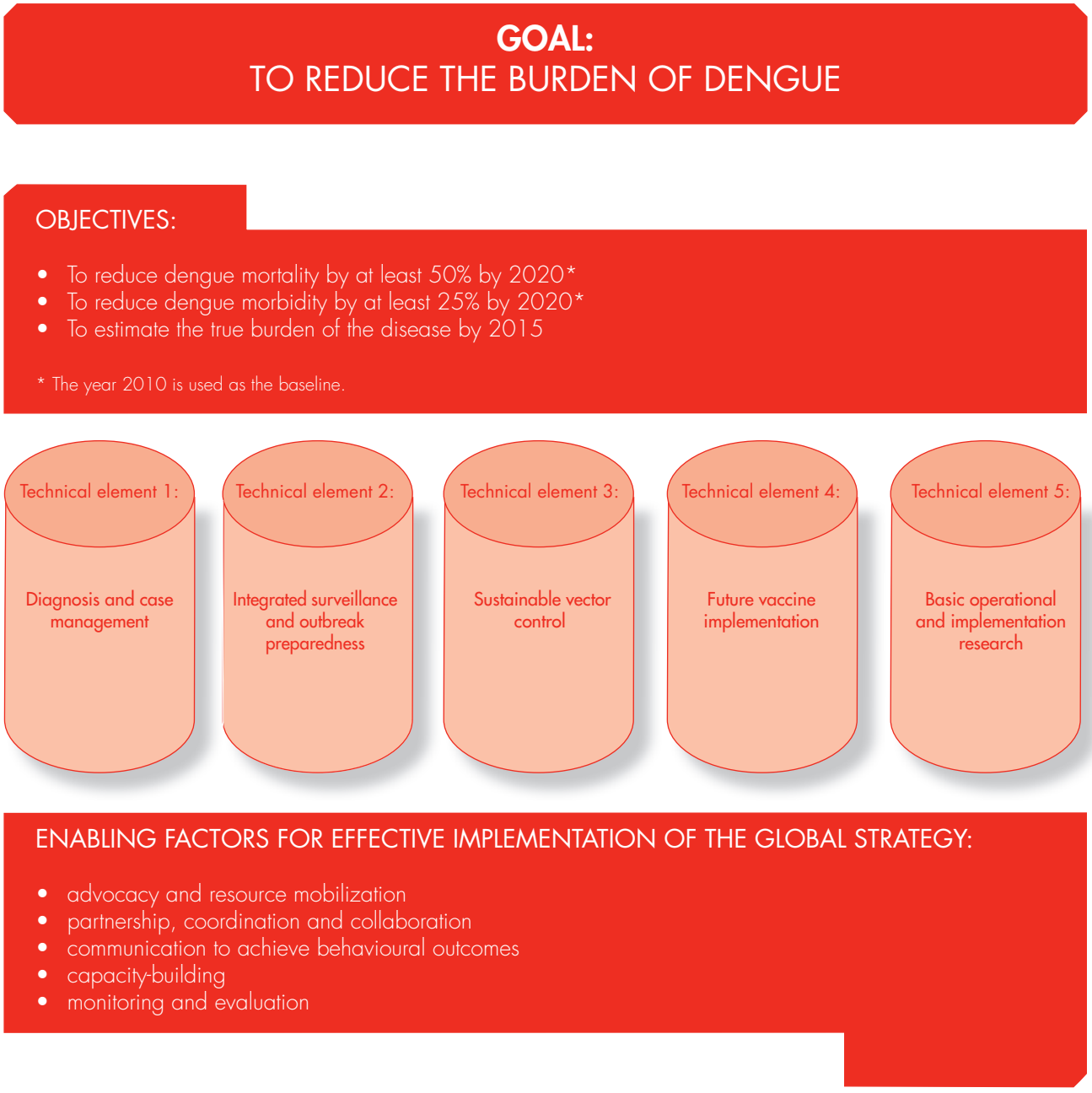
2.2 OVERVIEW OF TECHNICAL ELEMENTS AND ENABLING FACTORS FOR IMPLEMENTATION

The global strategy promotes coordination and collaboration among multisectoral partners, an integrated vector management approach and sustained control measures at all levels. Its guiding principle is to harmonize prevention, surveillance (entomological and epidemiological) and case management with existing health systems, such that they are sustainable, cost-effective and ecologically sound. This strategy should pave the way for reducing dengue morbidity and mortality worldwide through strengthened local and national capabilities and regional coordination. Mobilization and allocation of resources will also be crucial for successful implementation of the strategy *(Figure 4)*.

DENGUE IS ONE OF THE 17 NEGLECTED TROPICAL DISEASES (NTD) ADDRESSED IN THE NTD ROADMAP.

[1] The year 2010 is used as a baseline.

Figure 4. The global strategy for dengue prevention and control, 2012–2020



3. TECHNICAL ELEMENTS

3.1 DIAGNOSIS AND CASE MANAGEMENT

Mortality from dengue can be reduced to almost zero by implementing timely, appropriate clinical management, which involves early clinical and laboratory diagnosis, intravenous rehydration, staff training and hospital reorganization. The following technical elements are a prerequisite to achieving the first objective of the strategy: to reduce dengue mortality by at least 50% by 2020.

A successful clinical outcome requires efficient and early diagnosis of cases provided by accurate differential diagnosis, rapid laboratory assessment/confirmation, and early response to severe disease. Clinical incidence data are critical to mobilizing outbreak control. Research to provide better diagnostics and biomarkers predicting disease severity are urgently needed.

Dengue infection has a wide clinical spectrum that includes both severe and mild manifestations. Many viraemic infections may be inapparent. After the incubation period, the illness begins abruptly and is followed by three phases: febrile, critical and recovery (WHO, 2009). For a disease that is complex in its manifestations, management is relatively simple, inexpensive and highly effective in saving lives provided correct and timely interventions are instituted. The key is early recognition and understanding of the clinical problems during the different phases, leading to a rational approach to case management and a good clinical outcome. This is especially so for the treatment of plasma leakage with oral or intravenous rehydration. For mortality from dengue, investigations are necessary to establish the primary cause of deaths (including autopsies).

Laboratory confirmation of dengue virus infection is important. Although in practice diagnosis is often made by clinical signs and symptoms only, dengue can be confused clinically with other vector-borne viral and parasitic diseases, such as malaria and chikungunya and zika viruses. Diagnosis may involve detection of the virus, viral nucleic acid, antigens or antibodies, or a combination of these entities. Laboratory tests using NS1 (non-structural protein 1) antigen can provide early diagnosis in febrile patients. After the onset of illness, the virus can be detected in serum, plasma, circulating blood cells and other tissues for 4–5 days. During the acute stage of the disease, virus isolation, nucleic acid or antigen detection can be used to diagnose the infection. At the end of the acute phase of infection, serology is the method of choice for diagnosis. Serological assays to detect specific immunoglobulin M (IgM) or immunoglobulin G (IgG) antibodies to dengue virus are widely available, and WHO has taken a leading role in coordinating the production of standardized panels for comparison. These assays can provide an alternative to virus isolation or polymerase chain reaction to support the diagnosis of dengue fever. First-time (primary) dengue virus infections typically have

MORTALITY FROM DENGUE CAN BE REDUCED TO ALMOST ZERO BY IMPLEMENTING TIMELY, APPROPRIATE CLINICAL MANAGEMENT, WHICH INVOLVES EARLY CLINICAL AND LABORATORY DIAGNOSIS, INTRAVENOUS REHYDRATION, STAFF TRAINING AND HOSPITAL REORGANIZATION.

a stronger and more specific IgM response; subsequent (secondary) infections show a weaker IgM response but a strong IgG response. These differing IgM response patterns to infection underscore the need to evaluate the sensitivity and specificity of commercially available tests, especially for diagnosis of secondary dengue virus infections. Research is necessary, however, for improved and less expensive dengue diagnostics.

