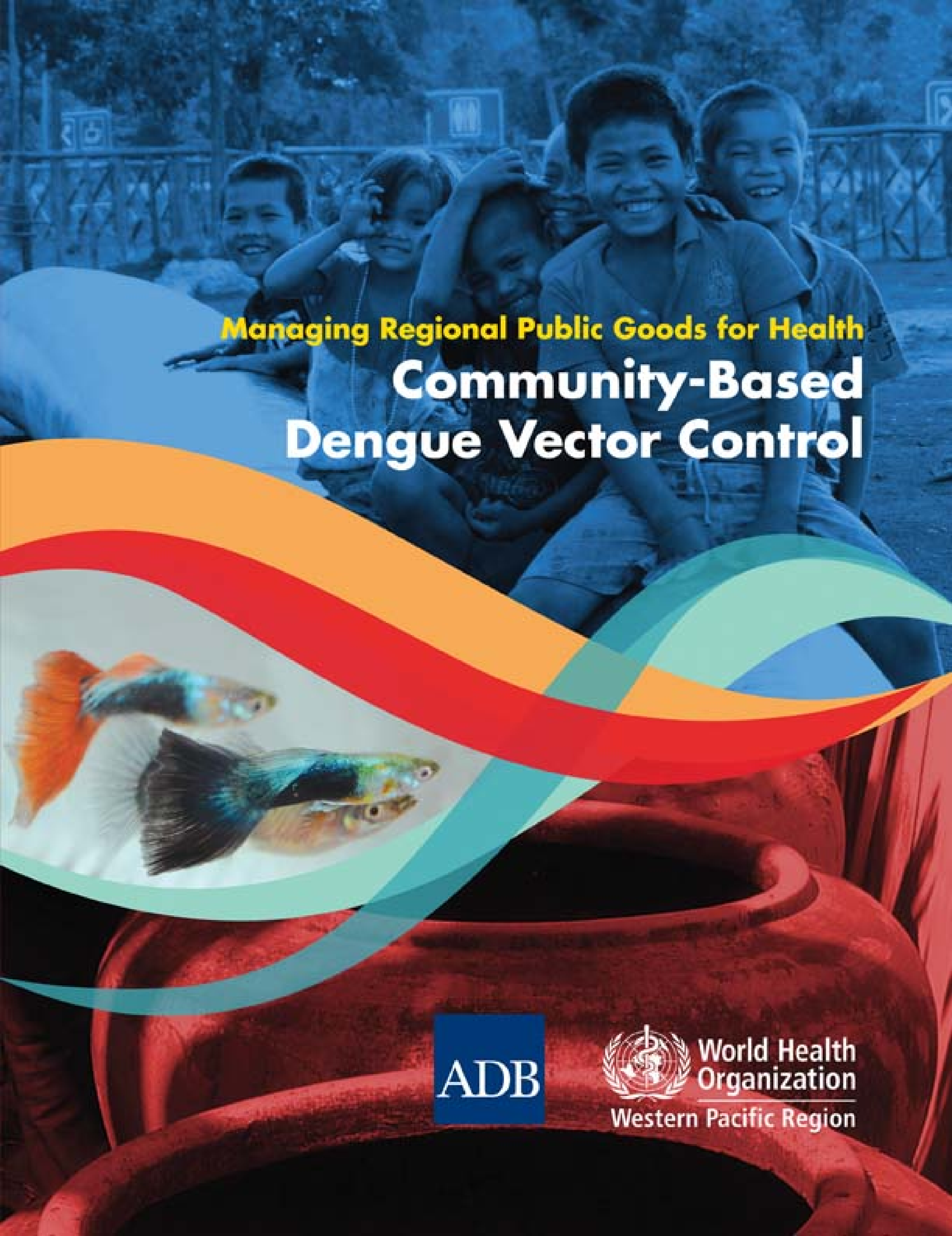
Managing Regional Public Goods for Health

Community-Based Dengue Vector Control



ADB

World Health Organization
Western Pacific Region

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ISBN 978-92-9092-914-7 (Print), 978-92-9061-598-9 (WHO), 978-92-9092-915-4 (PDF)
Publication Stock No. RPT125191-2

Cataloging-In-Publication Data

Asian Development Bank, World Health Organization.
Managing regional public goods for health: Community-based dengue vector control
Mandaluyong City, Philippines: Asian Development Bank, 2013.

1. Dengue. 2. Vector control. 3. Cambodia. 4. Lao People's Democratic Republic.
I. Asian Development Bank.

Note:
In this publication, "$" refers to US dollars.

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Printed on recycled paper.

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Foreword

A growing dengue threat is placing an increasing burden on families, health systems, and economic development in Asia. Despite an urgent need to implement an effective and sustainable vector-control strategy, dengue programs continue to focus primarily on responding to outbreaks rather than preventing them.

Now, an innovative partnership between the Asian Development Bank (ADB) and the World Health Organization (WHO) has shown that a low-cost dengue prevention strategy is feasible and sustainable. The research project in Cambodia and the Lao People's Democratic Republic involved placing small fish called guppies in household water containers to devour mosquito larvae. Backed by an intensive communication campaign, the project has proven to be an effective and simple community-based method of controlling the primary vectors of dengue fever. This success has led to the wider use of this method in the Lao People's Democratic Republic, using local resources.

At WHO and ADB, we are delighted with the achievements in Cambodia and the Lao People's Democratic Republic. We look forward to expanding the evidence for these interventions as WHO takes the approach to countries in the South Pacific, and includes the method in a dengue-prevention tool kit for governments and communities. This approach will help people across the region to protect themselves from this potentially deadly disease. ■

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Preface

This monograph provides a brief introduction to the global and regional impact of dengue fever; an overview of integrated vector management, which served as the framework for the community-based research project promoting the use of guppy fish in water storage jars, tanks, and drums in Cambodia and the Lao People's Democratic Republic (Lao PDR); an overview of the Communication for Behavioural Impact planning tool used to engage residents and plan the social mobilization and communication actions; and a summary of the results of the research project.

Large water storage containers account for 80% of containers found with *Aedes aegypti* mosquito larvae in Cambodia and the Lao PDR, and were thus the primary target of the research project. The project also promoted source reduction actions for miscellaneous smaller items commonly found to contain water and mosquito larvae, while encouraging members of the public to seek medical care for fevers that last longer than 24 hours. It is hoped that policy makers, elected officials at all levels, dengue program managers, and others involved in dengue prevention and control efforts will find this document a useful guide to the development of community-based efforts—in particular, the establishment of guppy fish breeding and distribution systems, the use of communication and social mobilization actions to promote and support specific actions that reduce mosquito breeding, and the evaluation of the impact of such efforts.

The project was developed by the World Health Organization (WHO) Western Pacific Regional Office (WPRO) at the request of and in collaboration with the Ministries of Health of Cambodia and the Lao PDR. The Asian Development Bank (ADB) provided funding, WHO staff provided technical oversight, and the health sector consulting firm HLSP was hired to work with Cambodia and the Lao PDR in the design, implementation, and evaluation of the project. This monograph was prepared by Dr. Linda S. Lloyd (consultant), Carol Beaver (HLSP consultant), and Dr. Chang Moh Seng (Regional Entomologist, WPRO). The monograph was reviewed and finalized in collaboration with ADB and WHO staff. ■

Acknowledgments

This monograph, prepared on behalf of the Asian Development Bank and the World Health Organization, documents a community-based research project that examined biological and environmental dengue vector control, in combination with communication strategies, for household behavioral change in Cambodia and the Lao People's Democratic Republic.

The monograph was written by Linda Lloyd, Carol Beaver, and Chang Moh Seng.

The authors wish to acknowledge the many people who contributed in the collection and analysis of information used in this monograph, including To Setha from Cambodia; and Tienkgham Pongvongsa and Bounpone Sidavong from the Lao People's Democratic Republic. Ma. Lourdes Amarillo and Perry Morrison conducted data analysis.

The authors further acknowledge the excellent management of the project by Barbara Lochmann, Gerard Servais, and Vincent De Wit from ADB; Henrietta Wells, Carol Beaver, Sokrin Khun, Kevin Palmer, Latsamy Siengsounthone, and Pich Vichet from HLSP. Technical support was provided by WHO through: Steven Bjorge, Chang Moh Seng, Chitsavang Chanthavisouk, Eva-Maria Christophel, Deyer Gopinath, Jeffrey Hii, and Md Abdur Rashid.

The following people reviewed the monograph and provided valuable assistance in its editing and production: Maricelle Abellar, Mary Ann Asico, Steven Bjorge, Eva-Maria Christophel, Peter Cordingley, Vincent De Wit, Madeline Dizon, Glenda Gonzales, Deyer Gopinath, Josef Ilumin, Aileen Magparangalan, Joshua Nealon, Gerard Servais, and Raman Velayudhan.

The development and production of the monograph was funded by the Asian Development Bank and the World Health Organization.

The authors remain responsible for any errors or omissions.

Abbreviations

ADB	–	Asian Development Bank
ASEAN	–	Association of Southeast Asian Nations
Bti	–	*Bacillus thuringiensis israelensis*
COMBI	–	Communication for Behavioural Impact
DPA	–	dengue project assistant
GMS	–	Greater Mekong Subregion
IEC	–	information, education, and communication
IVM	–	integrated vector management
KAP	–	knowledge, attitudes, and practices
Lao PDR	–	Lao People's Democratic Republic
LWU	–	Lao Women's Union
PAHO	–	Pan American Health Organization
SEIA	–	social economic impact analysis
VHV	–	village health volunteer
WPRO	–	Western Pacific Regional Office
WHO	–	World Health Organization
WHOPES	–	WHO Pesticide Evaluation Scheme

Executive Summary

Approximately 2.5 billion people are at risk of contracting dengue in the more than 100 tropical and subtropical countries where the *Aedes aegypti* mosquito is found. More than 70% of this population, or 1.8 billion people, live in countries in Asia and the Pacific. Most of these countries have developing or relatively weak economies, and may lack the resources required for addressing the continued emergence of dengue epidemics. Globally, 50 million-100 million cases of dengue fever occur annually. This includes more than 500,000 cases of severe dengue (previously known as dengue hemorrhagic fever), hundreds of thousands of hospitalizations, and more than 20,000 deaths, mainly among children and young adults. Dengue fever and severe dengue place significant burdens on families, communities, health systems, and economic growth. These burdens are especially acute during epidemics which result in illness and death, loss of productivity, strains on health-care services, and unplanned government expenditures for implementing large-scale emergency control actions.

Unfortunately, dengue prevention and control efforts are proving less than successful in reducing the global spread and negative impacts of the disease. Control programs tend to mainly comprise emergency responses to epidemics, leaving limited resources and capacity for sustained action. Thus, without sufficient budgetary support and intensified efforts at both the national and community level, maintaining and expanding dengue control activities will prove difficult. Innovative and more effective measures for controlling dengue are likewise needed to form a toolkit of vector control interventions that can be applied across a wide variety of ecological and epidemiological settings. This is particularly true in the face of global climate change, extreme weather events, and associated human responses to these and other environmental changes, all of which could facilitate further spread of the disease.

This report describes a promising, low-cost, year-round vector control measure that is **feasible** to implement, is **acceptable** and **safe** to the public, and, once established, has **minimal recurring costs**. Cambodia and the Lao People's Democratic Republic (Lao PDR) participated in an intervention research project using integrated vector management (IVM), to determine whether households would accept the use of guppy fish in their large water storage jars, tanks, and drums to control mosquito larvae and pupae, and if development of effective guppy distribution programs was feasible. The project also assessed whether household members could be motivated through community action and/or school-based programs to eliminate other, smaller, breeding sites on their property. The project teams used the Communication for Behavioral Impact (COMBI) planning tool of the World Health Organization (WHO) in developing the framework for delivering the interventions to selected villages. While both Cambodia and the Lao PDR incorporated household, community, and school-based approaches, the implementation of each approach was specific to the setting.

The project resulted in a decline in the number of mosquito larvae present in three key water containers (jars, cement tanks, and drums). Prior to project implementation, almost 40% of the containers in the Cambodian households had mosquito larvae; by the end of the intervention, less than 3% contained larvae. Similar results were obtained in the Lao PDR. Further, the project resulted in successful establishment of guppy breeding and distribution systems at the national, provincial, and local levels in both countries, and generated multisector collaboration between ministries, nonprofit groups, schools, and health centers. In Cambodia, 88% of the water containers contained guppies at the end of the study, while in the Lao PDR, 76% of the containers had guppies.

The project results indicate that the pilot interventions were effective and successful in mobilizing communities to establish and to maintain the guppy fish intervention, and in obtaining high levels of community acceptance of the fish in drinking water containers. Scale-up of the low-cost intervention is recommended in both countries. ■

Introduction

Dengue is the most rapidly expanding mosquito-borne viral disease affecting humans worldwide. Dengue is caused by a virus transmitted principally by the *Aedes aegypti* mosquito. With the number of cases of dengue fever and severe dengue (formerly known as dengue hemorrhagic fever) continuing to increase worldwide, dengue is a major threat to public health. About 2.5 billion people in the more than 100 tropical and subtropical countries where the *Ae. aegypti* mosquito is found are at risk of contracting dengue. Of this at-risk population, 1.8 billion (over 70%) live in countries in Asia and the Pacific (WHO 2012a). The majority of these countries have developing or relatively weak economies, and may not have the resources needed to combat the continued emergence of dengue fever and dengue epidemics.

Each year there are about 50 million to 100 million cases of dengue fever and 500,000 cases of severe dengue, resulting in hundreds of thousands of hospitalizations and over 20,000 deaths (WHO 2012a). Most of these deaths occur among children and young adults. Several important factors leading to the emergence of dengue fever as a major public health problem have been identified (Elder and Lloyd 2006):

- *Uncontrolled urbanization and increasing population growth*, resulting in substandard housing, and inadequate water, sewer, and waste management systems and sanitary landfills in urban areas.
- Significant increase in the *use of nonbiodegradable packaging*, coupled with nonexistent or ineffective trash collection services.
- Large-scale global *import and export of used tires*.
- *Increased travel by airplane*, allowing constant exchange of dengue viruses and other pathogens within and between countries. Improved infrastructure, including roads in the Mekong, has increased migration from rural to urban areas, as well as the general movement of people between rural and urban areas.
- *Limited financial and human resources in ministries of health*, leading to programs based on "crisis management" with emphasis on emergency control in response to epidemics rather than on integrated vector management to prevent epidemic transmission.

Impact of Dengue on Families, Communities, and Countries

The impact of dengue fever and severe dengue can be enormous and can place a significant burden on families, communities, and nations. The impact on the family can include loss of life, unplanned expenditures for medical care and hospitalization of sick family members, school and work absenteeism, and a loss of income if the patient is the family's source of income. The impact on a community and nation can include a productivity loss in the workforce due either to illness in economically active age groups or to the need to take care of ill family members; health-care services that are greatly strained or that collapse outright because of sudden, high demand caused by thousands of cases entering the health system during an epidemic; unplanned expenditures for large-scale emergency control actions; and a loss of revenue from tourism as a result of negative publicity.

Burden of Disease

When we speak of the "dengue burden of disease," we refer to the impact of dengue measured by the number of deaths from dengue fever, the number of cases, financial costs, or other indicators. A major effort has been made to capture the true costs of dengue infections in order to measure the burden of disease (Suaya et al. 2009).

Eight countries with a high dengue burden of disease (three in Asia and four in Latin America), accounting for 64% of dengue cases worldwide, participated in a multiyear study of *direct* medical costs (e.g., medications, visits to physicians, hospitalization) and *non-direct* medical costs (e.g., out-of-pocket expenses, food, lodging, transportation). The *indirect* costs of getting sick with dengue (e.g., paid workdays lost, school days lost, and days lost by other family members) were also calculated. The total cost for a hospitalized dengue patient ($571) was almost four times higher than the cost for a nonhospitalized patient. Students missed an average of 4 days of school; the days lost increased to 6 if they were hospitalized. Patients who were working lost an average of 7 days of work, or up to 10 days if they were hospitalized. The total average annual cost of dengue to the eight countries was $238 million, a significant cost to health-care systems, communities, and affected families.

In Viet Nam and Cambodia, studies have found the economic impact of dengue on families to be significant. In Viet Nam, the average cost to a family of treating a child hospitalized with dengue was about $61, with the greatest expenses being visits to the general practitioner, hospitalization, and lost income of the parents (Harving and Rönsholt 2007). In rural Cambodia, the average total cost to families did not significantly differ between dengue ($31) and other febrile illnesses ($27); however, the hospitalization of a child with dengue tripled the family's costs, while hospitalization with a febrile illness only doubled the costs. The debt incurred by families was significant ($23), especially when compared with their average weekly expenditure on food ($9.50) (Huy et al. 2009).

The large number of dengue fever and severe dengue cases seen each year throughout the world, including the Western Pacific Region of the World Health Organization (WHO), demands increased attention and focus from governments on dengue prevention and control efforts. ■

The cost of dengue is as devastating to families as the cost of a dengue epidemic is to a country.

Chapter 1
Dengue Vector Control

Approaches to the prevention and control of dengue fever have relied on the control of the *Ae. aegypti* mosquito. "Vector control" refers to actions used to control a "vector" (in this case the mosquito), which can transmit a pathogen (the four dengue viruses).

Most dengue control programs rely on field staff who go door to door checking homes and surrounding premises for mosquito larvae and pupae, the aquatic forms of the mosquito, in water-holding containers. This program structure is very labor intensive and requires a large number of field staff to inspect the premises and interior of each house, add temephos, a chemical that kills mosquito larvae, to containers in which they find water, educate families about mosquito control actions and dengue fever, and enforce public health laws. This process has proven to be ineffective over the long term because communities are not active partners in the control actions but rather passive participants or recipients of the control efforts (Gubler 2002).