Activities (triage and management decisions) at the primary and secondary care levels, where patients are first seen and evaluated, are critical in determining the clinical outcome of dengue (*Table 1*). A well-managed front-line response not only reduces the number of unnecessary hospital admissions but also saves the lives of severe dengue patients. Early notification of dengue cases seen in primary and secondary care facilities as well as commonly accepted definition of outbreak indicators ("triggers") are crucial for identifying outbreaks and initiating an early response. Systems of reference and counter-reference between different levels of health-care delivery services need to be established. There are no biomarkers for predicting which admissions are likely to develop severe disease, but studies to establish the predictive value of clinical and laboratory "warning signs" for severe dengue are under way. Research is necessary also for the treatment of plasma leakage with co-morbidities and in pregnancy.

Training is a crucial element in all areas of dengue case management, but especially for training of all medical and non-medical staff involved in dengue clinical management. Factors such as staff turnover and career path should be considered when planning the frequency

Table 1. Possible levels of dengue diagnostic tests and other functions in health centres

	Primary health centres	District centres	Reference centre
Dengue diagnostic tests			
– Virus culture			+
– Nucleic acid detection			+
– Antigen detection	+	+	+
• ELISA		+	+
• Rapid tests	+	+	+
– Serology			
• ELISA		+	+
• Rapid tests	+	+	+
Other functions			
– Training and supervision		+	+
– Quality assurance	+	+	+
– Surveillance activities	+	+	+
– Outbreak investigations			+
– Referral of problem specimens	+	+	+
– Investigation of problem specimens			+

of such training. Communities should be made aware of early signs and symptoms in order to improve their health-care-seeking behaviour.

In order for countries to achieve zero mortality from dengue, a country must:

Improve case management and diagnosis to prevent deaths from dengue

- improve early clinical case detection, especially for dengue with warning signs and severe dengue;
- improve management of severe cases with appropriate interventions especially careful intravenous rehydration and a greater evidence base for interventions.

Improve capacities to facilitate a reduction in the burden of the disease

- improve health service organization, including access and triage in endemic countries to prevent dengue deaths;
- improve health service reorganization for managing outbreak situations;
- build capacity and establish quality assurance in both the private and the public sector;
- develop evidence-based informed training material, including dengue courses;
- prepare for the arrival of vaccines and their public health implications, bearing in mind the challenges of widespread implementation.

3.2 INTEGRATED SURVEILLANCE AND OUTBREAK PREPAREDNESS

Surveillance is a critical component of any dengue prevention and control programme because it provides the information necessary for risk assessment and programme guidance, including epidemic response and programme evaluation. This technical element of the global strategy plays an important role in implementing and measuring its objectives, especially the objective of improving the estimate of the burden of dengue by 2015.

The overall objectives of public health surveillance that are most applicable to dengue are:

- to detect epidemics rapidly for early intervention;
- to measure the burden of the disease and provide data for the assessment of its social and economic impacts on affected communities;
- to monitor trends in the distribution and spread of dengue over time and geographically;
- to monitor environmental risk factors and to collaborate where possible with monitoring of other water, sanitation and hygiene-related diseases;
- to evaluate the effectiveness of dengue prevention and control programmes; and
- to facilitate planning and resource allocation on the basis of lessons learnt from programme evaluation.

Crowded hospital wards during a dengue outbreak

Surveillance can utilize both passive and active data collection processes, as well as those of event-based surveillance (further details in section 4.5), and also information related to social and economic impact. It is fundamental for setting goals and evaluating success. Understanding the spatial and temporal distribution of dengue cases and the entomological correlates of risk in given situations would allow planners to deploy resources to areas where they would have the greatest impact on reducing the disease. Although both entomological and epidemiological surveillance data have often been collected in countries, there are few instances in which health services integrate and fully utilize such information to control an outbreak and prevent its expansion. Surveillance activities should, ideally, include the rapid detection of human infection supported by valid clinical and laboratory diagnosis, vector surveillance, and monitoring of environmental and social risk factors for dengue epidemics to ensure that increased dengue transmission is detected early and that the response is rapid and appropriate. In order to achieve dengue surveillance, a country should:

Improve surveillance to enhance reporting, prevention and control of dengue

- improve country capacity to report on disease surveillance indicators – for clinical reasons, a minimum set of indicators should be reporting the number of dengue cases with clinical diagnosis, severe dengue cases and the number of dengue deaths. According to country necessities, further indicators may be collected;
- improve country capacity to report on environmental risk indicators, including mosquito breeding sites (i.e. household water storage containers, poor urban water drainage) and appropriate environmental control measures that are associated with lower mosquito indices (i.e. tightly fitting water storage lids, presence of fish or other biological control measures, and regular cleaning containers (Phuanukoonnon, et al., 2005);
- given the challenges of collecting national data, sentinel sites should be established and age-stratified seroprevalence and burden of disease (including economic costs) studies should be initiated. Serotype changes should be monitored continuously.

3.2.1 INTEGRATED SURVEILLANCE

The surveillance system for dengue should be a part of the national health information system, with a set of core indicators monitored at various levels of the health administration. Such a health information system is "an integrated effort to collect, process, report and use health information and knowledge to influence policy-making, programme action and research"[1]. Data quality also needs to be monitored and assessed periodically. Some countries already have a routine health information system and a parallel epidemic disease monitoring system for greater efficiency and decision-making at local, provincial, national and regional levels.

THE SURVEILLANCE SYSTEM FOR DENGUE SHOULD BE A PART OF THE NATIONAL HEALTH INFORMATION SYSTEM, WITH A SET OF CORE INDICATORS MONITORED AT VARIOUS LEVELS OF THE HEALTH ADMINISTRATION.

[1] Health Matrix Network is a WHO-hosted global partnership dedicated to strengthening health information.

A HARMONIZED EFFORT ACROSS NATIONAL DENGUE SURVEILLANCE SYSTEMS IS NEEDED FOR TO OBTAIN THE CRITICAL DATA OF THE DISEASE'S BURDEN NECESSARY TO ASSESS PROGRESS IN REACHING MORTALITY AND MORBIDITY REDUCTION GOALS.

A harmonized effort across national dengue surveillance systems is needed to obtain the critical data of the disease's burden necessary to assess progress in reaching mortality and morbidity reduction goals. The data currently generated by national surveillance programmes are highly variable and in some known endemic regions, such as Africa, almost no data exist on incidence.

Using a tiered system, detailed serotype-specific incidence data could be obtained from a small number of local, population-based studies at well-characterized sites in different regions of the world. The next level of data could come from sentinel hospitals with high-quality diagnostic capabilities that capture dengue cases from a broader geographical range. Country-wide dengue infection data could be obtained with universally standardized syndromic methods and clinical diagnosis, when possible. Using data from this tiered system, national and regional estimates of disease burden could be extrapolated from data collected in the different catchment systems. Efforts should focus on capturing the entire spectrum of disease (suspected, laboratory confirmed and severe cases of dengue).

3.2.2 OUTBREAK PREPAREDNESS

Outbreak preparedness is an important technical and operational element of the overall strategy. An effective response is based on well-developed contingency plans that are broadly disseminated and thoroughly understood and pre-tested before an epidemic. The plan should include relevant sectors and agencies. Important response components will include the logistic capability to deal with the inflow of patients, medical supplies and facilities, administration, political issues, vector control efforts and communication with participating partners and the mass media.

The dengue response plan should clearly articulate its aims, objectives and scope, the lead (coordinating) agency, the organizational links with other agencies that have direct responsibility for implementing aspects of the plan, and the "support" agencies (for example, social welfare agencies) that may be more involved in the recovery phase after an epidemic. Each agency should be assigned specific roles and responsibilities under the plan, and costs and resources should be identified.

The 10 priority areas for planning dengue emergency response, adapted from Rigau-Pérez and Clark (2005), are to:

1. Establish a multisectoral dengue action committee
2. Formalize an emergency action plan
3. Enhance disease surveillance
4. Perform diagnostic laboratory testing
5. Enhance vector surveillance and control
6. Protect special populations and reduce the impact of environmental determinants
7. Ensure appropriate patient care
8. Engage the community and relevant professional groups about dengue control as well as their participation in dengue prevention and control
9. Investigate the epidemic
10. Manage the mass media.

Lessons learnt from large numbers of international public health emergencies led to the revision of the IHR. The IHR (2005) emphasizes national capacity to monitor,

AN EFFECTIVE RESPONSE IS BASED ON WELL-DEVELOPED CONTINGENCY PLANS THAT ARE BROADLY DISSEMINATED AND THOROUGHLY UNDERSTOOD AND PRE-TESTED BEFORE AN EPIDEMIC.

identify and assess risks, and target preparedness planning and operational capacity, in order to rapidly detect outbreaks and respond in a timely manner.

Dengue activity may require consultation with, or notification to, WHO under the IHR (2005) (WHO, 2005a), depending on the risk assessment. For example, dengue activity may warrant communication with WHO in instances such as the first confirmation of locally-acquired dengue in a previously disease-free area, a newly predominant serotype or vector, atypical clinical presentations or excessively high case-fatality rates.

Rapid verification, risk assessment and information-sharing are critical to WHO coordination of the Global Outbreak Alert and Response Network (GOARN) and effective international response to major outbreaks. At the request of a member State, WHO rapidly deploys international GOARN teams of experts to the affected areas to integrate and coordinate activities in support of national efforts. There is recognition of the strong technical leadership and unique role of national and international nongovernmental organizations, particularly in reaching poor populations. This rapid response could be used as a mechanism to build global and local capacity to improve preparedness and reduce future vulnerability:

For countries in which dengue is endemic, the overall aim of an emergency plan is to reduce the risk of dengue transmission and to strengthen and sustain control measures thereby minimizing the clinical, social and economic impacts of the disease. Monitoring and evaluation should be planned and implemented to assess the impact of all interventions.

For countries in which dengue vectors are present without circulating virus, risk management plans should focus on strategies to reduce the risk of transmission. These should include rapid investigation of sporadic cases (clinically suspected or laboratory confirmed) to determine whether they are imported or locally-acquired, regular monitoring of vectors and their abundance (particularly in regions with recorded or suspected cases), social mobilization and integrated vector management. Once a locally-acquired case is confirmed, the response may be escalated to epidemic response to prevent further spread and/or interruption of transmission.

For countries in which there is risk of introducing dengue vectors, the focus of preparedness planning and activities should be on entomological surveillance

Space spraying for dengue vector control

at points of entry (ports, airports, ground crossing) and education of the health-care providers and the community about the risk of dengue in travellers, and its diagnosis and reporting requirements.

3.3 SUSTAINABLE VECTOR CONTROL

Effective vector control measures are critical to achieving and sustaining reduction of morbidity attributable to dengue. Preventive and vector control interventions aim to reduce dengue transmission, thereby decreasing the incidence of the infection and preventing outbreaks of the disease.

The mosquito *Aedes aegypti* is the primary vector of dengue. It has evolved to mate, feed, rest and lay eggs in and around urban human habitation. *Aedes aegypti* is a daytime feeder; its peak biting periods are early in the morning and before dusk in the evening. Female *Aedes aegypti* frequently bites multiple people during each feeding period.

The mosquito *Aedes albopictus*, a secondary dengue vector in Asia, has spread to North America and Europe largely due to the international trade in used tyres (a breeding habitat) and other goods (eg. lucky bamboo). Its spread is due to its tolerance to temperatures below freezing; it is able to hibernate and take shelter in microhabitats. Apart from these two well-established species, *Aedes polynesiensis* (in French Polynesia, the Cook Islands and Wallis and Futuna) and *Aedes scutellaris* (in New Guinea) have been shown to be vectors. (Rodhain F, Rosen L, 1997). *Aedes hensilli* was identified as an epidemic vector in the Federated States of Micronesia (Savage et al., 1998). *Aedes furcifer* and *Aedes luteocephalus* are among probable sylvatic vectors in western Africa.

There are well-documented historical examples of both yellow fever and dengue being eliminated or significantly reduced through *Ae. aegypti* control. More recently, Singapore and Cuba greatly reduced dengue transmission by enacting anti-Aedes legislation and through sustained actions against the vector (Gubler DJ, 2011).

Epidemic-prone countries typically initiate vector control measures after the onset of an epidemic which is too late to achieve significant impact. Endemic countries, on the other hand, too often carry out routine short-term interventions, which are neither sustained nor evaluated. Any successful control effort must be centred on the ability to sustain the intervention with sound monitoring and evaluation.

Control of dengue vectors has mainly been approached by source reduction: the elimination of containers that are favourable sites for oviposition and development of the aquatic stages. This can sometimes be accomplished by fitting lids or covers on containers or by killing the aquatic stages using insecticides. Some insecticides combine persistence in efficacy (thus requiring less frequent re-treatment) with absence of taste when

EFFECTIVE VECTOR CONTROL MEASURES ARE CRITICAL TO ACHIEVING AND SUSTAINING REDUCTION OF MORBIDITY ATTRIBUTABLE TO DENGUE. PREVENTIVE AND VECTOR CONTROL INTERVENTIONS AIM TO REDUCE DENGUE TRANSMISSION, THEREBY DECREASING THE INCIDENCE OF THE INFECTION AND PREVENTING OUTBREAKS OF THE DISEASE.

applied to potable water, and may improve community acceptance. Carrying out pupal surveys in human habitations can identify which containers are most productive; treating only these productive containers can be as effective as dealing with all containers (Tun-Lin W et al, 2009). The ability of the vector, however to exploit unconventional sites to lay eggs should not be underestimated. In the past few years, for example, breeding has been found in septic tanks in Puerto Rico and in rooftop gutters in Singapore. The degree to which immature populations must be reduced, short of total elimination, to significantly reduce incidence is seldom known for any endemic locality, compromising a potentially useful index of entomological surveillance.

Although insecticide space-spraying is recommended for vector control in epidemics, its efficacy in other situations has not been well documented (Ekpereonne E et al, 2010). Delivery of indoor space spraying is highly labour-intensive and, in most locations, it is impractical in the event of an outbreak.

Residual surface treatments of insecticides are intended to reduce the density of vectors and their longevity. Although indoor residual spraying is frequently successful against malaria vectors, its effect on *Aedes*, which often do not rest on interior walls is uncertain. Further research is required on the effect of residual insecticides on curtains, container covers, screens and other materials which often have good community acceptability. In general, methods that improve the ability to deliver persistent treatments more rapidly and efficiently into large urban communities in a sustained way are urgently needed.

The evolution and spread of resistance to insecticides is a major concern for the control of dengue vectors. Bioassay data demonstrate that resistance to organophosphates (temephos) and pyrethroids is widespread in *Ae. aegypti*, and resistance has also been reported in Ae. albopictus. Assessing the impact of insecticide resistance on vector control is complicated by variations in the methodology used to measure and report resistance, and by the lack of studies on the epidemiological consequences of insecticide resistance (Ranson H et al, 2009). Monitoring resistance is necessary to ensure that effective insecticides are being used and that changes in insecticide policy are based on sound scientific data. Monitoring must be well coordinated at the local level with other vector-borne disease control programmes and usage of insecticides in agriculture.

Innovative vector control tools are badly needed (Morisson AC et al., 2008) .Some recent developments in the pipeline are: insecticide-treated materials; lethal ovitraps; spatial repellents; genetically modified mosquitoes; and Wolbachia-infected Aedes. Some of these new tools could play a significant role in long-term dengue prevention and control strategies of Member

Used tires proliferate dengue vector breeding

States. Periodic monitoring and evaluation of all stages of vector suppression must ensure that appropriate standards are met; they are crucial to maximize efficacy and efficiency of the global strategy. Methods to assess the impact of vector interventions need to be established while those for risk assessment and response improved. Reliable, practical, standardized vector surveillance methods and entomological correlates of virus transmission (for example, entomological inoculation rate) are required.

Countries should adopt the integrated vector management approach to vector control as promoted by WHO (WHO, 2004, 2012c). Defined as a rational decision-making process to optimize the use of resources for vector control, it aims to improve efficacy, cost effectiveness, ecological soundness and sustainability of vector control interventions. Dengue vector control is most amenable to the implementation of the principles of integrated vector management, which ensure judicious use of insecticides in combination with other interventions.