In light of restructuring efforts to decentralize services, and chronic underfunding of dengue programs, critical issues that need to be addressed in order to provide effective vector control measures include how to

- maintain the quality of control actions in a decentralized system where decision making is at the state, provincial, or municipal level;
- ensure insecticide resistance is actively monitored and an insecticide resistance management strategy is developed and implemented;
- ensure that funding is adequate to maintain program infrastructure;
- increase the number of women working as field staff in vector control programs, given the positive role of women in health outreach programs, cultural constraints in some countries that do not allow men to enter premises or homes if male family members are not present, and concerns related to crime in areas undergoing rapid growth; and
- ensure the availability of trained local staff in technical areas such as communications and entomology that have traditionally been the responsibility of the ministry of health at the central level.

Rationale and Principles of Dengue Vector Control: Why Vector Control Is Needed for the Prevention and Control of Dengue

Vector control programs seek to reduce the number of adult mosquitoes that can transmit dengue. Vector control actions focus on the larval and pupal stages (the aquatic stages) of the mosquito, as it is easier to control the water-holding containers in which they are found than to eliminate adult mosquitoes. WHO recommends the use of two or more vector control approaches, known as integrated vector control, to minimize negative outcomes such as insecticide resistance and lack of sustainability, and to increase cost-effectiveness. Approaches used in integrated vector control include **environmental control** measures such as destroying, turning over, or removing items that can accumulate water (source reduction); preventing mosquitoes from entering the water-holding container so they cannot lay their eggs in it, by fitting a tight cover over the opening of the water jars or by other means; or emptying and refilling a water storage container every 7 days so the mosquito larvae and pupae are thrown out when the container is emptied. **Mechanical control** measures prevent water accumulation by modifying the design of homes, such as eliminating rain gutters where water can stagnate. Other approaches include **biological control** methods such as the use of guppy fish or *Mesocyclops*, a copepod, to eat the mosquito larvae, or *Bacillus thuringiensis israelensis* (Bti) bacteria, which release a toxin that kills the larvae after being ingested. **Chemical control** through the use of insecticides, some of which kill mosquito larvae (temephos is a widely used larvicide) and others that kill adult mosquitoes, are also effective when used properly and under the appropriate conditions.

These vector control methods can be successful if sufficient administrative and political support is provided for their full implementation. Integrated vector control is, at this time, the only available means of controlling dengue; there is currently no vaccine for preventing infection and there are no specific medicines for treating dengue fever and severe dengue. Most programs rely on environmental or chemical control actions often carried out by vector control field staff, and efforts to engage residents in reducing the number of water-holding containers have faced many barriers. These barriers include the need for community residents to store water because piped water is unreliable or unavailable, the reluctance of residents to throw away miscellaneous containers as these can be used for many other purposes, the lack of refuse collection services resulting in the accumulation of trash on property lots, and income generation from the recycling of various metal, glass, and plastic items.

A significant barrier to government programs is that communities have come to rely on the government for larvicides to control mosquito breeding in water storage containers, and have not fully accepted or understood their role in dengue prevention and control actions. In addition, the promotion of vector control actions that are not seen to be feasible by householders has resulted in the rejection of some control messages by communities.

Integrated Vector Management

Current vector control efforts have not succeeded in reducing the global spread and impact of dengue fever and severe dengue. Because most national dengue control programs are not equipped or staffed to manage all aspects of the prevention and control actions needed, chemical control methods continue to be relied on despite having been proven to be ineffective for a number of reasons. One of these methods is the use of temephos in water storage containers. Temephos is effective for a period of up to 3 months. However, frequent changes in the water may cause temephos to lose its effectiveness more quickly so that it must be replaced by vector control staff every 2, rather than 3, months. For most program staff, visiting every household twice a year is already difficult; quarterly visits would be nearly impossible. Dengue control programs therefore tend to be emergency responses to epidemics, with limited resources and capacity for sustained control of the mosquito. Without a consistent budget year to year, it is hard for programs to sustain achievements or to expand the use of a promising vector control strategy because of limited funds during non-epidemic years.

Integrated vector management (IVM) is a new approach to vector control. WHO established the Global Strategic Framework on IVM in 2004 (WHO 2004), and published the *Handbook for Integrated Vector Management* in 2012 (WHO 2012b). IVM, a decision-making process, encourages countries to optimize resources through a careful analysis of the local ecology of the vector-borne diseases found in the area, and the use of vector control measures that have been shown to be effective and are supported by scientific evidence (Table 1). IVM requires program managers to use a range of interventions that have been selected on the basis of local knowledge of the disease vectors, their habitats, the diseases they transmit, and the factors that contribute to their presence and transmission of the disease.

> Integrated vector management is not another program. It is a management strategy in which existing systems are reoriented to make them more efficient, cost-effective, ecologically sound, and sustainable.
>
> Source: WHO (2012b).

Table 1 Key Elements of an Integrated Vector Management Strategy

Key Element	Description	Dengue Prevention and Control Measures
Advocacy, social mobilization, and legislation	Promotion and embedding of IVM principles in the design of policies in all relevant agencies, organizations, and civil society; establishment or strengthening of public health laws and regulations; empowerment of communities	Use of WHO's Communication for Behavioural Impact (COMBI)[a] planning tool for social mobilization and communication activities

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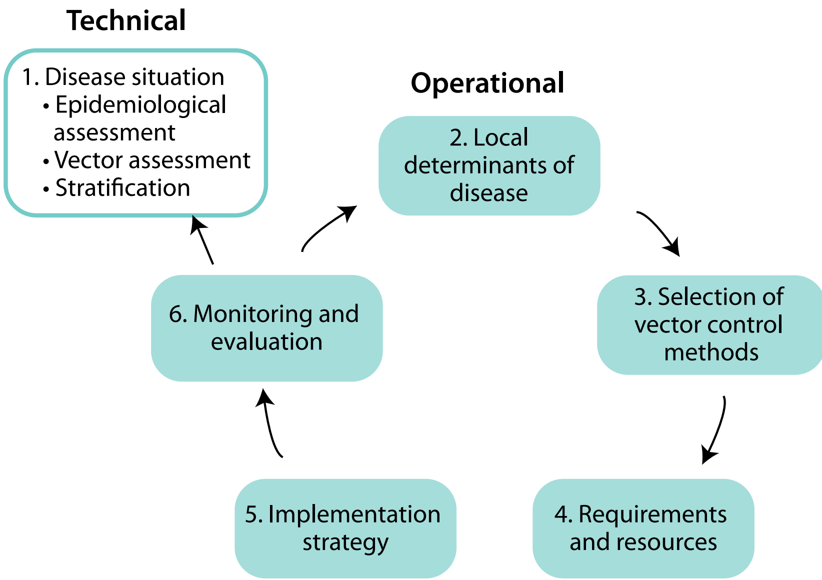
Table 1 continued

Key Element	Description	Dengue Prevention and Control Measures
Collaboration within the health sector and with other sectors	Consideration of all options for collaboration within and between the public and private sectors; application of the principles of subsidiarity in planning and decision making; strengthening of channels of communication among policy makers, vector-borne disease program managers, and other IVM partners	Involvement of the ministries of water and sanitation, education, and industry in addressing the non-health causes of dengue fever through revised policies
Integrated approach	Rational use of available resources through the integration of nonchemical and chemical vector control methods and other disease control methods to treat several diseases	Combination of chemical, environmental, and biological control measures, providing a synergistic effect
Evidence-based decision making	Adaptation of strategies and interventions to local ecology, epidemiology, and resources, guided by operational research and subject to routine monitoring and evaluation	Use of entomological data to identify the most productive containers and all options available for their control; use of data from community-based projects to identify barriers to community implementation of specific vector control measures
Capacity building	Provision of the essential material infrastructure, financial resources, and human resources at the national and local levels to manage IVM strategies on the basis of a situational analysis	Creation of ongoing training programs in data collection, analysis, and decision making for staff at all levels

IVM = integrated vector management, WHO = World Health Organization.
[a] Parks and Lloyd (2004).
Source: WHO (2012b), p. 4.

While integrated vector control focuses on the use of two or more vector control approaches to address a specific vector-borne disease, IVM requires an integrated decision-making process to determine which vector control methods should be used in a given situation. In IVM, the measures to be used would depend on the vector-borne diseases present in the area, the vector habitats, and the measures that are available to the ministry of health and health centers implementing the measures (Figure 1). However, the effectiveness of these methods is very much linked to active community involvement.

Figure 1 Decision Making in IVM



IVM = integrated vector management.
Note: The cycle suggests a continuous process of decision making in response to changes in local conditions of disease.
Source: WHO (2012b), p. 24.

Effective vector control will continue to elude countries that do not implement a plan to address the advocacy, social mobilization, and legislative aspects of integrated vector management.

IVM Implementation: Why a Multisector Approach Is Needed

A common question is: Why do we need to include sectors other than health, if dengue is a health issue? Since many of the causes of increased dengue worldwide are not related to the health sector, an integrated vector management strategy can bring together diverse groups to establish policies that address the key factors leading to the proliferation of *Ae. aegypti* breeding sites and disease transmission. For example, in countries undergoing significant growth, especially in urban areas, construction sites can be a significant source of mosquito breeding. Yet construction sites may not be included in routine vector control activities for lack of staff, and in the absence of legislation and policies that allow public health employees access to these sites, among other reasons. Another reason is the opportunity to link with other sectors through the administrative structure of municipal governments, especially in urban areas. Such linking may facilitate the review of regulations in sectors that affect mosquito breeding and encourage new collaborative approaches to integrated vector management.

For example, the identification of the most productive breeding containers in Cambodia supported focusing vector control efforts on those water-holding containers responsible for producing the greatest numbers of adult mosquitoes in order to use program resources more efficiently and reduce adult *Ae. aegypti* density (Chang et al. 2009). The study found that large water jars and cement tanks accounted for 89% of the productive containers. The use of guppy fish for mosquito control in Cambodia was tested on the basis of this information (Chang et al. 2008a). ■

Chapter 2
Biological Control Agents for Mosquito Control

Biological vector control refers to the use of organisms that are natural enemies of the *Ae. aegypti* mosquito to control the larval (aquatic) or adult stages of the mosquito life cycle (Table 2). Biological control uses organisms that prey on, parasitize, compete with, or otherwise reduce populations of the target vector species (WHO 2012c).

Biological control measures were commonly used before the introduction of insecticides in the 1940s. Insecticides dominated vector control approaches after their introduction, but damage to the environment, vector resistance to insecticides, and community resistance to their use have resulted in a new focus on biological control measures (EMRO 2003). In areas like Cambodia and the Lao PDR, biological control may be especially effective, given that about 80% of mosquito breeding takes place in large water jars, cement tanks, and other large water storage containers (Chang et al. 2009; HLSP 2010). The use of fish or *Mesocyclops* (in Viet Nam) has proven effective in controlling mosquito breeding in these containers where the method is accepted by community members (Chang et al. 2008a; Nam et al. 2005).

Table 2 Biological Control Agents

Biological Control Agent	Description	Use
Bacillus thuringiensis israelensis (Bti)	A biological larvicide often used in granules or briquettes	Bti is used in large water-holding containers, such as jars, drums, and cement tanks; ponds; and areas of standing water. Periodic checks are necessary as Bti has short durability, especially if there is frequent water exchange in the water jar or tank.
Mesocyclops	A small crustacean, known as a copepod, found in ponds or other bodies of water in the Americas and some countries in Asia	*Mesocyclops* are placed in large water-holding containers, such as jars, drums, and cement tanks. The copepods can last up to 6 months, but periodic checks are necessary as they need to be replaced each time the container is cleaned or refilled or if food is scarce.

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Table 2 continued

Biological Control Agent	Description	Use
Fish	Local species of fish that eat mosquito larvae. The small guppy fish has been particularly successful. It is recommended that native larvivorous fish be used because exotic species may escape into natural habitats and threaten indigenous fauna.	Fish are placed in large water-holding containers, such as jars, drums, cement tanks, ponds, drainage ditches, and wells. If there are no mosquito larvae to feed on, the fish will eat other organic material, such as algae. Periodic checking is required to ensure that the minimum number of fish is still in place.
Botanicals such as neem, rosemary oil, and garlic	Natural plant products found to have an insecticidal effect	Botanicals can be sprayed on surfaces, used to impregnate fabric, and included in oils, creams, and repellents.
Preservation of natural enemies in the environment	Caterpillars, other insects that prey on mosquito larvae, bats, birds	Reducing insecticide use through biological control methods ensures a healthy population of natural predators of larvae, pupae, and the adult mosquito.

Source: Linda Lloyd.

Factors in the Successful Use of Biological Control Measures

Project organization has been identified as key to the successful implementation of biological vector control (WHO 2012b). Within project organization, three essential components of success are:

- Organized breeding of fish or copepods to ensure continuous supply to the community;
- Community mobilization and participation to encourage acceptance and maintenance of the control agent in the targeted water containers; and
- Reliable distribution system for the fish or copepods, including restocking at the household level, and regular project monitoring.

All three components require a multidisciplinary, multisector approach, as shown in the successful use of guppy fish in a pilot study in Cambodia (Chang et al. 2008a), copepods in Viet Nam (Nam et al. 2005), and integrated vector control, including the use of guppy fish in Cambodia and the Lao PDR, reported here. These successes were built on local breeding and distribution programs managed at the community level, some through schools and others through local community groups. Community residents were engaged in the program early on, and were active participants in the planning, implementation, and monitoring activities. For dengue vector control to be sustainable, the biological control agent must be effective, safe, and accepted by the community.

Effectiveness

Biological control methods using larvivorous fish or other predators, such as *Mesocyclops*, have been effective in controlling *Ae. aegypti* larvae in a variety of large water-holding containers in Viet Nam, including water jars, drums, and cement tanks (Chang et al. 2008a; Kay et al. 2002). Although Bti is widely used for mosquito control in large bodies of water, such as ponds and wetlands (US EPA 1998), most information on its use in household water storage containers comes from demonstration studies. In a study in Colombia, a visible residue discouraged 40% of households from keeping the Bti briquette in their water tanks; however, the majority of householders who did keep the briquette in the water said they would continue to use it (Ocampo et al. 2009). In Thailand, *Aedes* larvae in water containers were found to be more effectively controlled when Bti and copepods were used together (Kosiyachinda, Bhumiratana, and Kittayapong 2003). A study in Cambodia on the effectiveness of Bti in domestic water jars found Bti to be effective for periods of 1–3 months, in water that was not exchanged as it would have been if the jars were in active use (Setha, Chantha, and Socheat 2007). Bti may therefore be an appropriate option for certain containers where water exchange is modest.

Safety

Before a pesticide can be used in the field, it must go through rigorous review to determine its safety and the parameters for approved use. This review is done by the World Health Organization through the WHO Pesticide Evaluation Scheme (WHOPES), established in 1960. WHOPES promotes and coordinates the testing and evaluation of pesticides for public health. It functions through the participation of representatives of governments, manufacturers of pesticides and pesticide application equipment, WHO Collaborating Centres and research institutions, as well as other WHO programmes, notably the International Programme on Chemical Safety (WHO 2012c).

WHOPES assesses the safety, efficacy, and operational acceptability of public health pesticides, and develops specifications for quality control and international trade. The safety of Bti for use in potable water has been assessed by the WHO Programme on Chemical Safety (WHO 2008). More information about pesticide safety is available from the national pesticide board responsible for approving pesticides in the country.

- **Bti** is unlikely to cause ill effects, according to studies in which laboratory animals suffered no measurable health effects after being fed large amounts of Bti. The health risk from exposure to Bti through drinking water is considered negligible, given the lack of toxicological concerns and over 50 years of Bti use as a pesticide with no known adverse effects.
- ***Mesocyclops*** is considered safe for use in domestic water containers. Copepods are naturally occurring, and have been found in many countries.

Because *Mesocyclops* is a host for guinea worm, however, it cannot be used in a few countries where there is ongoing transmission of the parasite *Dracunculus medinensis*.

- The use of **fish** as a biological control agent is backed by many years of safety and efficacy evidence generated primarily from studies for malaria vector control (EMRO 2003). In the research project in Cambodia and the Lao PDR, the introduction of guppy fish into water containers was approved by each country's national ethics committee and the WHO Western Pacific Regional Office (WPRO) Ethics Review Committee. Before the project was implemented, a field study was done to determine *E. coli* counts in the water before and after the introduction of guppies. There was no evidence that the introduction of fish was associated with a statistically significant increase in *E. coli* or total coliform contamination.
- **Botanicals** must also undergo extensive review to be registered for use as a pesticide. Specific information about the various botanicals being tested for efficacy in dengue vector control can be requested from the national pesticide board or WHO.

Community Acceptance

A challenge to the use of biological control agents is the possibility that communities may not wish to have these agents placed in their household water jars or tanks. In some regions of the world, communities view the addition of chemicals or biological control organisms with suspicion and either refuse outright to have them placed in the container or remove them once the vector control field staff have left the house.

The use of *Mesocyclops* has been effective in Viet Nam, where the elimination of *Ae. aegypti* in villages in intervention provinces has been reported (Nam et al. 2005). However, copepods have been used on a large scale only in Viet Nam. The successful use of *Mesocyclops* in that country has been attributed to the ability of *Mesocyclops* to survive in the large water containers where the *Aedes* mosquito primarily breeds, as long as there is water in the containers, and to the effective management of community education and outreach, monitoring, and copepod distribution by a network of women's associations and women's groups (Nam et al. 2005; Martin and Reid 2007).