COUNTRIES SHOULD ADOPT THE INTEGRATED VECTOR MANAGEMENT APPROACH TO VECTOR CONTROL AS PROMOTED BY WHO (WHO, 2004, 2012C). DEFINED AS A RATIONAL DECISION-MAKING PROCESS TO OPTIMIZE THE USE OF RESOURCES FOR VECTOR CONTROL, IT AIMS TO IMPROVE EFFICACY, COST EFFECTIVENESS, ECOLOGICAL SOUNDNESS AND SUSTAINABILITY OF VECTOR CONTROL INTERVENTIONS. DENGUE VECTOR CONTROL IS MOST AMENABLE TO THE IMPLEMENTATION OF THE PRINCIPLES OF INTEGRATED VECTOR MANAGEMENT, WHICH ENSURE JUDICIOUS USE OF INSECTICIDES IN COMBINATION WITH OTHER PREVENTION AND CONTROL INTERVENTIONS.

3.4 FUTURE VACCINE IMPLEMENTATION

The availability of a safe, efficacious and cost-effective vaccine would significantly alter the concept for dengue prevention. As the global spread of dengue persists, vaccine development has received increasing interest and support by researchers, vaccine manufacturers, policy-makers and funding agencies. But as has been repeatedly demonstrated, even a perfect vaccine is only as good as our ability to deliver it. Planning for the most effective implementation of vaccine delivery is a technical element that should begin to be addressed now.

The most advanced vaccine candidate, which is based on live-attenuated chimeric yellow fever-dengue virus, has progressed to phase III clinical trials (Guy B et al., 2011). Several other live-attenuated vaccines, as well as a subunit and a DNA vaccine, are in earlier stages of clinical development (Coller BA, 2011). Additional technological approaches, such as virus-vectored and inactivated vaccines, are under evaluation in preclinical studies (Schmitz J et al., 2011). Challenges to vaccine development include the need to provide protection against all four dengue viruses, as well as resolving questions about the immune correlates of protection. While proof of concept of vaccine efficacy is currently still missing, successful progression of ongoing efficacy trials could lead to the availability of a vaccine in 2–4 years.

Current dengue prevention and control strategies should therefore include vaccines as an important element to

anticipate and prepare for. This includes preparing for future decision-making on vaccine introduction and use, considering the integration of vaccines with other tools for dengue prevention and control, and investments in surveillance systems and safety monitoring of vaccines.

In order to provide guidance to national regulatory agencies and manufacturers on vaccine evaluation and registration, WHO has published Guidelines on the quality, safety and efficacy of dengue tetravalent vaccines (live, attenuated) (WHO, 2012b). These guidelines cover issues concerning manufacturing and quality control, pre-clinical development, and clinical evaluation of the first generation of live-attenuated dengue vaccines. Updates will likely be required as second-generation vaccines become available, which may be based on different technologies. Long-term safety and effectiveness of dengue vaccines will require particularly careful assessment. This includes the follow-up of vaccine trial participants for several years' post-vaccination, special post-licensure studies, and surveillance systems capable of monitoring vaccine impact on dengue epidemiology and its disease burden. In anticipation of vaccine licensure and introduction in at least some endemic countries in the near-term future, there is a need to ensure strong regulatory and surveillance capacity in endemic countries.

Evidence-based decision-making on the introduction of vaccines and their use will require not only reliable data on vaccine product characteristics (e.g. safety, efficacy, cost) but also information on effective vaccination strategies, their likely impact on disease burden and cost effectiveness. Moreover, various issues related to vaccine implementation (e.g. integration into the national immunization programme; logistics of vaccine storage and transport; financing and supply) will have to be addressed (WHO, 2005b).

Assuming proof of concept is met, some of the challenges for vaccine delivery are already evident: (i) the population at risk of dengue is huge and occurs throughout the tropics. It will be necessary for endemic countries to have rational means for deciding which segments of the population to protect when national resources or vaccine supply are limited; (ii) ease of delivery and cost will limit implementation. Ideally, a vaccine will be administered as a single dose, will protect against all four viruses, and will have a long duration of efficacy with no significant side-effects. In reality, some or all of these ideals will not be met. A vaccine that requires multiple doses, for example, or which cannot be incorporated in an expanded programme on immunization will require supplementary investments into delivery infrastructure; (iii) post-approval studies, monitoring of vaccinated populations and strong regulatory competency in dengue-endemic countries will be needed; (iv) the role of vector control, surveillance and case management in enhancing the impact of the vaccine must be determined. Although each country will require a different combination, some basic guidance for decision-making must be developed; (v) there is a possibility that dengue could be eliminated from some regions, such as islands or low endemic areas. How and where such a special target could be reached should be determined.

- Key considerations for countries in the development and implementation of vaccination strategies include the choice of target populations (e.g. age groups, location), delivery approaches (e.g. routine immunization, catch-up campaigns), vaccination schedules and overall immunization coverage in the population.
- Mathematical modelling approaches have been developed, which may contribute to informing the design of optimal dengue immunization strategies (WHO, 2011; Johansson MA, Hombach J, Cummings DA, 2011).
- Finally, it will be important to ensure that dengue vaccination strategies are well integrated with other interventions for dengue prevention and control.

3.5 BASIC, OPERATIONAL AND IMPLEMENTATION RESEARCH

Supporting all objectives of the strategy, and basic, operational and implementation research are needed. All partners should emphasize the value of research, and promote and support the efforts at all levels.

Dengue prevention and control programmes would be empowered with more effective tools. Research should address how the efficacy, cost-effectiveness, sustainability and scaling up of existing and promising new control methods can be enhanced. New diagnostic tools and means of vector control are needed. More effective approaches to fostering sustained community participation are also needed. Some core areas for research are:

- Improving clinical management of severe cases through locally-adapted training curricula that increase accurate clinical diagnosis. Research is also needed on, for example, alternate methods of fluid management, dealing with dengue in pregnancy and with co-morbidities, and better guidance on use of blood products.
- Developing specific and sensitive tests that can be used at point-of-care clinics to diagnose cases as early as possible; improving and standardizing quality control of currently available and future rapid diagnostic tests; identifying biomarkers of severe disease.
- Improving management of early epidemic response by national health services, including models for the rapid relay and analysis of information. Means of improving the coordination of vector control and medical assets during preparedness and response.
- Determining sensitive indicators of increased risk for dengue outbreaks as early warning signals. Defining risk factors for human infection, for example, the contribution of people with asymptomatic infections to transmission and/or the proximity of Ae. aegypti breeding sites to populations. Defining the relationship between mosquito parameters and transmission risk, and between vector interventions and epidemiological outcomes. Establishing action thresholds according to the epidemiological situation and developing tools for managing outbreak preparedness and response.
- Research on transmission dynamics, including evaluating the impact of virus population structure, urbanization and other land-use changes, human behavioural interactions and climate parameters on dengue epidemiology. Developing models to quantify combined vaccine and vector control approaches on transmission.
- Operational research, including the improvement of cost-effective implementation strategies, scaling-up of successful local interventions, evaluation protocols for effectiveness of human and entomological surveillance, household water management, conditions favouring sustained human behavioural change, models for identifying vulnerable groups or geographical localities, and evaluation of settings in selecting approaches (e.g. schools, workplaces, religious establishments).
- Integrated management of insecticide resistance among dengue vectors using non-insecticidal methods, rotation of insecticides, standardizing contemporary methods for detection and management of resistance, assessing the impact of resistance on dengue prevention programmes, and monitoring the role of unregulated and

broad-spectrum usage of insecticides (e.g. agricultural pest, nuisance fly control, household products) and its possible role in insecticide resistance.

- Development of more effective tools to prevent and control outbreaks of dengue by non-insecticidal methods (e.g. effective urban drainage), suppression of mosquito populations and their possible elimination through attractant traps, repellents, genetically modified mosquitoes, Wolbachia-based approaches, , insecticide-treated materials and rapid delivery of insecticide into houses where mosquitoes rest and bite people.
- Development and evaluation of dengue vaccines and their integration with existing interventions. In particular there is a need to address gaps in our knowledge about vaccine efficacy, long-term safety and effectiveness, immune correlates of protection, possible booster needs, herd immunity and co-administration with other vaccines; it is important to begin to develop optimal immunization strategies (including target populations, delivery approaches, vaccination schedules, immunization coverage); and strategies for integrating dengue vaccination with other dengue prevention and control methods.

MONITORING RESISTANCE IS NECESSARY TO ENSURE THAT EFFECTIVE INSECTICIDES ARE BEING USED AND THAT CHANGES IN INSECTICIDE POLICY ARE BASED ON SOUND SCIENTIFIC DATA.

4. ENABLING FACTORS FOR IMPLEMENTATION

Successful implementation of the global strategy requires five enabling factors: (i) advocacy and resource mobilization; (ii) partnership, coordination and collaboration; (iii) communication to achieve behavioural outcomes; (iv) capacity-building; and (v) monitoring and evaluation. At the national level, these elements require greater collaboration at all levels of government and other sectors; globally, implementation requires concerted action by Member States, effective global leadership and appropriate engagement of all relevant stakeholders.

4.1 ADVOCACY AND RESOURCE MOBILIZATION

For dengue prevention and control there is very little international advocacy or successful funding efforts. Whereas some research organizations are successfully raising funds for focused research work, almost no money is available for international control efforts. This funding gap affects all areas where international response could help, such as outbreak preparedness and response, development of training material, organization of training courses and support of research networks.

WHO should lead the global advocacy effort. It should coordinate with regional and country offices to develop and implement advocacy plans to increase the political support and resource mobilization needed for implementing the strategies and plans for the Americas and Asia-Pacific regions; and it should also assist in building relevant capacities in the African, Eastern Mediterranean and European regions. WHO is uniquely placed to encourage and facilitate closer integration of dengue surveillance and epidemic mitigation with the syndromic approaches required by the IHR (2005) (WHO, 2005a), particularly as it pertains to a common case definition and to harmonized data collection, analysis and dissemination. Advocacy packages for political support and resource mobilization need to be developed at regional and country levels. It would be ideal to focus efforts on dengue by using high-profile public figures as champions for the cause at national levels and utilize existing regional and global collaborations to promote the effort widely. An example of a regional initiative is the ASEAN (Association of South East Asian Nations) countries' decision to commemorate "ASEAN Dengue Day" on 15 June every year. Special advocacy campaigns should target the public sector, the private sector (including water and sanitation and related infrastructure) and sectors involved in developing new products for dengue prevention and control.

4.2 PARTNERSHIP, COORDINATION AND COLLABORATION

Dengue is the classic 21st century disease, driven by an urban adapted mosquito and easily transported by infected people or the vector through increasing

SPECIAL ADVOCACY CAMPAIGNS SHOULD TARGET THE PUBLIC SECTOR, THE PRIVATE SECTOR (INCLUDING WATER AND SANITATION AND RELATED INFRASTRUCTURE) AND SECTORS INVOLVED IN DEVELOPING NEW PRODUCTS FOR DENGUE PREVENTION AND CONTROL.

trade, changing land use and expanding urbanization. Successful dengue control programmes are characterized by multisectoral and interagency preparedness and response. Unfortunately, this is not often the case in most countries, and this approach should be promoted and encouraged at all levels in every endemic country. Equally important, internationally, different organizations working in dengue control or research are often not connected: development of networks for partnership, coordination and collaboration is highly desirable.

Dengue prevention and control needs an effective intersectoral approach, requiring coordination between the lead ministry (usually the Ministry of Health) and other relevant ministries and governmental agencies, the private sector (including private health-care providers), nongovernmental organizations and local communities. Resource sharing is an important aspect of coordination, and is critical in emergency situations when scarce or widely dispersed human and material resources must be mobilized rapidly and their use coordinated to mitigate the effects of an epidemic.

Coordination with urban planning and water resources management is especially important for prevention efforts and to reduce dengue morbidity. The projected rapid increases in urban populations in dengue-endemic countries further highlights the need for concurrent increases in improved and reliable supplies of piped drinking-water and sanitation in order to prevent water storage, reduce urban breeding sites and improve drainage, including near community water collection points.

Intersectoral and intra-sectoral collaboration among partners is key to the successful implementation of the global strategy. Networking facilitates a more coordinated approach than the individual and independent efforts of different sectors or departments, and provides a platform for partners to resolve cross- and intra-agency issues and to share best practices while reducing duplication of efforts. Networking for dengue control also helps to leverage the strengths of partners and to synergize their efforts, thereby enhancing the effectiveness and efficiency of actions for dengue prevention and control. Effective surveillance systems, for example, require networking among technical agencies and personnel who collect data and process data and who can assist in establishing sentinel sites. In many countries, inter-ministerial or inter-departmental activities remain a challenge due to a lack of attention to building relationships and hierarchal structures within the ministry, which must be addressed at the highest political level.

A dengue task force or steering committee is set up in many countries but is often activated only at times of epidemics. In order to effectively implement the global strategy, members of the taskforce should have relevant technical expertise and decision-making authority and should meet regularly to evaluate and monitor progress and provide strategic oversight. A greater level of cohesion among partners will be achieved by focusing efforts on team building and improved communication skills. Building partnerships with industry and allied sectors (such as water, sanitation and infrastructure development agencies) can prevent vector proliferation through product development and shared best practices. WHO needs to support efforts at harmonizing case definitions, data collection and processing, dissemination of data and cross-border exchange of information among Member countries at subregional and regional levels.

4.3 COMMUNICATION TO ACHIEVE BEHAVIOURAL OUTCOMES

Communication is integral to every activity needed to implement the technical elements in this strategy document. Dengue cases and dengue deaths can be reduced only through the behavioral actions of

those responsible for designing and implementing dengue prevention and control programmes, and by the adoption of risk reduction and health protection behaviors by the populations at risk. Knowledge is a prerequisite for action but it does not always convince and persuade people to act. Communication for Behavioural Impact (COMBI) is a systematic planning methodology adopted by WHO to design and implement behaviourally-focused communication strategies for modifying behaviours associated with dengue and other vector-borne diseases. Examples of how COMBI might be used in dengue prevention and control programmes include enhancing community mobilization for source reduction, appropriate use of household insecticides, appropriate and timely use of health services, diagnosis and reporting of dengue cases, and acceptance of dengue vaccination when it becomes recommended.

WHO needs to advocate for behavioural outcomes to partners and Member States and should include a section on communication to achieve it in all relevant documents (dengue and vector-borne diseases).

Awareness and capacity should be created at all programme levels to support:

- formative or inquiry research, which is conducted to identify existing behaviours that promote or impede programme outcomes;
- functional internal communication and behaviours related to programme outcomes (e.g. better coordination of each technical element or intervention, programme interaction with the at-risk population); and
- effective external communication and behaviours related to population outcomes (e.g. reduced disease, reduced deaths, crafting messages and their dissemination through mass media and other channels).

4.3.1 COMMUNICATION IN OUTBREAK RESPONSE

Effective communication linked to promoting specific, measurable, appropriate, realistic and time-bound (SMART) outbreak prevention and control behaviours are vital for:

- policy makers and senior managers to prioritize interventions and allocate resources (people, funds, supplies) so that teams on the ground might respond appropriately and rapidly;
- event managers to gather the intelligence data from many sources needed for assessing the event and identifying whether interventions are working and what technical inputs are needed to bring the event under control;
- rapid response and outbreak investigation teams to talk with health care workers, patients, public health officials, NGOs and response partners to rapidly assess the problem and implement appropriate control and prevention measures;
- risk communication staff, to design and implement appropriate risk communication strategies to prepare national systems, stakeholders and partners for response; and
- social mobilization and health promotion staff to design and implement behavioural and social interventions that will prepare communities for potential public health measures and to promote risk reduction.

Training of staff at national and regional levels must be coordinated and an inventory of expertise should be available for use as and when needed.