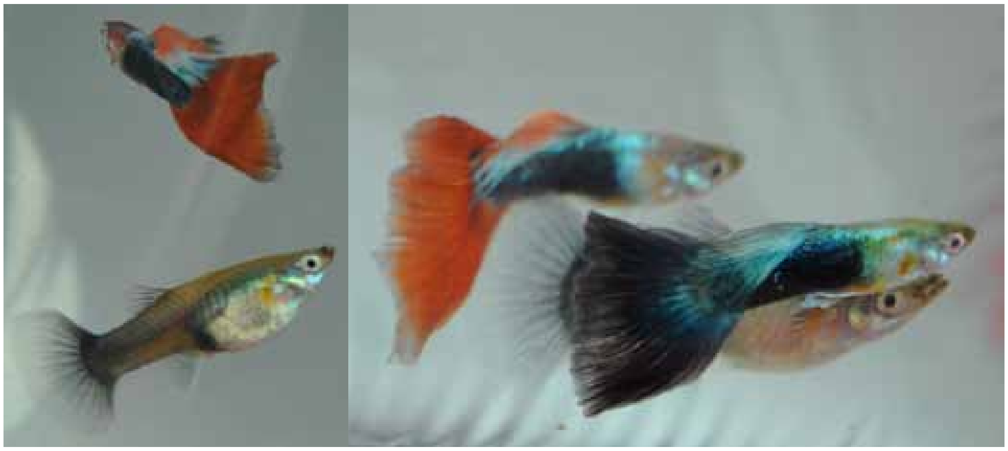
Communities in the Americas, on the other hand, are reluctant to have fish in domestic water containers. Often they allow fish only in drums with water used for watering plants or as emergency supply; these drums receive limited attention or care as the water is already viewed as "dirty." Aversion to the fishy odor and to the idea of using water with dissolved fish feces has been mentioned to explain the community resistance (Lloyd, unpublished data). According to other reports, the practice of having fish in the containers is more likely to be resisted in areas where people drink water directly from the containers, but may find acceptance in areas where people boil the water before drinking.

Biological Control and Guppy Fish

Malaria vector control has a long history of using fish to control the *Anopheles* mosquitoes that transmit the malaria parasites. The advent of indoor residual spraying with DDT led to a decline in the use of fish and other non-pesticide vector control approaches. When malaria cases began to rise in the 1970s, along with concerns about mosquito resistance to DDT and the environmental impact of using the pesticide, biological control methods, including those using fish, were reexamined and incorporated into integrated vector control efforts (EMRO 2003).

For dengue control, larvivorous fish, such as the guppy, have been used successfully as biological control agents in water jars and other large containers in many countries, including Thailand and Cambodia (on a small scale; Figure 2) (Chang et al. 2008a). The guppy fish is a hardy species that will eat algae and organic substances in water jars and tanks if there are no mosquito larvae. While guppy fish are native to South America, they are found in ponds throughout the Americas and Asia. In some countries they may be raised as food for larger fish or as ornamental fish for ponds and aquariums.

Figure 2 Guppy Fish (*Poecilia reticulata*) Used in Cambodia and the Lao PDR



Female and male guppy fish from breeding colonies maintained in Cambodia.
Source: To Setha and Chang Moh Seng.

The guppy fish grow to about 6 centimeters in length and the females can produce 40–50 offspring after a 1-month gestation period. Guppy fish are extremely efficient at eating larvae; in Cambodia, guppies reportedly eat an average of 102 larvae a day. Guppy fish can be mass-produced easily as they breed year round and can be bred in ponds cleared of other larvivorous fish and weeds, in hatcheries built for the purpose, or in large water jars as in Cambodia (EMRO 2003). Guppy fish may need additional food; ground rice husk is said to work well, and it is inexpensive and readily available (Chang et al. 2008a).

Once the stock is established, the guppy fish can be brought to the local level to establish local stocks. Young hatchlings, however, will not survive the stressful trip and should not be transported. For shorter trips, open containers, such as large plastic drums, can be used. For longer trips, the fish should be transported in closed containers holding chlorine-free water, such as large sealable plastic bags or containers with lids. See Chapter 4 for more information about the breeding and distribution systems in Cambodia and the Lao PDR.

Guppy Fish and Dengue Control in Cambodia and the Lao PDR

Cambodia

Two pilot experiences with guppy fish (Figure 2) in Cambodia yielded important lessons and served as a framework for the research project described in this monograph. The first project was a community-based field trial in 2006–2007 to test the use of guppy fish (*Poecilia reticulata*) in domestic water containers in Trapeang Kong commune, Kampong Speu (Chang et al. 2008a). About 1,000 households in 14 villages took part in the intervention; 260 other households in the same commune received routine vector control services and served as the comparison group. A stock of guppies was established at the Centre for Parasitology, Entomology and Malaria Control in Phnom Penh. When enough guppy fish were available, village health volunteers (VHVs) in the intervention villages received an initial stock to establish their local breeding stock. The VHVs were expected to maintain a sufficient stock of guppy fish for the 50 households under their responsibility, to educate the residents about dengue prevention and control, to visit the households twice a month during the 1 year project, and to replace lost guppy fish. Villagers were also told they could go to the homes of the VHVs at any time to obtain replacement fish. About 10%–20% of the guppy fish needed to be replaced monthly, so the breeding and distribution system was a key factor in the success of the program.

One year later, 25% of the intervention households were visited and entomological indices were compared with those found in the comparison group. Of the water storage containers in the intervention households that were appropriate for the fish, 57% contained guppy fish, and the intervention community had 79% less *Aedes* infestation than the households without fish. There was a highly significant difference between the intervention and comparison areas in the number of water jars and tanks found with *Aedes* larvae or pupae: only 10% of these containers in the intervention area were positive, compared with 50% among households without fish. The significant reduction in mosquito larvae and pupae in the water jars and tanks in the intervention households not only resulted in fewer adult mosquitoes produced from those water jars and tanks, but also reduced by 51% the number of smaller water containers without fish that were found to be with larvae and pupae.

A second project using guppy fish took place in 2008–2009 in Bati district, Bakeo province, Cambodia. A total of 13 health centers and their catchment areas participated. This project used the WHO COMBI planning tool (Parks and Lloyd 1994) to plan the community mobilization and communication activities associated with the implementation of the guppy fish strategy. VHVs were trained in basic dengue prevention and control measures, the benefits of using guppy fish for both larval and adult *Aedes* control, health education techniques (including outreach and house-to-house visits), and guppy fish breeding and distribution. Information, education, and communication materials, such as leaflets, posters, songs, and audio spots (broadcast from motorbicycle trailers), were produced to support the outreach activities of the volunteers and health center staff. The Bati district project refined and established a model for raising and distributing the guppy fish through the use of community volunteers and local health centers (HLSP 2010, 2012).

As part of the research project described in this monograph, a qualitative evaluation of the earlier COMBI strategies was made to gain a better understanding of perceptions of project management, effectiveness, and participation at different levels of the health and project structures. Key informant interviews were held with staff at the national and health center levels, VHVs, and village heads. Focus groups were used to gather information from mothers and 5th- and 6th-grade schoolchildren about their perceptions and knowledge of dengue, dengue prevention and control, dengue education efforts, and use of guppy fish in water jars and tanks to prevent dengue. The study found that community members, schoolchildren, VHVs, and health workers had good knowledge of dengue fever and its prevention and control, were motivated to create a community without dengue and without mosquitoes, and believed guppy fish were effective not only in controlling the larvae in their jars but also in reducing the number of adult mosquitoes and suspected dengue cases.

A very important finding from the qualitative evaluation was that health staff at the national and health center levels fully supported the community-based effort and felt that face-to-face dengue health education by the volunteers and use of posters and banners had been effective.

Source: HLSP (2010, 2012).

Lao PDR

Although there are no published accounts of the use of guppy fish in the Lao PDR before this research project, the COMBI planning tool for community mobilization has been in use in the country since 2003. The Lao PDR Women's Union has been involved in the planning and implementation of community mobilization efforts to increase community awareness of dengue and the importance of larval detection in the home, the distribution of temephos during dengue outbreaks, and the involvement of schools in dengue prevention and control activities (Chang et al. 2011).

Summary

The pilot projects with guppy fish in Cambodia and the previous experiences in the Lao PDR and the Bati project in Cambodia with the use of the COMBI planning tool provided a framework for the Regional Public Goods for Health: Combating Dengue in ASEAN research project funded by the Asian Development Bank (ADB).

These project experiences showed that VHVs must be sufficiently motivated, equipped with the skills they need to carry out their expected duties, and assigned a reasonable number of houses to cover. The COMBI experience in particular indicated the importance of having communities as active partners in the planning and implementation of social mobilization and communication activities, the possibility of effective partnership with schools and public transportation (*tuk-tuks*) in communication, and the importance of measuring perceptions of project impact across all levels, including the community, health staff, and partners. ■

Chapter 3
COMBI: Communication for Behavioural Impact

What Is COMBI?

Communication for Behavioural Impact (COMBI) is a planning tool for communication and social mobilization activities in support of program goals and objectives (Table 3) (Parks and Lloyd 2004). WHO promotes the use of COMBI by program managers, health educators, and communications specialists in mobilizing communities for the prevention and control of dengue, malaria, lymphatic filariasis, Chagas disease, HIV/AIDS, and tuberculosis, among others, as well as for breast-feeding campaigns.

Table 3 **Communication for Behavioural Impact** (COMBI)

COMBI IS:	COMBI IS NOT:
A planning tool	An intervention in and of itself
A blend of theory and practice: • Behavior change theories • Communication theory • Marketing practice using integrated marketing communication; it integrates all aspects of marketing, advertising, sales promotion, public relations, and direct marketing into a unified force	Focused on marketing and mass media
A broad integration of mobilization, communication, strategic planning, and evaluation of specific behaviors	An expansion of information, education, and communication programs

Source: Parks and Lloyd (2004).

Using the COMBI planning tool helps program staff understand the social, cultural, political, ecological, legal, and spiritual factors that facilitate or hinder the adoption of specific behaviors, such as reducing mosquito breeding sites or seeking medical care for a sick family member. In the case of dengue prevention and control, why residents follow some control measures but not others must be understood.

COMBI provides a structured process for obtaining the information needed to engage families, community leaders, dengue program staff, and health officials in helping individuals and communities adopt and maintain healthy behaviors.

Difference between COMBI and Information, Education, and Communication

Most dengue and vector control programs use the information, education, and communication (IEC) framework to communicate. A question commonly asked is: *How is COMBI different from IEC*? COMBI is different because it brings together and integrates mobilization, communication, and community participation into a single cohesive approach focused on behavior: someone doing something to improve his or her health and well-being. IEC is actually part of COMBI planning.

Years of experience and research have proven that knowledge does not automatically result in behavior change. Dengue is a good example. After years of IEC activities, many countries can show high levels of knowledge about dengue fever, its transmission, and the places where the mosquito breeds, yet entomological indices remain high and residents do not participate in vector control activities. The opposite is also true. Communities with low levels of knowledge of the disease may readily accept vector control recommendations. In the research project in Cambodia and the Lao PDR, the educational activities increased knowledge but did not help reduce the entomological indices (see Chapter 5).

The research project used the COMBI planning tool to identify critical gaps in knowledge and community perceptions that prevented the community from participating in vector control actions (for further discussion see Chapter 6). The COMBI process allowed the project team to identify behaviors that the residents could not feasibly adopt, for example, scrubbing, rinsing, and refilling the large water jars families use for water storage. This behavior was not feasible because of the size of the jars and because people would not throw precious water away. Placing larvivorous fish in the large water jars was found to be a sustainable way of eliminating mosquito larvae. The project developed a mobilization and communication strategy for implementing the guppy fish intervention in the two countries.

Effective Health Communication and Community Mobilization

Health communication is the planned and systematic use of communication strategies to **inform**, **influence**, and **motivate** individual and community decisions that improve health and quality of life. COMBI is about mobilizing and engaging people to move beyond IEC and focus on the behaviors that lead to the elimination of *Ae. aegypti* breeding sites.

Often people cannot change their behavior unless the setting in which they live or work also changes. The environment must therefore be made "enabling," or supportive of the new behaviors. It may be necessary to pass new laws or enforce existing ones, examine how houses and schools are designed and built to reduce mosquito breeding, look at national and municipal processes of installing water and sanitation systems, or improve vector control services. **At the household level, an enabling environment would be one where the recommended vector control strategies are feasible, as in the guppy fish research project**. As an alternative to cleaning the large water jars weekly, communities were encouraged to keep two or three guppy fish in each large jar to render it inhospitable to mosquito larvae or pupae.

COMBI effectively integrates health education, adult education, IEC, community mobilization, traditional and nontraditional media, public relations, and market research for the ultimate goal of behavior change (WHO 2002). The specific mix of COMBI communication actions differs between countries and even within a country because the behavior, the environment, and the resources available for implementing the strategy determine the scope and use of each communication action.

Cambodia and the Lao PDR used different combinations of the COMBI communication actions based on the factors (e.g., social, cultural, political) they needed to address in order to generate support for new and existing behaviors. The desired behavior involved keeping guppy fish in large water jars; the existing behaviors entailed doing away with small water containers no longer used by the household and taking anyone with a fever for more than 24 hours to a clinic or hospital. While both countries incorporated household, community, and school-based approaches, the implementation of each approach was specific to each country's circumstances.

Monitoring and Evaluation of Behaviors

All COMBI strategic communication and mobilization plans must include an evaluation of the behavioral impact so program planners can answer questions about *who* did *what*, *when*, and whether the expected *outcome* was achieved. For dengue prevention and control, this evaluation goes beyond the use of entomological indices as the indices simply measure mosquito, not human, behavior.

There are no standardized behavioral indicators for use at the program level. However, countries have used qualitative indicators to measure whether the behavior was being implemented, and in some cases at what frequency. Behavioral indicators that reflect how the behavior has been implemented—somewhat, partially, or completely—should be made part of the detailed COMBI plan so program managers can determine whether they need to reexamine specific steps or reinforce messages. In the case of the guppy fish, the absence of fish in the water jar may not necessarily mean that the homeowner has rejected the measure. Indicators, such as the presence of only the earlier of the four larval stages (first, second, and possibly third instar), might signify a recent absence of fish, as one would expect to find larvae at all stages of development and pupae if there had never been any fish in the jar. The absence of any larvae and pupae, on the other hand, might indicate the consistent and recent presence of fish.

Entomological indices help in understanding the key impact of keeping guppies in water jars such as: the presence or absence of mosquito larvae or pupae, the impact of the presence or absence of fish on mosquito breeding in the container over time, and the kinds of containers that are more likely to contain fish over time. But to understand the *human behavior of accepting and maintaining fish in the water jar*, one must look into all the various aspects of the behavior, such as: are there fish in the jar? how many? what do household members have to say about the fish? did they replace fish that died? why or why not? if fish are missing, what happened and why have they not been replaced? The answers to these and other questions cannot come from entomological indices but are critical in enabling the program to respond to gaps in the maintenance of the behavior. In Cambodia and the Lao PDR, entomological indices were used, along with the behavioral indicator of whether there was at least one fish in the water jar, tank, or drum, and information was obtained through key informant interviews and focus groups.

Importance of Communication and Social Mobilization in Implementing the Use of Guppy Fish in Large Water Storage Containers

COMBI is an ideal tool for dengue prevention and control. To be effective, COMBI focuses on those behaviors that will have the greatest impact on reducing the number of adult mosquitoes.

> COMBI recognizes that people are busy and have many responsibilities and demands on their time, and that health messages must compete for people's attention.

This means that the dengue vector control program must be able to identify the containers that produce the greatest number of adult mosquitoes (the "most productive" containers). The COMBI planning tool can then be used to develop and test vector control behaviors for the productive containers if existing control methods have not been successful, or to mobilize residents to adopt and maintain an existing method that has been shown to be acceptable to the community and can be implemented by household members. It is important to remember that vector surveillance is a critical part of planning for behavior change as information from vector surveillance is needed for monitoring which containers are the most productive over time.

In Cambodia and the Lao PDR, 80% of containers found with *Ae. aegypti* larvae are large water jars or cement tanks; however, water jars are the most numerous. Existing control messages for these containers, such as "scrub the inside, rinse, and refill once a week," have not been accepted by households because of their impracticability. Two pilot studies in Cambodia showed that, once the community members understood why they should keep the fish in their water containers and their concerns were addressed, there was good acceptance of the practice (Chang et al. 2008a; HLSP

2010). As a planning tool, COMBI provided a comprehensive social mobilization and communication strategy for introducing the new behavior and for reinforcing existing behavioral messages (Figure 3). Both new and existing messages said the same thing: the health of the family and the community must be protected.

Figure 3 Cambodian Posters with the Three Behavior Messages

Banner A Banner B Banner C

Banner A: "Keep guppies in water jars and tanks."
Banner B: "Go to a clinic or hospital if you have fever that lasts for more than 24 hours."
Banner C: "Turn over or remove containers that are not in use."

Source: To Setha.

COMBI in Action: Mobilizing and Coordinating the Response

The effective implementation of integrated vector control has been hampered by the inability of ministries of health to mobilize and coordinate the resources needed to achieve and sustain behavior changes among populations at risk of dengue fever and severe dengue. Behavior change takes place over time, but most social mobilization and communication actions for vector control are sporadic and often include vague or ambiguous messages. Even when messages have a behavioral focus, the behaviors being promoted are often ineffective at the household level or rejected by the community and the programs do not provide effective and feasible new behaviors in their place.

Most behavior messages for dengue vector control require the householder to do something regularly, such as check water jars weekly to make sure the guppy fish are still there, yet most communication plans do not include messages to maintain the behavior in the communities. The plans also do not include ongoing actions by the government to support the new behavior. In the case of the guppy fish, behavioral maintenance on the part of the health centers and ministries of health might include quarterly visits to the households breeding the guppy fish to make sure the community distribution system is still functioning and to address challenges that have come up. **The continued participation of the public sector is as important as the behavioral maintenance messages addressed to the community.**

Cambodia and the Lao PDR both had experience using COMBI in pilot projects. These experiences were positive and served as a framework for the research project. In Cambodia, the Bati district project covered 13 health centers in the Bati operational health district (HLSP 2010). The project followed the COMBI approach of using several integrated strategies to communicate the key behavioral messages, including the use of guppies for dengue vector control by households. VHVs were trained in basic dengue prevention and control measures, and in basic health education techniques, such as outreach education and house-to-house visits. They were also taught the benefits of using guppy fish for dengue prevention and were trained to breed and distribute the guppy fish. The volunteers distributed the guppy fish to villagers and told them about the effectiveness of the fish against mosquito larvae and about the care of guppies in the water jar.