4.4 CAPACITY-BUILDING

Capacity-building has been neglected at all levels of dengue prevention and control. Ongoing efforts, such as training courses often are not sustained or scaled-up to the national level. Effective implementation of the global strategy requires adequate staff with access to appropriate equipment and facilities, and the knowledge, competencies and skills to effectively execute, monitor and evaluate the dengue control programme. Programme management should be strengthened for effective sustainable dengue prevention and control.

Social scientists and communication specialists, public health entomologists, vector control personnel, epidemiologists, diagnostic laboratory staff, and health-care personnal play essential roles and need to work together. Training activities, including in-service training, should be tailored to the needs of the various groups of personnel, integrate adult learning techniques and focus on improving the performance of multidisciplinary teams. WHO has published guidance on several components of dengue control programmes such as diagnosis, case management, prevention and control, and communication strategies. Efforts must be made to adapt these documents for local needs at country and regional levels. Wider dissemination of available materials would significantly benefit all stakeholders and avoid duplication of efforts (*Annex 4*).

4.4.1 STRENGTHENING LOCAL MANAGEMENT CAPABILITIES FOR INFORMED DECISION-MAKING

Local health systems are increasingly responsible a wide variety of disease prevention and control activities. However, they are generally not prepared for the management of dengue outbreaks and resources (human, technical and financial) are insufficient. "Table top" or simulation exercises should be developed by WHO for use at the local level. The sometimes long inter-epidemic periods are a challenge to maintaining response management expertise. Managers need support from their superiors so that dengue prevention and control activities continue to receive appropriate attention within the broader communicable disease control programme. Decision-makers, planners and programme managers have many other responsibilities and may not know how to prioritize control and outbreak measures with adequate safeguard to manage potential changes in the epidemiology of the disease. They need access to a panel of technical experts to inform their decision-making.

Sustainability and continuity of control measures are essential. Dengue prevention and control needs a more participatory approach at the local level, and key decision-makers need to forge partnerships with community leaders for better communication and collaboration. There is a need to recognize and use when possible the existing networks for responding to public health emergencies that can extend from government to community level. Ministries of health services at the local level should also integrate key components (surveillance, entomology, environment, communication, laboratory) for better decision-making and efficient use of resources. In order to ensure implementation and sustainability of control programmes at the local level, the national regulation (on vector control or pesticides) may be adapted to integrate surveillance and control measures as mandatory contributions of local authorities (including community leaders) to the national plan.

4.5 MONITORING AND EVALUATION

A functional monitoring and evaluation system is vital to the successful implementation of the dengue strategy. Monitoring and evaluation guides the planning and implementation of the global strategy, assesses its effectiveness, identifies areas for improvement and optimizes the use of resources.

Monitoring and evaluation is a very weak link in nearly all dengue programmes and needs to be strengthened and integrated urgently. Relevant training programmes are available at both the national and international levels.

The combination of monitoring and evaluation allows the identification of successes and shortcomings, from which lessons learnt, can inform decision-making. A major challenge is to identify indicators for use at each level of the health system that can be measured objectively and systematically. At decentralized levels of the system, indicators for resource use, processes, behaviour, epidemiology, and entomology need to be developed by Member States.

The use of one national system to collect, analyse, interpret and use monitoring and evaluation data is encouraged to reduce the reporting burden. Improving the quality and consistency of information requires, common indicators, clear data collection methods, and uniform analysis and interpretation.

WHO collects a minimum set of dengue indicators from Member States, which include:

- number of suspected dengue cases,
- number of severe dengue cases,
- number of deaths from suspected and confirmed severe dengue,
- number of cases confirmed by the laboratory, and
- serotype in circulation.

The global strategy needs to standardize indicators. Although the best assessment of the dengue burden and its trends today must rely on a combination of suspected cases and confirmed data, accurate surveillance should be the ultimate goal for programmes. Routine surveillance has two particular advantages for estimating case incidence, spatially and through time. Data compiled annually allow for the effects of changes in the array of factors that influence dengue outbreaks and prevalence from place to place (at the level of cities, provinces, etc.) and from year to year, especially the factors linked to climatic variation, serotype change and control interventions. For these reasons, monitoring and evaluation is critical and should be a key component for dengue surveillance programmes, systems that provide guidance and risk assessment, and outbreak response plans. WHO should coordinate metrics for surveillance and assessment through the selection of well-characterized field sites where the variables can be defined and by developing epidemiological metrics and methods for their estimation (e.g. vector thresholds, virus prevalence and/or incidence).

REFERENCES

Amarasinghe A et al (2011). Dengue virus infection in Africa. Emerging Infectious Diseases, 17:1349–1354.

Arimaa Y, Matsui T (2011). Epidemiologic update of dengue in the Western Pacific Region, 2010. Western Pacific Surveillance and Response Journal, 2:4–9.

Barreto ML, Teixeira MG (2008). Dengue fever: a call for local, national, and international action. Lancet, 372: 205.

Beatty ME et al (2011). Health economics of dengue: A systematic literature review and expert panel's assessment. American Journal of Tropical Medicine and Hygiene, 84:473–488.

Cattand P et al (2006). Tropical diseases lacking adequate control measures: dengue, leishmaniasis, and African trypanosomiasis. In: Disease control priorities in developing countries, 2nd ed. New York, Oxford University Press:451–466.

CDC (2010). Locally acquired dengue – Key West, Florida, 2009–2010. Morbidity and Mortality Weekly Report, 59:577–581.

Coller BA, Clements DE (2011). Dengue vaccines: progress and challenges. Current Opinion in Immunology, 23:391–398.

CONASS (2011). Dengue situação atual, desafios e estratégias para enfrentamento [Dengue: present situation, challenges and strategies for confronting it]. Brazil Conselho Nacional de Secretários de Saúde (also available at: http://www.conass.org.br/; accessed April 2012).

Ekpereonne E et al (2010). Effectiveness of peridomestic space spraying with insecticide on dengue transmission; systematic review. Tropical Medicine and International Health, 15:619–631.

Gubler DJ, Meltzer MI (1999). Impact of dengue/dengue hemorrhagic fever on the developing world. Advances in Virus Research, 53:35–70.

Gubler DJ (2011). Prevention and control of Aedes aegypti-borne disease: lesson learned from past successes and failures. Asia Pacific Journal of Molecular Biology and Biotechnology, 19:111–114.

Guy B et al (2011). From research to phase III: preclinical, industrial and clinical development of the Sanofi Pasteur tetravalent dengue vaccine. Vaccine, 29, 7229–7241.

La Ruche G et al (2010). First two autochthonous dengue virus infections in metropolitan France, September 2010, Eurosurveillance, 15, Issue 39, 30 September 2010.

Johansson MA, Hombach J, Cummings DA (2011). Models of the impact of dengue vaccines: A review of current research and potential approaches. Vaccine, 29:5860–5868.

Meltzer MI et al (1998). Using disability-adjusted life years to assess the economic impact of dengue in Puerto Rico: 1984–1994. American Journal of Tropical Medicine and Hygiene, 59:265–271.

Morrison AC et al., (2008). Defining challenges and proposing solutions for control of the virus vector *Aedes aegypti*. *PLoS Medecine,* 2008, 18: 5(3):e68.

Nathan MB, Dayal-Drager R (2007). Recent epidemiological trends, the global strategy and public health advances in dengue [working paper 3.1]. In: Report of the Scientific Working Group meeting on Dengue, Geneva, 1–5 October 2006. Geneva, World Health Organization, Special Programme for Research and Training in Tropical Diseases: 29–34.

NTD/VEM (2008). Capacity development to meet the supply–demand gap in public health entomology. A working paper for the WHO Neglected Tropical Diseases Strategic and Technical Advisory Group, 17-18 April 2008. Geneva, World Health Organization.

Phuanukoonnon S et al (2005). Effectiveness of dengue control practices in household water containers in Northeast Thailand. Tropical Medicine and International Health, 10:755–763.

PAHO (1997). Plan continental de ampliación e intensificación del combate al Aedes aegypti. Informe de un grupo de trabajo, Caracas, Venezuela. Abril 1997 [Continental Plan of expansion and intensification of the fight against Aedes aegypti. Report of a working group, Caracas, Venezuela, 1997]. Washington, DC, Pan American Health Organization, (also available at: http://www.paho.org/Spanish/AD/DPC/CD/doc407.pdf; accessed April 2012).

Ranson H et al (2009). Insecticide resistance in dengue vectors. TropIKA Reviews (also available at: http://www.tropika.net/svc/review/Chinnock-20100601-Review-Dengue-Insecticides; accessed April 2012).

Rigau-Pérez JG, Clark GG (2005). Còmo responder a una epidemia de dengue: vision global y experiencia en Puerto Rico [How to respond to a dengue outbreak: global vision and experience in Puerto Rico]. Pan American Journal of Public Health, 17:282–293.

Rodhain F, Rosen L (1997). Mosquito vectors and dengue virus–vector relationships. In: Gubler DJ, Kano G, eds. Dengue and dengue haemorrhagic fever. CAB International Wallingford, Oxon, UK:45–60.

San Martin JL et al (2010). The epidemiology of dengue in the Americas over the last three decades: a worrisome reality. American Journal of Tropical Medicine and Hygiene, 82:128–135.

Savage HM et al (1998). Epidemic of dengue-4 virus in Yap State, Federated States of Micronesia, and implication of Aedes hensilli as an epidemic vector. American Journal of Tropical Medicine and Hygiene, 58:519–524.

Schmitz J et al (2011). Next generation dengue vaccines: a review of candidates in preclinical development. Vaccine, 29:7276–7284.

SEARO/WHO (2011). Comprehensive guidelines for prevention and control of dengue and dengue haemorrhagic fever [revised and expanded edition]. New Delhi, WHO Regional Office for South-East Asia (also available at: http://www.searo.who.int/en/Section10/Section332/Section554.htm; accessed April 2012).

Shepard DS et al (2004). Cost-effectiveness of a paediatric dengue vaccine. Vaccine, 22:1275–1280.

Simmons CP et al (2012). Dengue. New England Journal of Medicine, 366:1423–1432.

Suaya J, Shepard DS, Beatty ME (2007). Dengue: burden of disease and costs of illness [working paper 3.2]. In: Report of the Scientific Working Group meeting on Dengue, Geneva, 1–5 October 2006. Geneva, World Health Organization, Special Programme for Research and Training in Tropical Diseases:35–49.

Suaya J et al (2009). Cost of dengue cases in eight countries in the Americas and Asia: a prospective study. American Journal of Tropical Medicine and Hygiene, 80:846–855.

Lancet editorial (2008). International action needed on dengue, Lancet, 371:1216.

Townson H et al (2005). Exploiting the potential of vector control for disease prevention. Bulletin of the World Health Organization, 83:942–947.

Tun-Lin W et al (2009). Reducing costs and operational constraints of dengue vector control by targeting productive breeding places: a multi-country non-inferiority cluster randomized trial. Tropical Medicine and International Health, 14:1143–1153.

UNFPA (2008). State of world population 2007: unleashing the potential of urban growth. New York, United Nations Population Fund (also available at: http://www.unfpa.org/swp/2007/english/introduction.html; accessed April 2012).

WHO (2002). Dengue fever and dengue haemorrhagic fever prevention and control. World Health Assembly Resolution WHA55.19, adopted by the 55th World Health Assembly, 2002 (http://apps.who.int/gb/archive/pdf_files/WHA55/ea5519.pdf).

WHO (2004). Global strategic framework for integrated vector management. Geneva. World Health Organization (WHO/CDS/CPE/PVC/2004.10; also available at:
(http://whqlibdoc.who.int/hq/2004/WHO_CDS_CPE_PVC_2004_10.pdf; accessed April 2012)

WHO (2005a). Revision of the International Health Regulations. World Health Assembly Resolution WHA58.3, adopted by the 58th World Health Assembly, 2005 (http://apps.who.int/gb/ebwha/pdf_files/WHA58-REC1/english/Resolutions.pdf).

WHO (2005b). Vaccine introduction guidelines – adding a vaccine to national immunization programme: decision and implementation. Geneva, World Health Organization (also available at:http://whqlibdoc.who.int/hq/2005/WHO_IVB_05.18.pdf; accessed April 2012).

WHO (2007). Everybody's business – strengthening health systems to improve health outcomes: WHO's framework for action. Geneva, World Health Organization (also available at: http://www.who.int/healthsystems/strategy/everybodys_business.pdf; accessed April 2012).

WHO (2009). Dengue: guidelines for diagnosis, treatment, prevention and control. Geneva, World Health Organization (also available at: http://whqlibdoc.who.int/publications/2009/9789241547871_eng.pdf; accessed April 2012).

WHO (2011). Report of the meeting of the WHO/VMI workshop on dengue modeling. Geneva, World Health Organization (also available at: http://whqlibdoc.who.int/hq/2011/WHO_IVB_11.02_eng.pdf; accessed April 2012).

WHO (2012a). Dengue and severe dengue [factsheet no. 117, revised January 2012]. Geneva, World Health Organization
(also available at: http://www.who.int/mediacentre/factsheets/fs117/en/; accessed April 2012).

WHO (2012b). Guidelines on the quality, safety and efficacy of dengue tetravalent vaccines (live, attenuated) [in press]. Geneva, World Health Organization (WHO/BS/11.2159).

WHO (2012c). Handbook for integrated vector management. Geneva, World Health Organization.

WHO/UNICEF (2008). Progress on drinking-water and sanitation: special focus on sanitation. New York, United Nations Children's Fund and Geneva, World Health Organization, 2008 (also available at: http://www.who.int/water_sanitation_health/monitoring/jmp2008.pdf; accessed April 2012).

ANNEXES

ANNEX 1. THE WORSENING GLOBAL DENGUE SITUATION

Ancestral dengue apparently arose in West Africa, where a sylvatic cycle still exists, but surveillance data from the WHO African Region are inadequate. Outbreak reports are available, especially from the east coastal regions, but are incomplete, and there is evidence that dengue outbreaks are increasing in size and frequency (Nathan MB et. al, 2007). For example, dengue has recently been confirmed as a leading cause of febrile illness among African peacekeepers assigned to Somalia. Dengue is not officially reported to WHO by countries in the region.

During 1960–2010, a total of 22 countries in Africa reported sporadic cases or outbreaks of dengue; 12 other countries in Africa reported dengue only in travellers. The presence of disease and high prevalence of antibody to dengue virus in limited serological surveys suggest endemic dengue virus infection in all or many parts of Africa. Dengue is likely under recognized and underreported in Africa because of low awareness by health-care providers, other prevalent febrile illnesses (especially malaria), and lack of diagnostic testing and systematic surveillance. Other hypotheses to explain low reported numbers of cases include cross-protection from other endemic flavivirus infections, genetic host factors protecting against infection of the disease, and low vector competence and transmission efficiency (Amarasinghe A et al., 2011).

Interruption of dengue transmission in much of the Region of the Americas resulted from the Ae. aegypti eradication campaign in the Americas, mainly during the 1960s and early 1970s. However, vector surveillance and control measures were not sustained and there were subsequent reinfestations of the mosquito, followed by outbreaks in the Caribbean, and in Central and South America (PAHO, 1997). In response to this situation, the region developed guidelines for the prevention and control of dengue (PAHO, 1997). The region has evolved from a low dengue endemic state to a hyperendemic state with indigenous transmission now observed in almost all countries. A PAHO initiative – the integrated management strategy for dengue prevention – seems to be the most promising approach for disease control (San Martin JL et al., 2010).

Dengue is 'endemic' in many countries in the South-East Asia Region although there is significant variation between countries and within each country. At present, the Democratic People's Republic of Korea is the only country in the region that has no reports of indigenous dengue cases. Cases of dengue typically vary throughout the year and assume a regular pattern, normally in association with changes of temperature and rainfall. In different countries the seasonal pattern of dengue differs, high numbers of cases occur in India between August and November, in Indonesia, the peak is in January to February and in Myanmar and Sri Lanka increased numbers of cases are reported between May and August. Severe dengue is endemic in most of the countries of the South-East Asia Region (SEARO/WHO, 2011).