In the Lao PDR, two dengue-related COMBI projects were organized; neither one included the use of guppies in water jars and tanks. In 2003, WHO and WPRO, in collaboration with the Lao PDR Ministry of Health, tested the feasibility of using COMBI as the planning tool for dengue prevention and control activities in the country. A pilot area in the capital, Vientiane (at that time, Vientiane municipality), was selected, and four villages in two districts participated in the COMBI project. A second COMBI project in Savannakhet covered five health centers in Kaison public health district (HLSP 2010, 2012). The project used COMBI to address several behaviors, including managing discarded water containers, broken jars, and coconut shells; cleaning the inside of water jars; cleaning the compound yard; checking containers for larvae every weekend; and distributing temephos to villagers. VHVs were trained in basic dengue prevention and control measures, basic health education techniques such as outreach education and house-to-house visits, and the recording on project forms of larvae found in water containers.

Evaluation of the Use of the COMBI Planning Tool

COMBI is a planning tool, not an intervention. Proper evaluation of its use should be concerned with whether the communication and mobilization plan, developed through the COMBI process, met its objectives, in order to explain why the program achieved its behavioral goal, or why it did not. The Lao PDR participated in the evaluation of the multi-country process evaluation done in 2005. The findings showed that the use of the COMBI tool was effective in bringing together diverse groups and creating multisector support that had both a horizontal dimension (e.g., health staff supported by the mayor's office and local civic organizations, and intersectoral collaboration) and a vertical one (from the central ministry down to the field staff) (Elder 2005). The planning tool was recently revised from 15 steps to 10, following a qualitative evaluation (PAHO 2011) (Annex 1).

Need for Better Social Mobilization and Communications Planning for Dengue Prevention and Control

Careful planning, in-depth knowledge and understanding of the factors that will affect how and whether a behavior is feasible and acceptable to the target population, and good-quality monitoring and evaluation of behavior change—all these are necessary elements of successful dengue vector control. COMBI provides a social mobilization and communication approach that connects knowledge and behavior, addresses the cost and value of engaging in healthy behaviors, recognizes the gradual stages of behavior change, and creates a supportive environment for behavior change.

Because dengue can present as a mild illness, people may underestimate its seriousness, especially in a non-epidemic year. This perception affects what people will do to prevent the disease, and how much effort they are willing to put into dengue prevention efforts. High levels of knowledge about dengue and how it is transmitted do not necessarily translate into full engagement of residents in vector control efforts. Even those residents who follow the recommended vector control actions may still have *Ae. aegypti* or other mosquitoes in their homes or come down with dengue if their neighbors do not participate in controlling domestic breeding sites, or if they get bitten by an infected mosquito at their place of work or study.

The challenge for vector control is how community participation can be integrated into source reduction efforts. Regardless of the dengue program structure, several issues remain: how to engage residents meaningfully in sustained control actions, how to communicate effectively with residents in ever-growing urban and semiurban areas in light of reduced vector control staffing and chronic budget shortfalls, and how to measure the impact of residents' actions on *Ae. aegypti* breeding sites.

COMBI can be an effective tool in helping dengue prevention and control programs meet today's vector control needs and challenges (Elder and Lloyd 2006).

Chapter 4
Impact of Community Mobilization and Use of Guppy Fish on Mosquito Breeding in Cambodia and the Lao PDR: A Research Project

The research project took place in Cambodia and the Lao PDR between September 2009 and December 2011. The Cambodian and the Lao PDR Ministries of Health sought assistance in developing and testing sustainable approaches to controlling mosquito breeding in large water jars, tanks, and drums found in households, which account for over 80% of *Ae. aegypti* breeding sites in the two countries. The project was financed by ADB, and was developed and implemented collaboratively by the Ministries of Health, the WHO WPRO, the WHO country offices in Cambodia and the Lao PDR, ADB, and HLSP, the consulting firm that won the technical assistance contract.

The project was submitted as a research project to each country's National Ethics Committee and to the WHO WPRO Ethical Review Committee and was approved by these committees before the project activities began.

Project Outcome and Output

The research project built on earlier experiences in social mobilization for dengue prevention and control in the two countries, using the WHO COMBI planning tool. In Cambodia, the project was able to use existing stock of guppy fish as the approach had previously been tested on a small scale (Chang et al. 2008a).

Outcome

The project was expected to lower the incidence of dengue fever and severe dengue in the project areas by reducing the vector density of mosquito larvae and pupae in large household water containers.

Output

The research project was expected to have the following outputs:

- **Pilot-tested community-based strategies for reducing the sources of dengue vectors.** An important part of the research project was determining community acceptance of guppy fish, as well as the appropriateness of domestic water containers, such as water jars and tanks, as fish habitat. Baseline, follow-up, and final entomological and knowledge, attitudes, and practices (KAP) surveys were done to measure changes in entomological indices and knowledge over time.

- **Strengthened communication for source reduction.** Community groups, including health workers, schoolchildren and teachers, women's organizations, and religious groups, were mobilized to help reduce the sources of adult mosquitoes (source reduction) and learn how to keep the guppy fish in water jars and tanks, discard or turn over unused containers, and identify dengue symptoms and warning signs of severe dengue. Figure 4 shows a typical home environment in the Lao PDR, similar to what can be found in Cambodia.

Figure 4 Dengue Project Officer's House with Project Posters, Intervention Site in the Lao PDR

Source: To Setha.

In both Cambodia and the Lao PDR, the project targeted the most productive breeding sites of the *Aedes* mosquito in and around houses (Figure 5). Environmental control measures were used to manage water jars, tanks, and drums; animal watering and feeding troughs; tires; discarded and broken jars, bottles, or plates; and upturned coconut shells. Temples were also included, as ceremonial ponds are potential breeding sites for the mosquito. During a small outbreak in one of the intervention villages in Cambodia, investigators found mosquitoes breeding in an upturned boat. The discovery reinforced the importance of thoroughly exploring the surrounding environment for anything that can hold water.

Figure 5 Targeted Mosquito Breeding Sites in Cambodia and the Lao PDR

Source: Bounpone Sidavong and HLSP (2012).

Project Design

Dengue program managers must fully understand the evidence base of the vector control strategies used in their program. Newer mosquito control and community mobilization strategies that have been tested only at the pilot level must be evaluated before they are applied on a wider scale. These evaluations can help establish appropriate indicators for routine program monitoring or periodic program evaluation.

Measuring the impact of the various mosquito control strategies, especially when they are combined in an integrated vector management framework, presents ongoing challenges in the creation of this evidence base (WHO 2012b).

Measuring the impact of community participation in vector control activities on the reduction of mosquito larvae and pupae, and adult mosquitoes, has been particularly challenging.

The design of the research project involved the selection of intervention and comparison villages. The research villages received the project interventions—guppy fish, plus community mobilization activities. The comparison villages, on the other hand, received routine vector control services.

Project Sites in Cambodia and the Lao PDR

In Cambodia, Kampong Cham province was chosen as the study site because of its high number of dengue cases. The villages that took part in the study were selected by the provincial health office. Villages in the Tong Rong and Prey Krabau health center catchment areas served as intervention sites, while villages covered by the Khor health center were comparison sites.

In the Lao PDR, major outbreaks in Savannakhet province led to its selection. Participating villages were chosen on the basis of dengue endemicity. Ten villages in Songkhone district served as intervention sites, and eight villages in Xayphouthong district as comparison sites.

Project Components

Small Research Studies

Several small research studies were done to make sure that the vector control options being offered were effective, safe, and feasible for implementation at the household level. These studies, which were part of the preliminary research phase (called "formative research" in the WHO COMBI planning tool), were as follows:

- Laboratory-based evaluation of the five-sweep net sampling technique for the recovery of *Ae. aegypti* larvae and pupae from water jars, tanks, and drums;
- Testing of the viability and effectiveness of local fish in eating mosquito larvae and pupae, compared with guppy fish; and
- Conduct of a water quality survey for *E. coli* in water jars with guppy fish, and development of a water quality monitoring and response plan to prevent and mitigate outcomes in case of increased risk of water contamination associated with guppy fish introduction. Water quality monitoring was a requirement of the WHO Ethics Committee.

Community Mobilization

The COMBI planning tool (Parks and Lloyd 2004) was used in all three stages of the project (preparation, implementation, and evaluation) in both countries. Project leaders in the two countries had previously used the planning tool for dengue control. The lessons they learned were applied by project staff at the country level during initial project preparation. Following the project inception meeting in Manila in February 2010, the COMBI planning approach was used to fine-tune the community mobilization action plans at the national, provincial, district, and village levels. The approach was found to be useful in engaging key players in the planning and implementation of all aspects of the project. No one involved in the project received any incentives or fees.

To ensure that all involved clearly understood the behavioral objectives of the project and the responsibilities of each member of the project team, the COMBI planning process included the following:

- Participation by a multidisciplinary team in the planning;
- Formative research, including focus group discussions and interviews with people in the areas who had prior COMBI experience;
- Determination of desired *behavioral* objectives (Table 4), which everyone agreed to and which became the core messages of the project;
- Formulation of strategies and activities, and preparation and dissemination of the COMBI community mobilization plan; and
- Assignment of responsibilities to the various team members and volunteer groups.

Table 4 COMBI Behavioral Objectives for Cambodia and the Lao PDR

Desired Behavioral Impact	
Cambodia	**The Lao PDR**
Turn over small containers (those you want to keep) to stop the tiger (*Aedes*) mosquito from breeding.	Every Saturday empty all your water storage containers. Scrub vigorously the inside walls of the containers before refilling (for containers you are able to empty).
Collect all discarded containers around your house (those you do not want to keep) and put them in the ground or burn them to stop mosquitoes from breeding.	Every Saturday collect anything in your compound that can hold rainwater (other than your main water containers) and either throw them away or store them out of the rain.
If your child gets fever and does not get better in 1 or 2 days, take him or her to the hospital. Do not try to treat dengue at home.	If you have fever, think of the possibility of dengue and consult a doctor. Don’t wait. Dengue can be fatal.
Put “seven color fish” (guppies) in all your jars and tanks so they can eat mosquito larvae. If there are 1 or 2 fish in your jar or tank, there will be no *Aedes* mosquito larvae.	Every Saturday check that there are at least 2 healthy guppies in each water container.

Source: Carol Beaver, To Setha, and Bounpone Sidavong.

The COMBI integrated communication and mobilization strategies and related activities are summarized in Table 5.

Table 5 COMBI Strategies and Activities, by Country

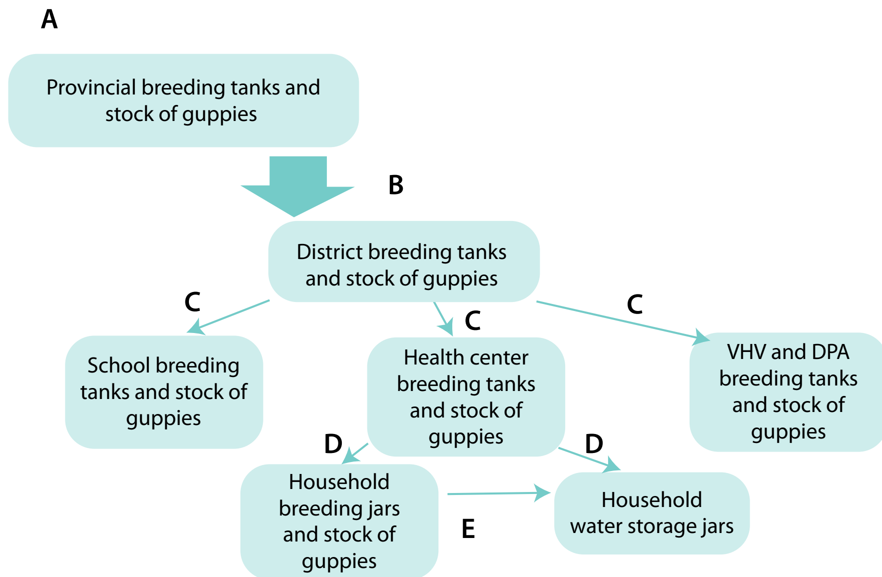
COMBI Component	Activities to Induce Desired Behavior	
	Cambodia	**The Lao PDR**
Public relations and advocacy	Advocacy meetings at national, provincial, district, and village levels before and during the project, with government officials, representatives of ministries of health and education, villagers, health staff, monks, teachers, and others participating	Advocacy meetings at national, provincial, district, and village levels before and during the project, with government officials, representatives of ministries of health and education, villagers, health staff, LWU members, monks, teachers, and others participating
Personal selling and interpersonal communication	Household visits by village health volunteers (VHVs) and health center staff	Household visits by dengue project assistants (DPAs) and LWU officials
Sustained appropriate advertising	Advertising on TV and radio; mobile education program with songs (*tuk-tuk* campaign); information, education, and communication (IEC) materials using community posters, bunting, t-shirts, caps	Advertising on TV and radio; posters and leaflets; IEC materials using community posters, bunting, t-shirts, caps
Point-of-service promotion	Calendar; schoolchildren advocating the use of guppies at household level	Schoolchildren advocating the use of guppies at household level; distribution of t-shirts, caps, leaflets with guppy logo
Community mobilization	Community meetings; school dengue and guppies drama competition; discussion of use of guppies for dengue control at school and community meetings	School-based anti-dengue and guppy poster competitions; discussion of use of guppies for dengue control at school, community, and LWU meetings; LWU activities; village-head activities

COMBI = Communication for Behavioural Impact (planning tool of the World Health Organization);
IEC = information, education, and communication; LWU = Lao Women's Union.
Source: Carol Beaver.

Establishment of the Guppy Fish Breeding and Distribution System

The primary objective of the project was to establish local capacity to raise and distribute guppy fish to households. Figure 6 shows the process of setting up breeding tanks and distributing guppies through the system and eventually to households. In Cambodia, the guppy fish were bred from guppy stocks at the Ministry of Health central level. The guppies were transferred to the provincial offices and from there to the intervention villages for breeding and distribution to households via VHVs (Figure 7). The Lao PDR did not have guppy fish stocks, so guppies were purchased from Thailand. Tanks were built at primary schools for rearing guppies, the idea being that schoolchildren would learn about guppies and be motivated to take fish from the school tank to put in water jars and tanks in their homes. Dengue project assistants (DPAs) also distributed fish to households (Figure 7).

Figure 6 Guppy Fish Breeding and Distribution System



DPA = dengue project assistant, VHV = village health volunteer.
Source: Carol Beaver.

Figure 7 Guppy Fish Distribution by Village Health Volunteers in Cambodia (A and B) and Dengue Project Assistants and Householders in the Lao PDR (C and D)

Source: To Setha.

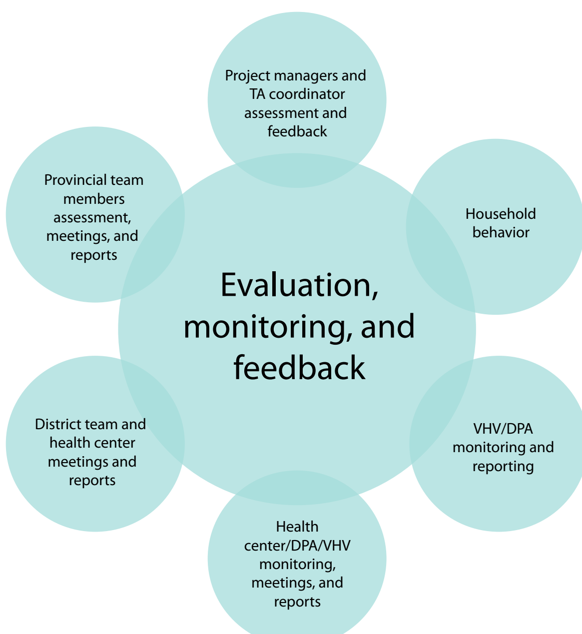
Project Evaluation, Monitoring, and Feedback

Programs and research studies have traditionally used entomological indicators to measure community participation. The indicators include the percentage of containers surveyed and found to have mosquito larvae or pupae (Container Index), the percentage of houses found to have at least one container with mosquito larvae or pupae (House Index), and the number of containers found to have mosquito larvae or pupae in every 100 households (Breteau Index).

However, these entomological indicators are not very effective in measuring human behavior. The presence or absence of mosquito larvae or pupae in a container does not indicate whether household members took any actions to implement the recommended control strategies. Without knowing how the community is reacting to a recommended control strategy, program managers do not know whether they should continue to promote a specific action or carry out a strategy to correct an "error" in the implementation of the behavior.

The **project evaluation, monitoring, and feedback** process in the research project was multidimensional and took place at all levels of the project, as shown in Figures 8 and 9. Project evaluation, monitoring, and feedback is a key component of any program, as it allows rapid response to emerging challenges and opportunities, and sustains the shared vision of all stakeholders, from community residents to the dengue program manager and elected officials. In the project, the tools used in monitoring and evaluating project implementation and outcomes were both qualitative (e.g., observation of key breeding containers, interviews with stakeholders) and quantitative (e.g., entomological surveys and knowledge, attitudes and practices surveys).

Figure 8 Project Evaluation, Monitoring, and Feedback Process



DPA = dengue project assistants, TA = technical assistance, VHV = village health volunteer.
Source: Carol Beaver.

Figure 9 **Project Monitoring and Feedback in Practice**

Photos show project consultants at a monitoring visit with team members in Cambodia (A); a district team manager in the Lao PDR reviewing the weekly reports of the dengue project assistants (B); national and provincial project managers in the Lao PDR discussing the challenges and outcomes of guppy fish breeding at a school (C); and project consultants meeting with country managers and health center staff in Cambodia (D).

Source: Carol Beaver, To Setha, and Bounpone Sidavong.

Project Stages in Cambodia

Preparation

Advocacy. During this phase there was a high level of advocacy with provincial and district health officials, as well as with community leaders and teachers in the project sites. The project manager met with senior staff from other government ministries and key agencies to promote the project and future strategies for addressing the problem of dengue.

Selection of village health volunteers. Forty-one VHVs in Prey Krabau and 51 in Tong Rong were selected by the director of the health center, in consultation with village leaders. VHVs were not paid for their work on this project. They were responsible for maintaining stocks of guppies in the villages, as well as for distributing guppy fish, monitoring the numbers of guppies in jars and replacing the fish as required, educating villagers in dengue vector control, and encouraging householders to keep guppies in their jars. Health center staff provided supervision and support.