In the Western Pacific Region, although the number of reported cases dropped to around 50 000 annually in 1999 and 2000 after the large epidemic in 1998, dengue has again increased in overall activity over the past decade. In 2010, countries and areas reported a total of 353 907 cases, of which 1073 people died, for a case-fatality ratio of 0.30%. While incidence of dengue was largest in the Lao People's Democratic

Republic, the total numbers of cases and deaths reported were largest for the Philippines. The island nations have been especially susceptible to epidemics, as have happened in 2011 in Micronesia and the Marshall Islands. Increases in reported number of cases in other areas, such as Singapore and Malaysia, appear to indicate sustained epidemic activity in those countries. The continued epidemic dengue activity in the Region highlights the need for timely and routine regional sharing of information (Arimaa Y, Matsui T, 2011).

In the European Region, the last dengue epidemic was reported from 1926 to 1928 in Greece with high mortality and Ae. aegypti was the vector and since then the transmission of the disease was not reported. However the 1990s has witnessed a rapid establishment of the mosquito Aedes albopictus (considered as a secondary vector of dengue) mainly through global trade of used tires (and, to a lesser extent, of lucky bamboo). Ae. albopictus has become increasingly established in European Union Member States, including France, Greece, Italy, Slovenia and Spain. This mosquito species is also established in other European countries such as Albania, Bosnia and Herzegovina, Croatia, Monaco, Montenegro, San Marino, Switzerland and the Vatican City. The threat of possible outbreaks of dengue fever now exists in Europe, and local transmission of dengue was reported for the first time in France and Croatia in 2010; imported cases were detected in several other European countries.

Dengue is regarded as an emerging disease in the Eastern Mediterranean Region, laboratory confirmed cases being first reported officially to WHO only in the past two decades. Generally, cases have been detected along the coast lines of countries facing the Red Sea and Arabian Sea, and in Pakistan. The current situation of these diseases in countries of the Region can be stratified as follows:

- Group A: Saudi Arabia, Pakistan and Yemen, where the disease is emerging as a major public health problem, there have been repeated outbreaks in the past two decades in urban centres (and reports that the disease is spreading to rural areas in Pakistan and Yemen); The city of Lahore (Pakistan) had a major outbreak in 2011 with over 300 deaths.
- Group B: Sudan, Djibouti and Somalia, where small outbreaks of the disease are becoming more frequent, multiple virus serotypes are co-circulating, and it is likely that the disease is expanding geographically within these countries;
- Group C: Oman, where imported cases have been reported but there is no evidence of endemicity or local transmission of the disease;
- Group D: other countries, where the disease has not yet appeared and inability of the surveillance system to detect occurrence of the disease in these countries cannot be ruled out.

ANNEX 2. UNDERLYING CAUSES OF THE WORSENING GLOBAL DENGUE SITUATION

Determinants for the rise of dengue

The increasing incidence, severity and frequency of dengue epidemics are linked to trends in human ecology, demography and globalization, and may have been influenced by climate change.

Demographic trends and urbanization

According to the United Nations, the number of people living in urban environments surpassed that of the rural populace for the first time in 2008 (UNFPA, 2008). Unplanned urbanization creates an environment that is associated with the proliferation of a range of disease vectors. Substandard housing, inadequate water supply, solid waste and sewerage systems all favour the establishment of larval habitats of Ae. aegypti. Between 1990 and 2006, the urban population without improved drinking-water sources increased from 107 million to 137 million (WHO/UNICEF, 2008). The high human population density and close proximity to larval habitats ensure an intimacy between the virus, vector and human host. Although dengue is most closely associated with poor and crowded urban and periurban areas, it also affects more affluent neighbourhoods of tropical and sub-tropical countries, and there is evidence of increasing rural transmission. Dengue is closely linked to human behaviour, water storage practices and rapid population movement.

Transportation and trade

Increasing mobility within cities, between cities and between countries and continents collectively contribute to enhanced risk of vector-borne disease outbreaks (and many other communicable diseases), and in the specific case of dengue, increasing disease severity associated with the spread of multiple virus serotypes.

International travel and trade are also facilitating the geographical spread of disease vectors. *Ae. albopictus*, an Asian mosquito which is also a vector of dengue and chikungunya, is now widespread in the Americas, Africa and Europe, due in large part to the international trade in used tires (which, when they contain water, are suitable oviposition sites for egg-laying females). Moreover Ae. albopictus has been incriminated as a vector most recently in Europe, where, for the first time, an outbreak of Chikungunya occurred in northern Italy in 2007 and dengue outbreaks in France and Croatia in 2010.

Climate change

Not only are vector-borne diseases highly sensitive to changes in temperature and precipitation, but, particularly in the case of urban vector-borne diseases, also to changes in human behaviour. As a consequence of climate change, the endemicity of vector-borne diseases will change and epidemics could occur in areas presently unaccustomed to them and hitherto unprepared for responding robustly to such events. However, the accuracy and predictability of the models that seek to determine the future epidemiological impact of climate change on such diseases remain a source of considerable uncertainty and debate.

Capacity-building and intersectoral coordination

In recent decades there has been a decline in management and technical expertise in vector control in most WHO regions, at least in part as the result of failure to adapt to the decentralization of health services and a dearth of career path opportunities for medical entomologists. These growing deficiencies compromise national capacities to adequately implement routine vector surveillance and control operations and to effectively respond to epidemics (Townson H et al, 2005; NTD/VEM, 2008). In addition, most of the

disease-control programmes in countries are organized vertically within the Ministry of Health and, in some cases, the Ministry of the Environment. In all these cases, intersectoral coordination and effective implementation remain a challenge. Some of the local factors impeding effective dengue prevention and control are:

- inadequate capacity (human resources, funds and development and implementation of basic outbreak response plan);
- significant gaps in knowledge in diagnosis, case management and vector control;
- lack of evidence-based decision making at policy and programme levels; and
- limited intersectoral collaboration.

ANNEX 3. GLOBAL COMMITMENT: WORLD HEALTH ASSEMBLY AND RELATED RESOLUTIONS

The Global strategic framework for dengue prevention and control provides a basis for strengthening specific activities in a manner that is compatible with national health systems and the epidemiology of the disease. Member States have expressed their opinions and deliberated the burden of the disease in several WHO regional committees and assemblies (see textbox below). WHO is the only United Nations agency to address dengue and mosquito-borne arboviral diseases and, in line with this endorsement, has to scale up activities and reduce the global burden of this disease.

CHRONOLOGICAL LIST OF WORLD HEALTH ASSEMBLY RESOLUTIONS AND REGIONAL COMMITTEE RESOLUTIONS ADOPTED SINCE 2000

WORLD HEALTH ASSEMBLY

2002 – WHA55: Dengue fever and dengue haemorrhagic fever prevention and Control (WHA55.17)

2005 – WHA58: Revision of the International Health Regulations (WHA58.3)

REGIONAL COMMITTEE RESOLUTIONS

2001 – PAHO: Dengue and Dengue Haemorrhagic fever (CD43.R4)

2008 – SEAR: Dengue prevention and control (SEA/RC61/R5)

2008 – WPR: Dengue fever and dengue haemorrhagic fever prevention and Control (WPR/RC59.R6)

2011 – EMR: Dengue: call for urgent interventions for a rapidly expanding emerging Disease (EM/RC/58.R4)

REGULAR TECHNICAL UPDATES TO REGIONAL COMMITTEE MEETINGS

ANNEX 4. WHO WEB SITES FOR RELEVANT DOCUMENTS AND INFORMATION

World Health Organization:
http://www.who.int/denguecontrol/en/

Pan American Health Organization Regional Office of the World Health Organization:
http://new.paho.org/hq/index.php?option=com_content&task=view&id=264&Itemid=363

WHO Regional Office for South-East Asia:
http://www.searo.who.int/EN/Section10/Section332.htm

WHO Regional Office for the Western Pacific:
http://www.wpro.who.int/topics/dengue/en/

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