Establishment of guppy fish breeding stocks. Stocks of guppy fish were established at the national, provincial, district, and village levels. Fish stocks from the earlier Bati district project were used to establish stocks at the Tong Rong health center, and from there rearing was established at the houses of the VHVs. Each health center had 10 jars for rearing fish and each VHV was given two jars to establish local fish stocks. Building up the guppy stocks took 3 months.

Implementation

Official launch. The project was officially launched in Cambodia on 29 July 2010. The launch was attended by the deputy governor of the province, other senior government officials, health department staff, schoolchildren, school teachers, and other community representatives (Figure 10).

Figure 10 Project Launch in Cambodia

Source: To Setha.

Distribution of guppy fish. VHVs visited each house assigned to them at least once a month. During the visit the VHV recorded the number of water containers, the number of containers that had fish, and the number with missing fish. VHVs replaced missing guppies, and community members were encouraged to go to the VHV's house for replacement guppies when needed. In some villages, 10%–20% of the guppies were lost over time, making it even more important to maintain fish stocks at the health centers and in the villages. The loss of fish from jars was due to a variety of reasons, including the following:

- They were washed out during heavy rains;
- The jars were cleaned;
- Children played with the fish; or
- Lizards and other predators ate the fish.

Community education. Banners were distributed to health centers and schools; if they were damaged (e.g., from heavy wind and rain) or lost they were replaced. A 3-month mobile education program using *tuk-tuks* was carried out in the intervention villages (Figure 11). The *tuk-tuk* toured the villages playing songs and broadcasting key messages. The driver would stop at a central place in each village, long enough to allow people to hear all the songs and messages.

School-based activities. After negotiations with the head of the provincial education department, it was agreed that all schools in the intervention sites would participate.

Figure 11 *Tuk-tuk* Mobile Education Activity, Cambodia

Source: To Setha.

Figure 12 School Drama Show, Cambodia

Photos show a "teacher" explaining to her "students" why they should keep guppy fish in water jars (A); a schoolchild telling her "parents" about guppy fish (B); "guppy fish" swimming in a jar and eating larvae and pupae (C); and "*Aedes aegypti* mosquitoes" crying because the guppy fish have eaten their "babies" (larvae and pupae) and people have destroyed their other breeding sites, and there is nowhere safe (D).

Source: Carol Beaver and To Setha.

School-based activities included the following:

- **Drama competitions.** Every school put together a drama show (Figure 12). The best show in each intervention village received a prize, and the drama show from both intervention sites that was pronounced the best by Cambodia National Center for Parasitology, Entomology and Malaria Control staff also received a prize.
- **Classroom teaching.** Every week teachers of grades 3–6 allocated 15 minutes for dengue-related teaching and motivation.
- **Student activity.** Students made sure there were guppy fish in the water jars and that empty jars in their homes and immediate surroundings were turned over. Teachers checked students' homes and gave performance scores to the children. Children with high scores received an award (a t-shirt, writing book, or reading book with a guppy logo).

Training and capacity building. Health center staff, village health workers, and teachers underwent project orientation, training, and skills development.

Monitoring, supervision, and support. The project manager and two members of the Cambodia National Center for Parasitology, Entomology and Malaria Control team met monthly with health center staff, and VHV meetings were held every 2 months to allow the timely resolution of issues. VHVs reported the following types of problems at these meetings:

- The need to tend rice fields and perform other activities;
- Other health-related responsibilities, which limited the time that could be devoted to the project; and
- The need to spend more time with households that did not want guppies in their water jars or that had missing guppy fish.

Evaluation

Entomology and knowledge, attitudes, and practices surveys. Baseline entomology and knowledge, attitudes, and practices (KAP) surveys were undertaken before the guppy fish were distributed and again at the end of the project. Follow-up entomology surveys were done every 3 months during the project.

Project stages: The Lao PDR

Preparation

Advocacy. A high level of advocacy was conducted with provincial and district health officials, the district governor, the Lao Women's Union (LWU), community leaders, and teachers.

Selection of dengue project assistants. The provincial project management team decided it would be more effective to have designated dengue workers at the village level rather than add an additional burden to VHVs. Village heads identified 218 dengue project assistants (DPAs) in consultation with the project team for the district. The DPAs were not paid for their time.

Breeding and distribution of guppy fish. Guppy fish were purchased from Thailand and transferred to the provincial malaria station office to establish a fish stock. After that fish stocks were also established at the district health office, and locally at health centers and primary schools in the project villages. The DPAs were responsible for distributing guppy fish to each household. About 20% of the guppies had to be replaced every quarter.

At the start, most of the fish died within days. The district team manager thought the water jars were too crowded and that the fish had died for lack of oxygen. He transferred his remaining stock to a large cement tank and bought an aerator for the tank. This setup worked well and the number of guppies increased quickly.

Implementation

Official launch. The project was officially launched on 10 September 2010. The launch was attended by the deputy governor of the province, senior government officials, health department staff, LWU representatives, schoolchildren and teachers, and other community representatives. The district governor fully supported the project and signed a decree formalizing the role of DPAs.

Monitoring, supervision, and support. Formal project meetings were held in the provinces, districts, and villages. The district team supervised the DPAs.

Community education. Bunting and posters with the behavioral messages were distributed to all schools. A logo was developed (Figure 13) and the provincial team negotiated with the TV broadcaster to develop a new advertisement for dengue control. The district team worked closely with the local radio broadcaster to provide information on dengue control regularly. In villages where there was a loudspeaker, the DPAs broadcast messages on dengue control.

School-based activities. Teachers visited students' homes to monitor the use of guppies and the impact of the cleanup campaign. Every Monday morning children were reminded about the importance of dengue control and their responsibilities. Every Monday children also turned in a form where they listed the dengue control actions they had taken over the weekend.

Figure 13 **The Lao PDR Program Logo**

Source: To Setha.

Training and capacity-building. Training and capacity-building workshops and meetings were held with district team members, DPAs, and health center staff.

Evaluation

Entomology and knowledge, attitudes, and practices surveys. Baseline entomology and KAP surveys were done before the guppy fish were distributed and again at the end of the project. During the project there were quarterly follow-up entomology surveys.

Project Costs in the Two Countries

Table 6 gives the country costs of the project per person and per household, for mobilization, communication, and education activities, and for the guppy breeding and distribution systems. Not included here are the supervision and oversight costs of the breeding and distribution system and the cost of monitoring the fish in community water jars.

The fish are extremely inexpensive to maintain. Cambodia has successfully bred large numbers of guppies using only readily available rice husks for food. When compared with the cost of purchasing temephos to be put into every water jar and tank every 2–3 months, the marginal costs of maintaining the guppy fish, once established, are little or none. ■

Once a guppy fish breeding system is established, almost no marginal cost is incurred in maintaining the guppies at the village and household level.

Table 6 Project Costs per Person and per Household in the Intervention Sites

Item	Cambodia	The Lao PDR
Costs per Person[a] ($)		
Mobilization and education activities	5.00	2.00
Guppy breeding and distribution system	0.25	0.22
Costs per Household[b] ($)		
Mobilization and education activities	24.00	12.56
Guppy breeding and distribution system	1.27	1.24

[a] Total number of people in the intervention villages: 22,085 in Cambodia and 12,598 in the Lao PDR.
[b] Total number of households in the intervention villages: 4,417 in Cambodia and 2,009 in the Lao PDR.

Source: HLSP (2012).

Chapter 5
Project Evaluation

The research project was intended to provide evidence to the national, provincial, and district levels of the dengue control program and other stakeholders on relevant approaches to integrated vector management and community mobilization strategies. The evaluation design included: the collection of baseline data in the intervention and comparison villages, the implementation of activities aimed at behavior change in the intervention villages, the conduct of quarterly entomology surveys, and the collection of final data in the intervention and comparison villages at the end of project implementation in Cambodia and the Lao PDR. The results of the research project provided insights into the effectiveness and feasibility of the interventions in the two countries. Many other dengue-endemic countries will benefit from those insights, and so will regional dengue control efforts, for which regional recommendations and guidelines can be further improved.

Goal and Objectives of the Evaluation

The **goal** of the evaluation was to provide data to support evidence-based decision making regarding the options available for integrated vector management, and for community mobilization as a framework for the delivery of the vector control interventions.

The **objectives** of the evaluation were:

- To assess the effectiveness of a community-based dengue intervention using guppy fish, in combination with a communication and social mobilization strategy for behavior change:
  - To achieve change in human behavior related to dengue control practices residents were to be encouraged to keep guppy fish in their large water storage jars, tanks, and drums; eliminate other mosquito breeding sites in and around the house; and go to a health center or hospital if someone in the household has fever for more than 24 hours.
  - Mosquito and mosquito larvae and pupae densities at the household level were also to be reduced.
- To assess the sustainability of the interventions.

Evaluation Activities and Timeline

The evaluation activities and timeline are given in Table 7. The core components of the evaluation were:

- Process evaluation (evaluation of the ways in which the services and goods provided under the project met or did not meet expectations—what happened, in what sequence, and did it happen as planned) through
  - a review of project reports;
  - focus group discussions; and
  - key informant interviews.
- Output evaluation (evaluation of whether the intended result, effect, or consequence occurred as a result of the project activities) through
  - a review of project reports;
  - focus group discussions at the end of the project;
  - key informant interviews at the end of the project;
  - baseline, quarterly, and final (end-of-project) entomology/guppy surveys: and
  - baseline and final (end-of-project) KAP surveys.

Table 7 Evaluation Activities and Timeline

Evaluation Activity	Feb–Jun 2010	Jun 2010	Sep 2010	Dec 2010	Mar 2011	Jun 2011	Sep-Oct 2011
Small research projects	Research completed						
Entomology/ Guppy surveys, Cambodia		Baseline survey	Quarterly survey	Quarterly survey	Quarterly survey	Quarterly survey	Final survey
Entomology/ Guppy surveys, the Lao PDR			Baseline survey	Quarterly survey	Quarterly survey	Quarterly survey	Final survey
KAP surveys, Cambodia			Baseline survey				Final survey
KAP surveys, the Lao PDR			Baseline survey				Final survey
Focus group discussions and key informant interviews, Cambodia and the Lao PDR							Focus group discussions and key informant interviews
Review of project reports							Review
Data analysis and project evaluation	Final evaluation in October and November 2011; the evaluation team met in November 2011 to discuss the overall evaluation findings.						

KAP = knowledge, attitudes, and practices.
Source: HLSP (2012).

Evaluation Methods Used

Entomology/Guppy Surveys

The same sample of households visited for the baseline entomology/guppy surveys was visited for the final survey. However, different households were visited for the follow-up quarterly entomology/guppy surveys. Households included in the evaluation were finalized after a review of the list of randomly selected households and on the basis of accessibility and advice received from village authorities. Households whose inclusion in the survey was not feasible, according to village authorities, were considered part of the nonresponse group.

Surveyors were trained to use a standard sampling procedure for the entomological surveys. The Cambodia National Center for Parasitology, Entomology and Malaria Control and the University of the Philippines Manila conducted a small research study to calibrate the sweep-net method used in the entomology surveys. The number of guppy fish in the water jars, tanks, and drums was based on direct observation by the surveyors.

Knowledge, Attitudes, and Practices Surveys

The same sample of households visited for the baseline and final entomology/guppy surveys also took part in the baseline and final KAP surveys. The KAP questionnaire was developed in consultation with project and external experts in the field and after a review of the scientific literature. It was translated into local languages by the country project managers and tested on a small scale in each country before the baseline survey.

Focus Group Discussions and Key Informant Interviews

Focus group discussions and key informant interviews were held in Cambodia and the Lao PDR with residents, community leaders, schoolchildren, teachers, and health center and district staff in previous research intervention areas, to identify lessons learned and understand the impact of the earlier studies on the community (Figure 14). Findings from the interviews and focus group discussions were used in planning the intervention and mobilization strategies of the research project.

Evaluation Results

Process Evaluation

Guppy fish breeding and distribution. Guppy fish breeding and distribution systems were established in both countries. Cambodia, drawing on its previous experience with the use of guppy fish, duplicated the system found to be useful in the country. Consequently, the system of guppy fish breeding and distribution to the health centers was established within the time period originally planned.

The project in the Lao PDR faced initial challenges as the country did not have enough stocks of guppy fish and had had no experience implementing a guppy fish breeding and distribution system. As a result, the fish stocks and distribution system were not established within the time period originally planned.

Figure 14 **Focus Group Discussion with Women, the Lao PDR**

Source: Sokrin Khun.

Figure 15 **Fish Successfully Breeding in a Large Cement Tank in the Lao PDR**

Source: To Setha.

The distribution of breeding stocks of guppies to schools, health centers, and village health workers' homes was delayed further by the need to construct large cement tanks (1 meter wide, 1 meter deep, and 2 meters long) for breeding the fish (Figure 15). The water jars in the Lao PDR were only about one-third the capacity of those in Cambodia and were too small to serve as guppy breeding sites. This experience highlights the importance of testing before large-scale implementation to allow adjustments to fit the local reality.

Community mobilization. Great effort was put into community mobilization. The five integrated communication actions from the COMBI planning tool were used in developing the mix of activities each country considered appropriate for its local context. As Table 8 shows, the project achieved, and in most cases exceeded, its performance goals. It is as important to evaluate how the process went as to measure the impact of the intervention. This type of evaluation looks into whether and how the delivery of the intervention may have affected the project outcomes. For example, delays or unplanned changes in any component, such as changes in the behavioral messages or the delivery of the guppy fish to the households, could adversely affect the use of fish in water jars. This negative impact may be incorrectly attributed to rejection of the dengue control method when in reality the people were merely confused by the messages or never received their fish.

Table 8 Process Results, by COMBI Communication Action (Community Mobilization Output Indicators)

Activities to Influence Behaviors	Operational Definitions	Achievements	
		Cambodia	**The Lao PDR**
Advocacy meetings (promotion and motivation)	N = no. of meetings held D = no. of meetings planned Performance target: 90%	100% of planned advocacy meetings held	100% of planned advocacy meetings held
Household visits (motivation and education)	N = no. of households visited D = no. of households planned Performance target: 85%	100% visited at least once a month by VHVs, health center staff, or CNM team during implementation period	Estimated 95% visited at least once a week during implementation period
Community meetings (motivation)	N = no. of meetings held D = no. of meetings planned Performance target: 80%	100% of planned meetings held	100% of planned meetings held in each village in November 2009; meetings then held in the villages, as recommended by health center staff

continued on next page

Table 8 continued

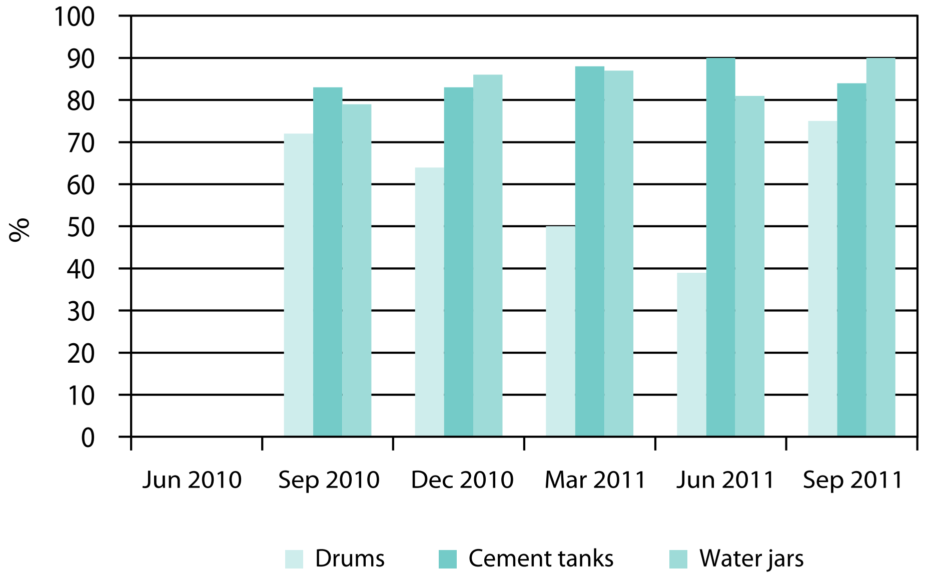
Activities to Influence Behaviors	Operational Definitions	Achievements: Cambodia	Achievements: The Lao PDR
Advertising, TV, and radio (education and motivation)		*Stakeholders agreed that advertising was not necessary under the program as current media activities regarding dengue control already included the use of guppies.*	
Tuk-tuk activity (mobile education and motivation)		100% of planned campaigns completed	100% of planned radio broadcasting in the local districts completed
Community drama show (involved schoolchildren)	N = no. of drama shows D = no. of shows planned **Performance target: 100%**	75% of planned dramas completed	
Bunting/Posters (reminder messages and motivation)	N = no. of bunting/ posters distributed; D = no. of bunting/ posters to be distributed **Performance target 75%**	100% of target groups received bunting/posters; reported 85% displayed and estimated 20% lost or badly damaged and subsequently replaced	100% of target groups received bunting/posters; reported 85% displayed and estimated 20% lost or badly damaged and subsequently replaced
School poster competition (reminder messages)	N = no. of prizes given D = no. of prizes planned **Performance target: 70%**		All schools in the intervention site took part in the competition; however, no prizes were given.
Calendar (point-of-service promotion)	N = no. of calendars distributed D = no. of calendars planned for distribution **Performance target: 70%**	Reported 100% target households, health centers, and schools	
Prizes for high achievement (motivation)		Prizes given to VHVs	

CNM = Cambodia National Center for Parasitology, Entomology and Malaria Control; COMBI = Communication for Behavioural Impact (WHO planning tool); VHV = village health volunteer.
Source: HLSP (2012).

Impact Evaluation

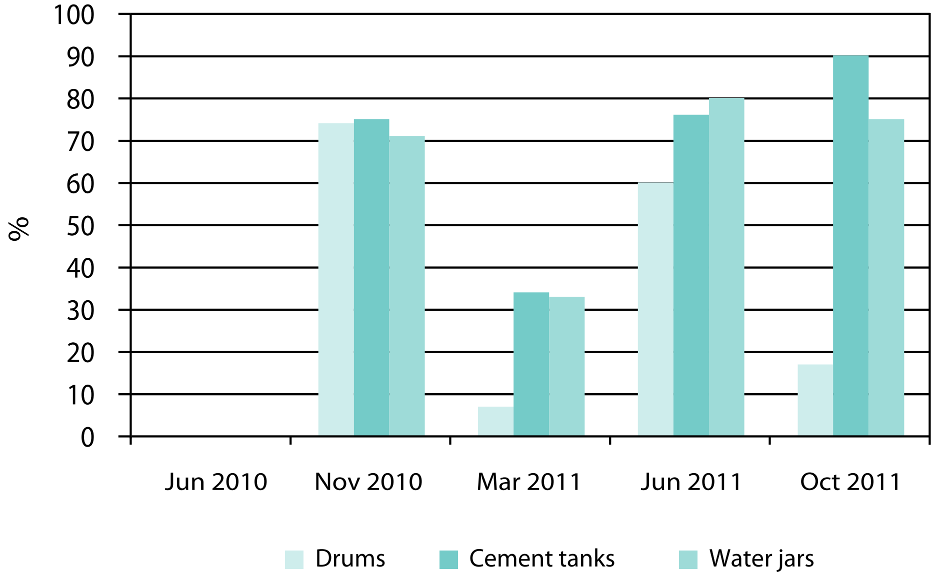
Measurement of behavior change among householders. A distinction must be made between active acceptance by the community of the fish in its water storage containers, and passive acceptance. With active acceptance householders are generally more motivated to replace the fish that die or disappear from the containers, while with passive acceptance householders may accept the fish but will not go out of their way to replace them if they die. In both countries households actively accepted the guppies: almost all accepted the fish in their water jars, tanks, and drums when first asked, and maintained the fish over time (Figures 16 and 17).

Figure 16 Water Containers with Guppy Fish in the Intervention Villages at the Time of the Survey, Cambodia



Source: HLSP (2012).

Figure 17 Water Containers with Guppy Fish in the Intervention Villages at the Time of the Survey, the Lao PDR



Source: HLSP (2012).

In addition to the initial acceptance of the fish, the presence or absence of the guppy fish during the project period was considered in assessing sustained community acceptance of the fish. Information about the percentage of homes with fish and the percentage of all large water containers with fish can be very helpful in program planning when combined with information from interviews with householders about why they have fish in their water containers or why they do not.

The practice of keeping guppy fish in larger bodies of water, including ponds, for aesthetic reasons and mosquito control is fairly common in both Cambodia and the Lao PDR. The use of guppies to control dengue has featured in dengue education messages on radio and television in both countries for several years, although there were no formal program strategies for distributing guppy fish to households. In November 2009, while visiting a village as part of the project start-up, a team member holding guppy fish in a plastic bag was approached by a young girl who asked if she could have some of the fish. When asked why she wanted the fish, the girl said, "Because they stop dengue." When asked how she knew, she replied, "Because they say so on TV."

By the end of the project implementation period in **Cambodia**, 88% of the water jars, tanks, and drums contained guppy fish. Figure 16 shows the coverage, by type of container, at the time of the various surveys. There was a drop in the percentage of drums with guppy fish during the second, third, and fourth surveys as these surveys were done during the dry season, when drums are not used. The presence of guppy fish in water jars and tanks, on the other hand, remained high throughout the year; over 79% of these containers had fish at any given time.

Between June 2010 (baseline survey) and September 2011 (final, or fifth, survey), over 80% of the three targeted water containers had guppy fish in them, as shown in Table 9. Water jars, tanks, and drums in the comparison villages were also inspected. As in the intervention villages, none of the targeted containers in the comparison villages had fish at baseline. Of interest, however, is the spillover effect from the intervention villages to the comparison villages, where a small number of water jars, tanks, and drums were found with guppy fish after the intervention started (range: 2%–7%).

Table 9 Water Containers with Guppy Fish in the Intervention Villages at the Time of the Survey, Cambodia

		Jun-10	Sep-10	Dec-10	Mar-11	Jun-11	Sep-11
All water containers	Total number	573	582	444	450	514	518
	Percentage with guppy fish	0	80	85	86	81	88

Source: HLSP (2012).

In the **Lao PDR**, 76% of the water jars, tanks, and drums had guppy fish in them at the end of the project. Coverage was high for all three containers at the time of the first survey, and then dropped in the second survey, which took place during the dry season (Figure 17). At the time of the third survey and the fourth (final) survey, coverage with guppies had increased above that seen in the first survey in water jars and tanks, but declined in drums (Table 10). The drop in the presence of guppy fish in drums was more than that in the other types of containers, but the figures are based on a low number of drums to start with (24–43 drums, compared with 331–426 water jars), which decreased during the project. Water jars and tanks accounted for most of the productive containers with guppies. At the time of the fourth (final) survey, 90% of water jars and 75% of tanks had guppy fish in them.

From June 2010 (baseline survey) to September 2011 (fourth, or final, survey), over 70% of the water jars, tanks, and drums had guppy fish in them (Table 10). According to the dengue project assistants (DPAs), the percentage of jars with guppies was low in the second survey (March 2010) because even jars that were empty on account of the dry season were included in the count (Figure 17) although only jars with water in them should have been included. A spillover effect was also found in the Lao PDR comparison villages, where after the intervention was implemented, the number of water jars, tanks, and drums found with fish ranged from 1% to 3%.

Table 10 Water Containers with Guppy Fish in the Intervention Villages at the Time of the Survey, the Lao PDR

		Jun-10	Nov-10	Mar-10	Jun-11	Oct-11
All water jars, tanks, and drums	Total number		465	507	557	590
	Percentage with guppy fish		72	32	77	76

Source: HLSP (2012).

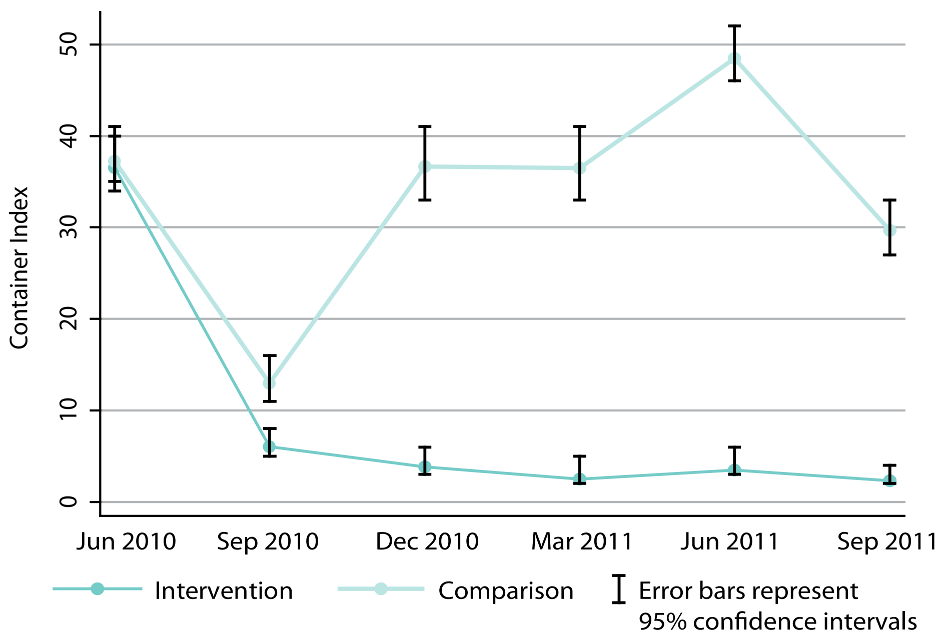
Measurement of the impact on mosquito larval and pupal indices at the household level. Standard entomological indices were calculated to determine the effect of the intervention on the adult and aquatic phases of the mosquito life cycle. These indices included the House Index (the number of houses found with at least one container with larvae or pupae), the Container Index (the number of containers with at least one larva or pupa in it), and the Breteau Index (the number of houses with at least one container with larvae or pupae for every 100 houses). Only information on the House and Container indices will be discussed in this monograph. The entomological data could not be linked with data on dengue cases, however.

In the comparison villages in **Cambodia**, the container indices started to increase in September 2010, and remained high throughout the final entomology/guppy survey in September 2011 (Figure 18). There was a drop in the number of containers with *Aedes* larvae after the baseline survey because of the application of the chemical larvicide temephos in the control area in July 2010 in response to a dengue outbreak. As seen in Figure 18, the number of containers with mosquito larvae quickly rose back to the baseline level in the comparison villages between the September and December 2010 surveys, indicating that the impact of the temephos was short lived.

The increase in containers positive for larvae and pupae from less than 40% of all containers to 50% in June 2011 is attributed to annual seasonal fluctuations.

In contrast, the proportion of water containers found with mosquito larvae and pupae in the intervention villages dropped between the baseline and September 2010 surveys, and remained low throughout the intervention period. During the dengue outbreak, the decision was made to rely on the guppy fish to eat the mosquito larvae and pupae, and not add temephos to the containers. Unlike the comparison villages, the intervention villages experienced no increase in the proportion of positive containers, indicating that the use of guppies suppressed seasonal fluctuations in mosquito breeding. The percentage of containers with *Aedes* larvae and pupae in the September, December, March, and June surveys and the final survey in September 2011 varied only slightly although it never reached zero. This was to be expected because even with the best control there will always be a few containers without fish. The results by village show exactly the same pattern as in the aggregated intervention and comparison areas.

Figure 18 Percentage of Water Containers with *Aedes aegypti* Larvae or Pupae (Container Index), by Village and Survey Time Point, Cambodia

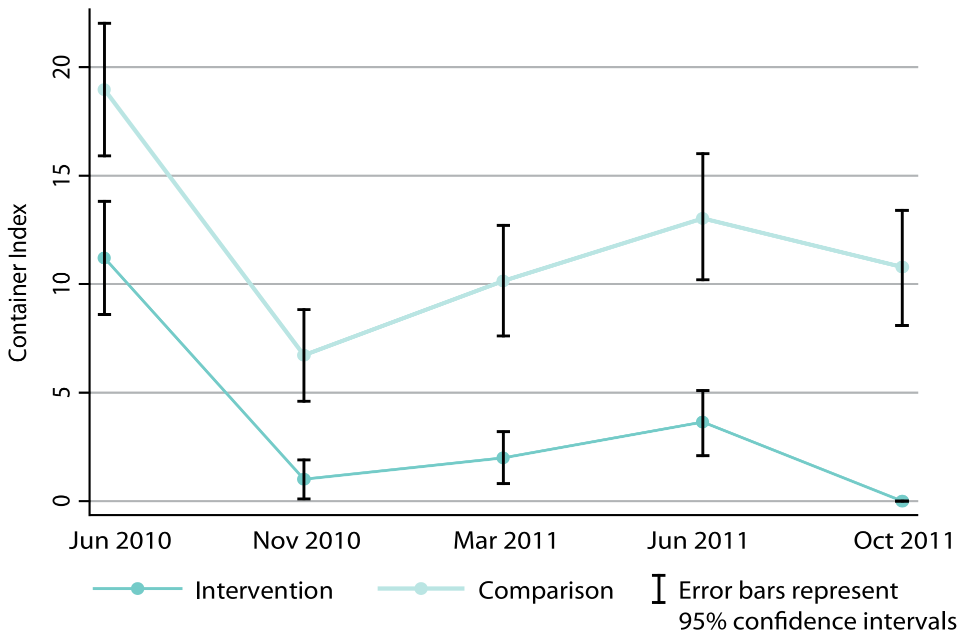


Source: HLSP (2012).

Overall, the results from the **Lao PDR** do not present as clear a picture as the data from Cambodia. As seen in Figure 19, there was a drop in the proportion of containers with *Aedes* larvae and pupae between the baseline and first follow-up surveys in the intervention and comparison villages, reflecting the normal seasonal drop after the rainy season. However, the drop was greater in the intervention villages and the proportion of containers with *Aedes* larvae and pupae remained lower in those villages than in the comparison villages throughout the intervention period.

The normal seasonal fluctuations seen in the intervention villages, although at a lower container positivity rate, reflect the delay in attaining high levels of guppy coverage due to challenges faced in establishing the guppy fish stock and distribution system. However, the Lao PDR had very positive results and the two countries had very similar Container indices in the final, October 2011, survey (Figures 18 and 19).

Figure 19 Percentage of Water Containers with *Aedes aegypti* Larvae or Pupae (Container Index), by Village and Survey Time Point, the Lao PDR



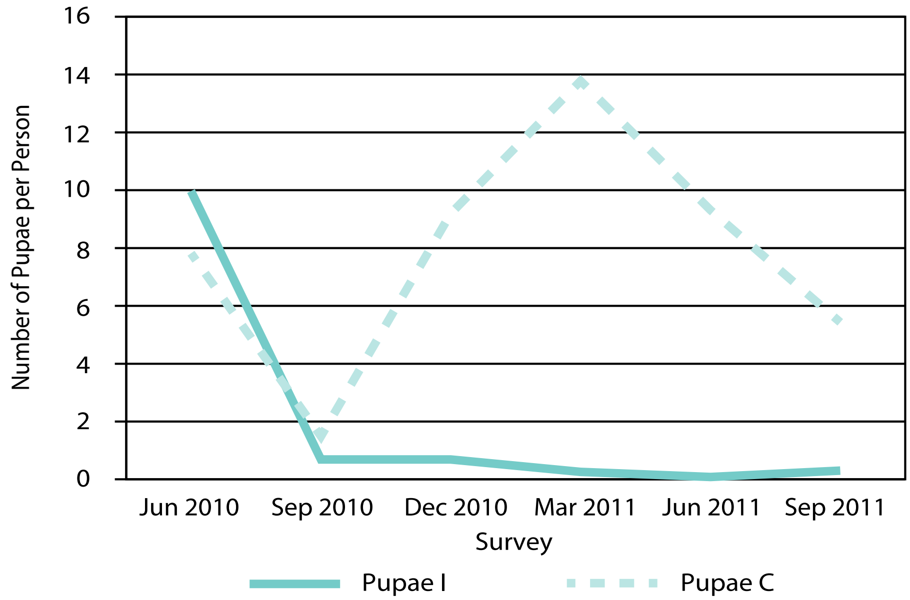
Source: HLSP (2012).

Measurement of the impact on mosquito pupae and adult densities at the household level. Because the number of mosquito pupae is highly correlated with the number of adult mosquitoes, the mean number of *Ae. aegypti* pupae per person was calculated to determine how many potential adult mosquitoes would emerge from the containers (TDR/WHO 2006).

In the comparison villages in **Cambodia,** the number of pupae collected from all container types increased after the first follow-up survey, reached a peak in the third follow-up survey, and then decreased, reflecting the seasonal trend (Figure 20). In the intervention area, on the other hand, the mean number of pupae dropped after the baseline survey and stayed very low, almost at zero, throughout the project intervention, an indication that the guppy fish were eating most of the mosquito larvae and pupae.

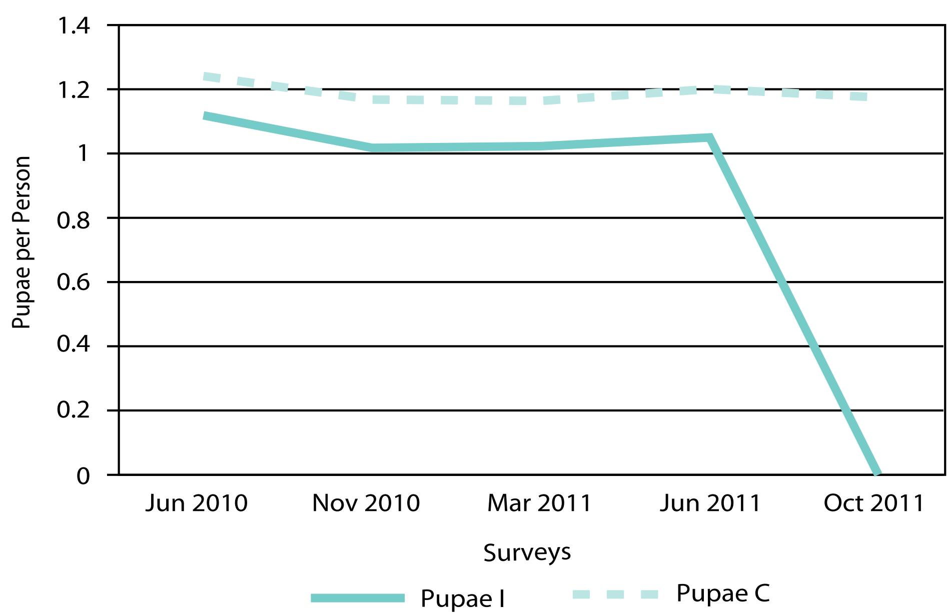
The collection of adult mosquitoes inside homes, an indirect measure of contact between people and mosquitoes, showed that the mean number of *Ae. aegypti* mosquitoes per person also dropped after the baseline survey and remained low through the follow-up and final surveys in the intervention villages in Cambodia.

Figure 20 Mean Number of *Aedes aegypti* Pupae per Person at the Time of the Survey, Cambodia



Pupae I = pupae in intervention villages, Pupae C = pupae in comparison villages.
Source: HLSP (2012).

Figure 21 Mean Number of *Aedes aegypti* Pupae per Person at the Time of the Survey, the Lao PDR



Pupae I = pupae in intervention villages, Pupae C = pupae in comparison villages.
Source: HLSP (2012).

The number of adult mosquitoes captured in the comparison villages also decreased between the baseline and first follow-up survey, then steadily increased, following the seasonal increase seen with the percentage of large water storage jars with larvae and pupae (Figure 18). As with the results from the pupae surveys, this trend indicates that the guppy fish had an effect on adult mosquito populations. The number does not drop to zero because not all mosquito breeding sites were amenable to the use of guppy fish.

In the **Lao PDR**, the results of the pupae sampling surveys more clearly show that the impact of the guppy fish on adult *Ae. aegypti* populations was delayed (Figure 21). As noted earlier, problems encountered with breeding the guppy fish at the community level delayed the impact on pupal counts. In the comparison villages the mean number of pupae remained almost the same across the entomological survey time points. In the intervention villages the mean number of pupae was similar to that in the comparison villages, but then dropped to zero in the final survey.

Figure 22 Elimination of Potential *Aedes aegypti* Breeding Sites in Cambodia

Source: HLSP (2012).

Elimination of other breeding sites in and around the house. Although 80% of *Ae. aegypti* breeding sites were found in water jars, tanks, and drums, the containers making up the remaining 20% were also important. An underlying principle of this project was that implementing an effective control method that was acceptable to the community, cost little, and could fairly easily be maintained by the local health and education systems and householders would not only eliminate the greatest source of adult *Ae. aegypti* mosquitoes but also allow program staff to focus on the more complex behaviors required for the diverse containers that compose the remaining 20%.

Program constraints did not allow the conduct of tracking surveys to determine the degree of acceptance of the behavioral messages targeting other mosquito breeding sites around the houses and compounds. Project team members, in particular village health volunteers (VHVs) and dengue project assistants (DPAs), observed that householders turned over unused containers, emptied others, and discarded rubbish as a result of the project intervention (Figure 22). Others involved in the project also noted that, most of the time, householders willingly acceded to the request to remove potential breeding sites. In one village the householders stated that they cleaned out animal feed and water troughs weekly to keep mosquitoes from breeding in them.

Conclusions

The project demonstrated the efficacy of the combined use of guppy fish, environmental control interventions, and social mobilization to reduce *Ae. aegypti* larvae, pupae, and adult mosquito densities, as demonstrated by declines in the House and Container indices, and in the number of pupae and adult mosquitoes per person. The declines in container positivity were between two and six times greater in those containers with guppy fish as compared with those containers targeted for elimination or other preventive actions by the householder (data not shown).

> The combination of a biological control and social mobilization intervention was very effective in reducing the source of the adult *Aedes* mosquito.

The project validated the use of guppy fish in large water containers of the type traditionally used in Cambodia and the Lao PDR. In so doing it also validated the use of guppy fish as part of an integrated dengue control strategy that should be considered by other countries in the region where large water containers are the most productive containers for *Ae. aegypti* breeding. The COMBI planning tool also proved useful in refining community mobilization and communication strategies, and was endorsed by all key stakeholders at the national, provincial, and district levels.

Knowing how many houses have containers positive for *Aedes* larvae and pupae, and which containers are positive for mosquito larvae and pupae, is useful in targeting the houses that often have positive containers for additional education and motivation visits. The households may need extra help understanding the behavior or may be impeded in its adoption by a particular barrier. Such information, particularly about an increase in House or Container indices after a period of decline, can also help the dengue control program detect the need for additional reinforcement messages in the community. But focusing on the most productive containers does not mean that vector surveillance can skip other potential mosquito breeding sites. Vector surveillance must continue so that other containers of importance can be identified and addressed in the next round of social mobilization and communication activities.

The implementation of biological control alone is neither practical nor advisable since containers not suitable for fish are still viable sources of adult mosquitoes and need to be dealt with through other behavioral measures. Also, addressing some vector sources and not others may result in inconsistent messages, depending on the number and type of productive containers in a specific area or country.

Field observation, supported by survey data, validated the finding that the presence of between one and three guppy fish per water jar was enough to totally eliminate mosquito larvae and pupae from large water containers. The application of temephos in the comparison villages in Cambodia during the July 2010 outbreak provided a good demonstration of the short-lived impact of the chemical larvicide. The guppy fish, on the other hand, were shown to be an effective response to the outbreak and provided a long-term prevention method that suppressed the normal seasonal fluctuations in mosquito breeding.

The implementation stage in both countries was relatively short—11 months in Cambodia and 9 months in the Lao PDR. While there have been positive outcomes, household behavior change is unlikely to be sustained in the long term without ongoing support at the village level. This is true not just for the use of guppy fish.

> The great failure of dengue prevention and control programs is that they have not been able to engage the community in long-term vector control actions.

This project was considered effective and successful by villagers and district health staff in both countries in mobilizing the community to prevent and control dengue fever. Signs of community participation from the grassroots in maintaining guppy fish and discarding containers were reported, but the involvement was still at an early stage. More time and resources are needed to sustain the success. ■

Chapter 6
Lessons Learned and a Way Forward

Coordinated and Sustained Dengue Prevention and Control

Although *Ae. aegypti* was almost eradicated in the Region of the Americas in the 1960s and early 1970s, it has recolonized many areas in even greater numbers than before the eradication campaigns of the 1950s and 1960s. The recolonization has occurred because of complacency, reduced vector surveillance and control services, and increased urbanization without adequate housing and water, sewage, and waste management systems. The proliferating water storage containers and nonrecyclable products provide numerous and highly productive breeding sites for mosquitoes. In the Pacific Islands dengue fever was reintroduced in the early 1970s after an absence of more than 25 years, and epidemic activity has increased in recent years with major epidemics of severe dengue on several islands (Ostroff 2012). Even in areas where control has been successful, entomological and disease surveillance, and prevention and control measures, must be maintained.

Countries in the Western Pacific Region remain at high risk of having a dengue outbreak. The risk in the Greater Mekong Subregion (GMS) is particularly high because of socioeconomic factors, including inadequate sanitation and water supply systems, and the presence of large numbers of water storage containers on household premises. Perhaps the greatest challenge to the GMS is to implement a sectorwide dengue strategy for which a structured, evidence-based approach to decision making like integrated vector management (IVM) is required. A multisector approach that takes into account the social and ecological factors that together affect dengue prevention and control is essential (Spiegel et al. 2005). Failure to take these factors into account is a major reason that dengue control strategies have been ineffective so far. With a whole-system approach, bridges can be built between key players involved in dengue prevention and control across various disciplines and institutions. The link between poor health status, poverty, and social dislocation in many societies suggests that a multisector approach is required (Green-Thompson 2000).

A social and economic impact analysis (SEIA) may be useful for dengue decision making in the GMS. An SEIA identifies key social and economic issues, their interrelation and consequent impact on dengue incidence, the spread and burden of disease, barriers to prevention and access to early diagnosis and case management, and potential impact in the future (Stanley et al. 2004). A necessary component of the analysis would be a biophysical and ecological assessment. The information obtained through the SEIA helps decision makers address the following critical issues in dengue prevention and case management:

- **Coordinated multisector approach to dengue prevention, control, and case management.** Water and sanitation agencies are engaged very little or not at all in national dengue policy and have even less involvement locally. Key activities and interventions are often provided by different agencies supported by various organizational and funding arrangements of greater or lesser sustainability. The extent of private and public mix in the funding and provision of services varies within and between countries. Often the component parts work as separate entities with little interaction, yet for dengue control to succeed, all the key actors must work together.
- **Better access to early diagnosis and case management at the national and local levels.** This is important because the prevention and control of dengue is very difficult and, while there is no specific treatment for dengue, early diagnosis and effective case management are available. It is particularly important to establish an effective referral system for managing severe dengue, as appropriate case management, when provided early, saves lives.
- **Sustainable implementation of a cohesive strategy to strengthen national capacity for dengue prevention and control.** Improvements must be made in capabilities for policy development, strategic and financial planning, social sciences, entomology, epidemiology, and clinical management. For dengue control measures to be sustainable, nongovernment organizations, government agencies, and communities must work together as partners.

Dengue prevention and control requires a multisector approach that takes into account the social and ecological factors that affect it. Failure to take these factors into account is a major reason dengue control strategies have been ineffective so far.

Source: Spiegel et al. (2005).

Lessons Learned in Dengue Vector Control

This project, as well as previous dengue vector control projects and national programs in the GMS over the past few years, has provided insights into the positive and negative factors that affect the outcomes of dengue prevention and control programs.

Vector control measures will not work unless householders accept them.

In Cambodia and the Lao PDR, 80% of containers found with *Ae. aegypti* larvae and pupae were large water jars or cement tanks. The other 20% were miscellaneous items such as small jars, cans, bottles, feed bins, coconut shells, tires, and upturned boats. Previous control messages for these containers, such as "scrub, rinse, and refill once a week," were burdensome and time consuming in both countries; for that reason, most people cleaned the containers very irregularly, if at all. In Cambodia, the water jars are much larger than those in the Lao PDR and therefore very difficult to scrub out and turn over. Attempts have been made to address the problem of *Aedes* breeding in water jars, by covering the jars and using copepods (*Mesocyclops*) (Chang et al. 2008a; Kay et al. 2002). Householders complained that constantly removing the covers from the jars and putting them back on was a chore. But mosquitoes can enter an uncovered or improperly covered jar. During a visit to a village in Cambodia in the early stage of the project, one householder, when asked if she had any jar covers, replied: "Yes they are upstairs. I don't leave them on the jars as the children play with them and they get damaged." Attempts to promote the use of *Mesocyclops* in large water storage jars in Cambodia, following the successful experience in Viet Nam, were rejected by householders for various reasons.

Two pilot studies in Cambodia showed good acceptance of fish in water jars among community members once the purpose was understood and community concerns were addressed. Overall, the research project revealed that the use of guppy fish in water containers is acceptable to householders in both countries. More importantly, it showed that householders are willing to maintain guppies in water jars by replacing those that are lost or agreeing to have them replaced by the VHVs and DPAs.

> If people see value in an activity, there is a good chance they will continue it. As householders maintained guppies during the life of this project by replacing or agreeing to have others replace lost guppies, it is reasonable to assume they saw value in keeping guppies in their water jars, as well as in removing other potential breeding sites around their homes.

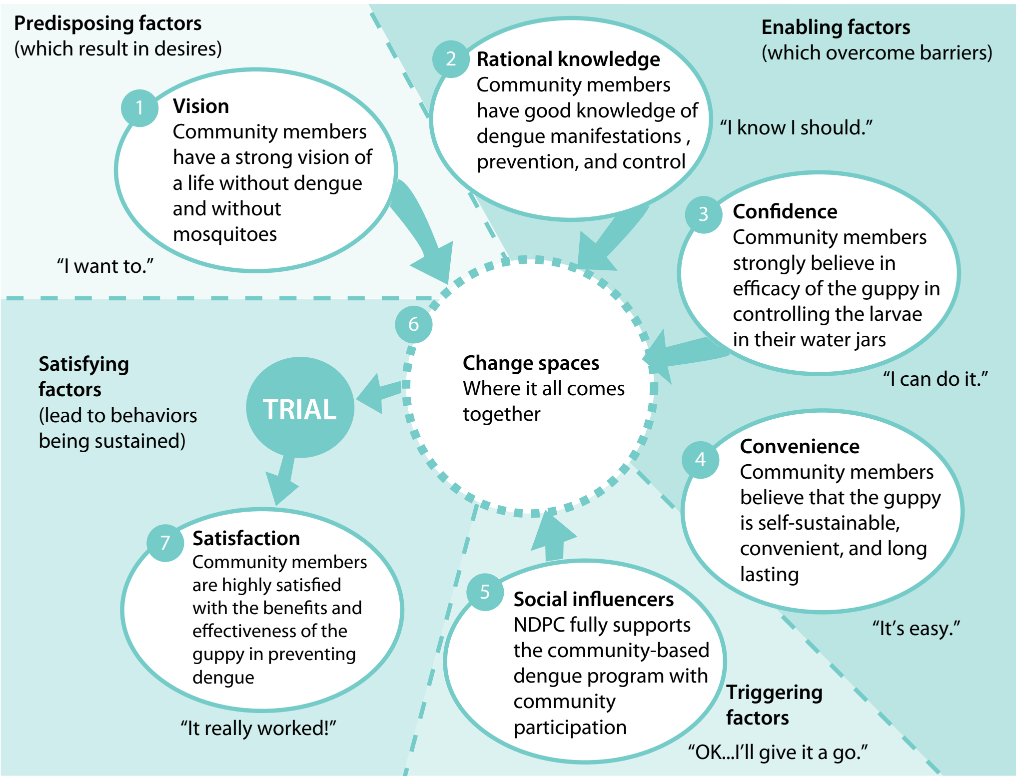
Importance of an Enabling Environment and User-Friendly Technology

Field testing under real-life conditions, as demonstrated in this project, provided evidence that guppies are a user-friendly technology for controlling mosquitoes. One important factor in the acceptance of guppies was the fact that people, particularly children, *liked* them. If an activity is something that people do not like to do or see no value in doing, they will not do it, as evidenced by the reluctance to scrub and rinse jars weekly or use jar covers.

At the household level, an enabling environment makes the recommended vector control strategies feasible. Because cleaning the large water jars once a week was found to be unfeasible, the research project offered an alternative solution to the community: keep two or three guppy fish in each large jar so families would no longer have mosquito larvae in their water jars.

A review of the earlier Bati district project looked into the factors that led to sustained behavior change (the 7 Doors Model, Figure 23). The combined approach of using guppies and environmental control actions supported by community mobilization and integrated communication strategies, all with the same behavioral change objectives, was found to create an enabling environment for vector control.

Figure 23 The *7 Doors Model* of Behavior Change



NDPC = National Dengue Prevention and Control Program.
Source: Carol Beaver adapted from Les Robinson, 7 Doors Model. http://www.media.socialchange.net.au/strategy/7_Doors_Model.html

> Community-based environmental and biological control approaches must go hand in hand with education and mobilization initiatives that support community behavior change.
>
> Source: Nature Education (2012).

Besides devising communication strategies to remind community residents to carry out the behavior, ministries of health must also draw up a plan for sustaining their own efforts to motivate and guide householders in the behavior.

For control strategies to be effective in the medium to long term, there needs to be sustained effort to motivate householders. Provincial and district health departments must monitor how the distribution system is working, how the village health volunteers (VHVs) and dengue project assistants (DPAs) are coping with their additional role, and whether there is a plan for recruiting new VHVs and DPAs as people move on to other things.

How the COMBI Planning Tool Helped

The COMBI planning tool (Parks and Lloyd 2004) had been used previously in both countries and had been well received. In the research project it was useful in refining community mobilization strategies and in engaging key stakeholders at the national, provincial, and district levels. Perhaps the most important element in the planning process was the situation analysis and formative research. This work informed and reinforced key communications, enabling community members to understand why fish were useful, to agree to keep fish in water jars and tanks, and to remove other potential breeding sites.

In both countries, there was a concerted effort to define clearly the behavioral objectives that were the basis of all the communication activities, and then to agree to those objectives. It was also recognized that there had to be a shared understanding of the *behaviors* (activities) expected of all key players, who had to make sure that householders had access to guppies when they needed them, and to motivate families to keep guppies and to remove or turn over other containers.

Multiple communication strategies, all centered on the desired behavioral changes, were used because pre-project discussions about what might work for vector control within the household had to involve not only householders and their advocates (such as members of the LWU and heads of villages) but also those whose behaviors would influence the householders' acceptance of guppies and container management (VHVs, DPAs, teachers).

Importance of Community-Specific Mobilization Strategies

While Cambodia and the Lao PDR used household-, community-, and school-based approaches, their implementation of each approach was specific to the factors (e.g., social, cultural, political, environmental) that had to be addressed to gain support for the primary (new) behavior of controlling the containers that account for 80% of breeding sites, and the secondary (existing) behaviors pertaining to the rest of the breeding sites, plus seeking medical care for any fever that lasts for more than 24 hours. The research project included all containers to maximize the overall impact on larvae, pupae, and adult mosquitoes.

When it comes to developing community mobilization strategies, *one size does not fit all*.

Capacity Building

Dengue prevention programs require an interdisciplinary approach and committed year-long involvement of community leaders and householders. This project did not fund country project staff positions. In both Cambodia and the Lao PDR country project staff had to fulfill their normal work roles in addition to their functions under the project. VHVs and DPAs had to divide their time between several health programs, community responsibilities, and work on their fields or farms.

Both time and knowledge constraints had to be dealt with in the project implementation plan. Project implementers in Cambodia had the benefit of relevant previous experience in breeding and distributing guppies, but their knowledge was limited, particularly in dealing with diseases affecting guppy stocks. Capacity constraints also affected data collection and management. Most dengue-endemic countries have limited capacity for monitoring and evaluation. Not knowing how to use assessment tools, staff use them incorrectly or do not use them at all, leading to poor-quality data and decision making. Training at all levels was developed as part of the project to address these capacity constraints.

General Challenges Facing Dengue Control Programs

Certain challenges faced by all dengue control programs in resource-limited countries affected the project in both countries to some extent. Dengue-endemic countries must train their health staff to identify the warning signs of severe dengue and to establish effective referral systems for case management in order to prevent deaths. Late referral to a hospital is a leading cause of death among patients with severe dengue. A further issue is the limited number of national staff dedicated to dengue control and their often-competing priorities.

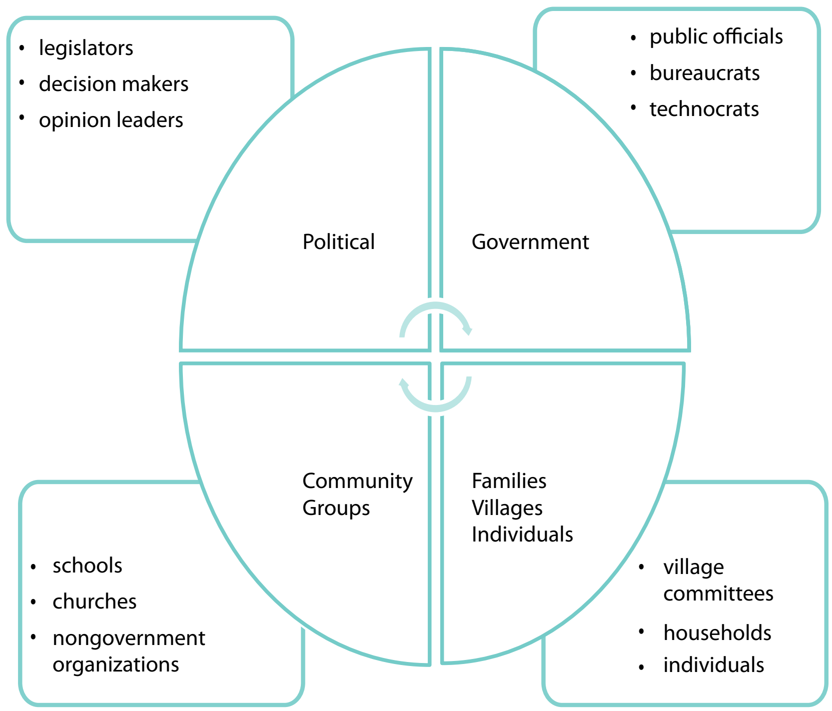
Why Integrated Vector Management Is Essential

IVM is a decision-making tool that allows public health officials to make rational decisions regarding vector control in order to optimize resources and select the mix of vector control measures that best meets the needs of the community and the vector control program. The key elements of an IVM strategy tackle all the factors that lead to continued dengue transmission and dengue fever epidemics, including *Aedes* control strategies, legislation and policies, weaknesses in infrastructure that result in water storage and accumulation of refuse in compounds, and limited capacity of programs to meet today's challenges (Table 1, Chapter 1).

Why Widespread Social Mobilization Is Essential

Social mobilization refers to the act of bringing people together to raise awareness and demand for action on public health issues, and on prevention and care, and to support the delivery of needed resources, services, and changes in policy (Stimson et al. 2003). Social mobilization places on the public agenda issues that have impact on the broader society, such as dengue, and facilitates a widespread, coordinated response. Unfortunately, social mobilization is often interpreted as mobilizing villages and households rather than mobilizing all critical sectors of society—political institutions, government, communities, families, households, and individuals—as shown in Figure 24.

Figure 24 **Social Mobilization—Engagement and Participation**



Source: Carol Beaver adapted from Stimson et al. (2003).

Wider-Scale Implementation in Cambodia and the Lao PDR

The key questions in this regard are: *Is the approach sustainable (and therefore worth expanding)?* and *Is wider-scale implementation possible and advisable?* The implementation stage in both countries was short—11 months in Cambodia and 9 months in the Lao PDR. While there have been positive outcomes, **household behavior change is unlikely to be sustained in the long term without ongoing support at the village level**.

The definition of sustainability adopted for this project is "the continuation of programs when the financial, organizational, and technical support of external donors/organizations has ceased" (Swiss Development Cooperation 1991). Research suggests that the following factors can influence sustainability: project design and implementation factors, factors within the organization setting, and factors in the broader community environment (Shediac-Rizkallah 1998).

The sustainability of this approach to dengue vector control depends on the interaction among the following factors, at both the household and health sector levels:

- Acceptability;
- Financial sustainability; and
- Institutional sustainability.

In line with the measurement of sustainability, 11 criteria that should be considered when planning for sustainability have been proposed (Shediac-Rizkallah 1998). A twelfth criterion, intrinsic impetus for change and review, was added to the core criteria on the basis of practical experience (Table 11).

Table 11 Criteria for Assessing Potential for Project Sustainability

Project design and implementation factors
1. Project negotiation process
2. Project effectiveness
3. Project duration
4. Project financing
5. Project type
6. Training
Factors within the organizational setting
7. Institutional strength
8. Integration with existing programs and services
9. Program champions and leaders
Factors in the broader community environment
10. Socioeconomic and political considerations
11. Community participation
12. Impetus for change and review

Source: Carol Beaver adapted from Shediac-Rizkallah (2008).

The performance in Cambodia and the Lao PDR scored well against all criteria when assessed in qualitative terms—"strong," "medium," and "no potential to exist in the future"—by the project evaluation team. In both countries there is strong impetus for change to control dengue. While it is not possible at this time to comment on the future sustainability of the project, the assessment showed that the project approach has the potential to be sustainable in the longer term. Having the majority of factors in place is necessary for sustainability, but it is not a sufficient prerequisite.

Three essential factors will determine sustainability:

- **Adequate funding** for breeding and distribution systems in other districts, training, and ongoing monitoring;
- A **focused and sustained commitment** to implement source reduction and maintain it in the long term, which implies intrinsic impetus for change and review in the responsible organization; and
- **Incentives to motivate and sustain** the key implementers in order to sustain their effort.

As noted earlier, this project did not provide incentives for all involved other than their own internal commitment to help their communities and some caps and t-shirts. For national and provincial program staff, district teams, and health center staff, there was the additional incentive of supporting their respective organizations.

There is a strong possibility that the approach will be expanded and perhaps supported with a mixed model of funding. Cambodia is studying ways of incorporating the use of guppy fish into an integrated vector control strategy. Phnom Penh now has a national guppy breeding center established with WHO assistance toward the end of the project (Figure 25). A local nongovernment organization that was created in the country to manage a health equity fund with external funding has also shown interest in supporting prevention programs. The organization is likely to support or manage local initiatives such as dengue control, in particular the breeding and distribution of guppies.

Figure 25 Guppy Breeding Center, Phnom Penh, Cambodia

Source: To Setha.

In the Lao PDR, the vector control program managers have developed a draft strategy for integrated dengue vector control that includes the current approach, and are discussing the proposal with government officials. In addition, a handbook on guppy fish breeding and management (Ministry of Health and Ministry of Agriculture and Forestry, Lao People's Democratic Republic, forthcoming) was developed and the use of guppy fish was discussed at a dengue workshop for 10 provinces involved in the ADB Communicable Disease Project (CDC-2), and at meetings held to discuss the project further with local, district, and provincial leaders.

Moving Forward in Cambodia, the Lao PDR, and Other Countries: Decision-Making Support

All countries where dengue is an issue should undertake a situational analysis that includes a COMBI planning process to review and develop or revise their dengue vector control strategies. This way, they can determine the way forward that best meets their needs, and that is achievable and sustainable in the medium to long term. They are likely to find that they will have to use integrated vector management comprising environmental and biological control strategies.

In other countries, especially those where large water containers are commonly used in rural areas, the effectiveness of guppy fish and the COMBI planning tool should also be assessed. Many of the small Pacific Islands that are prone to major dengue outbreaks and that commonly store water in large metal drums should be among these countries. To move forward, key decision makers need to understand the following clearly:

- The current situation, together with its impact and costs;
- Likely future scenarios and their impact and costs;
- Funding entities and the projects they are funding;
- Sustainable funding models;
- Potential benefits and savings from changes in vector control strategy;
- Opportunities that exist to close the gap between the current situation and desirable future scenarios; and
- A strategic plan that is financially achievable and sustainable in the medium term.

The Best Model

Effective dengue prevention and control will not be possible unless efforts to prevent mosquito breeding become a broader societal concern, and the approach most suited to the community or country concerned is taken. Someone else's strategy or approach, blindly accepted as the best model, is unlikely to work or be affordable.

> Integrated action and community participation must be high on the agenda for any dengue control strategy.

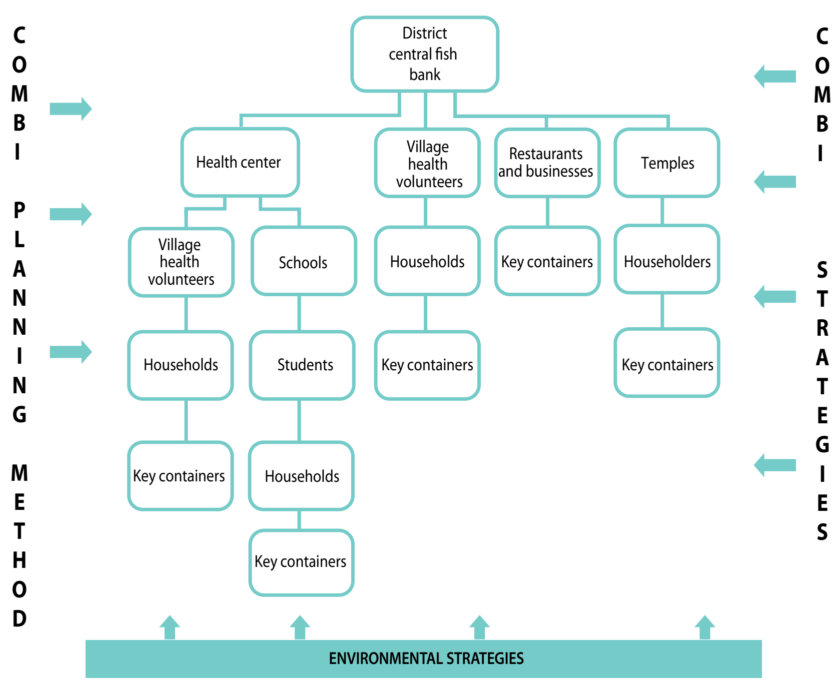
There also needs to be a medium- to long-term view of what is required, in a particular situation, to motivate and support all key players and to keep them motivated. The short-term nature of the research project did not allow project planners and evaluators to determine the resources (who, what, and with what degree of effort) that would be needed in the medium to long term to retain the high level of compliance in both countries. However, the evaluation results, in particular from the focus group discussions, suggest that householders will maintain the effort if they are reminded and supported over time.

Motivation generally diminishes as the desired goal and main motivating factor, in this case decreasing vector density through the use of guppy fish, is achieved. A mix of COMBI activities must therefore continue at the district and village levels to sustain the desired behavioral change. There have been some post-project discussions in Cambodia and the Lao PDR about how to move forward. As seen in the Lao PDR, temples could play a key role in guppy breeding and distribution (Figure 26). The possibility of expanding the integrated strategy to include businesses (especially those that store tires), restaurants, and hotels, in particular those with ornamental ponds, has been discussed.

A visit by 40 participants from the project villages to Thatong village, near the capital city in the Lao PDR, provided an example of the forward thinking that is taking place in the two countries. The head of the village, LWU volunteers, and monks from Thatong temple presented their experiences in using larvivorous fish to combat dengue in their communities. The temple manages fish breeding, and the volunteers take charge of community education and guppy distribution. The volunteers receive no incentive except a t-shirt; they said that preventing the loss of time and resources due to dengue fever in their communities is incentive enough. The group uses a carrot-and-stick approach: fish are distributed to the villagers with explanations of the health benefits of their use, and villagers found to have larvae in their water jars are reported and subsequently fined. Initiated by a monk in 2009, the intervention now covers 492 households, visited regularly by more than 200 LWU volunteers.

The key to success in Thatong village was felt to be the strong village leader, who persevered through many village meetings to encourage community acceptance, and previous successful experiences with community-based health initiatives. There are plans to place fish tanks at health centers so dengue patients can be sent home with fish, and to have the volunteers visit other villages to promote the intervention. A guppy breeding distribution system that involves businesses and temples is part of the Lao PDR's draft dengue vector integrated management strategy (Figure 26).

Figure 26 Example of a Fish Breeding and Distribution System, the Lao PDR



COMBI = Communication for Behavioural Impact (planning tool of the World Health Organization).
Source: Carol Beaver.

Summary

Effective dengue prevention and control programs require a coordinated, sustained multisector approach to addressing the environmental, behavioral, and social contexts of mosquito breeding and disease transmission. The research project used integrated vector management as the framework for the development of an effective, low-cost, community-based strategy that included mobilizing the community to organize and promote the use of guppy fish for the control of *Ae. aegypti* larvae and pupae in large water storage jars, tanks, and drums. The guppy fish distribution system, once established, was not difficult or costly to maintain, and could be managed at the local level.

Lessons learned during the project that may be helpful to other countries seeking to implement a similar process include the importance of working with communities as true partners in planning and implementing social mobilization and communication activities; creating partnerships with schools and nontraditional partners (for example, public transportation) for effective communication and education activities; ensuring that community volunteers are motivated, have the skills to fulfill their expected duties, and are given a reasonable number of houses to cover; and measuring perceptions of the project's impact across all levels including the community, health staff, and other partners and stakeholders. ■

Annex
Revised COMBI Planning Process

Original 15 Steps	New 10-Step Process
1. Assemble a multidisciplinary planning team	1. Assemble a multidisciplinary planning team
2. State preliminary behavioral objectives	2. Establish a methodology for documenting the process, and managing and sharing information (includes the previous step 11)
3. Plan and conduct formative research	3. Identify the preliminary behavioral objectives and test their feasibility (includes the previous step 6)
4. Invite feedback on formative research	4. Plan and conduct formative research
5. Analyze, prioritize, and finalize behavioral objectives	5. Share and discuss the results of the formative research and finalize the behavioral objectives (includes the previous steps 4 and 5)
6. Segment target groups	6. Pretest messages and materials
7. Develop a strategy	7. Establish a monitoring and evaluation system
8. Pretest behaviors, messages, and materials	8. Strengthen staff skills
9. Establish a monitoring system	9. Write an operational plan (includes the previous steps 7, 12, 13, and 14)
10. Strengthen staff skills	10. Implement the operational plan, revise it according to the results, and replicate it in another area
11. Set up systems to manage and share information	
12. Structure the program	
13. Prepare a strategic implementation plan	
14. Determine the budget	
15. Conduct a pilot test and revise the strategic implementation plan	

COMBI = Communication for Behavioural Impact (planning tool of the World Health Organization).
Note: The 10-step COMBI planning process, developed by consensus, has been accepted and is in use in the WHO Region of the Americas.
Source: PAHO (2011).

References

Chang, M. S., E. V. Christophel, D. Gopinath, and Md. A. Rashid. 2011. Challenges and Future Perspective for Dengue Vector Control in the Western Pacific Region. *Western Pacific Surveillance and Response Journal 2*, 9–16. doi:10.5365.

Chang, M. S., T. Setha, J. Nealon, and D. Socheat. 2009. Pupal Sampling for *Aedes aegypti* (L.) Surveillance and Potential Stratification of Dengue High-Risk Areas in Cambodia. *Tropical Medicine and International Health* 14(10): 1233–1240.

Chang, M. S., T. Setha, J. Nealon, D. Socheat, N. Chantha, and M. B. Nathan. 2008a. Community-Based Use of the Larvivorous Fish *Poeciliareticulata* to Control the Dengue Vector *Aedes aegypti* in Domestic Water Storage Containers in Rural Cambodia. *Journal of Vector Ecology* 33(1): 139–144.

———. 2008b. The Effect of Long-Lasting Insecticidal Water Container Covers on Field Populations of *Aedes aegypti* (L.) Mosquitoes in Cambodia. *Journal of Vector Biology* 33(2): 333–341.

Eastern Mediterranean Regional Office (EMRO), World Health Organization (WHO). 2003. *Use of Fish for Mosquito Control*. WHO-EM/MAL/289/E/G. Cairo: EMRO.

Elder, J. E. 2005. *Evaluation of Communication for Behavioural Impact (COMBI) Efforts to Control Aedes aegypti Breeding Sites in Six Countries*. Final report submitted to the World Health Organization and the US Centers for Disease Control and Prevention.

Elder, J. E., and L. S. Lloyd. 2006. *Achieving Behavior Change for Dengue Control: Issues of Methods, Scaling-Up and Sustainability*. Report to the Scientific Working Group on Dengue, WHO–Tropical Disease Research (TDR). Geneva: TDR/WHO. http://www.tropika.net/review/061001-Dengue_Behaviour_change/article.pdf

Green-Thompson, R. 2000. *HIV/AIDS and TB: The Dual Epidemic and its Challenges*. Record of proceedings, Section 2: Communicable Diseases. HIV/AIDS and TB Health Summit, South Africa. http://www.doh.gov.za/docs/misc/hsummit01/section2c.pdf

Gubler, D. J. 2002. Epidemic Dengue/Dengue Hemorrhagic Fever as a Public Health, Social and Economic Problem in the 21st Century. *Trends in Microbiology* 10(2): 100–103.

Harving, M. L., and F. F. Rönsholt. 2007. The Economic Impact of Dengue Hemorrhagic Fever on Family Level in Southern Vietnam. *Danish Medical Bulletin* 54(2): 170–172.

HLSP. 2010. *Inception Report: Regional Public Goods for Health—Combating Dengue in ASEAN*. Prepared for Asian Development Bank (ADB) Technical Assistance (TA) 7268-REG. February.

———. 2012. *Final Report: Regional Public Goods for Health—Combating Dengue in ASEAN*. Prepared for Asian Development Bank (ADB) TA 7268-REG. December.

Huy, R., O. Wichmann, M. Beatty, C. Ngan, S. Duong, H. S. Margolis, and S. Vong. 2009. Cost of Dengue and Other Febrile Illnesses to Households in Rural Cambodia: A Prospective Community-Based Case-Control Study. *BMC Public Health* 9: 155.

Kay, B. H., V. S. Nam, T. V. Tien, N. T. Yen, T. V. Phong, V. T. B. Diep, T. U. Ninh, A. Bektas, and J. G. Aaskov. 2002. Control of *Aedes* Vectors of Dengue in Three Provinces of Vietnam by Use of *Mesocyclops* (Copepoda) and Community-Based Methods Validated by Entomologic, Clinical and Serological Surveillance. *American Journal of Tropical Medicine and Hygiene* 66(1): 40–48.

Kosiyachinda, P., A. Bhumiratana, and P. Kittayapong. 2003. Enhancement of the Efficacy of a Combination of *Mesocyclopsaspericornis* and *Bacillus thuringiensis* var. *Israelensis* by Community-Based Products in Controlling *Aedes aegypti* Larvae in Thailand. *American Journal of Tropical Medicine and Hygiene* 69(2): 206–212.

Martin, G. G., and J. W. Reid. 2007. Cyclopoid Copepods. *American Mosquito Control Association Bulletin* 23(2, Suppl): 65–92.

Nam, V. S., N. T. Yen, T. V. Phong, T. U. Ninh, L. Q. Mai, L. V. Lo, L. T. Nghia, A. Bektas, A. Briscombe, J. G. Aaskov, P. A. Ryan, and B. H. Kay. 2005. Elimination of Dengue by Community Programs Using *Mesocyclops* (Copepoda) against *Aedes aegypti* in Central Vietnam. *American Journal of Tropical Medicine and Hygiene* 72(1): 67–73.

Nature Education. 2012. http://www.nature.com/scitable/topicpage/controlling-dengue-outbreaks-22403714 (accessed 23 March 2012)

Ocampo, C. B., C. González, C. A. Morales, M. Pérez, D. Wesson, and C. S. Apperson. 2009. Evaluation of Community-Based Strategies for *Aedes aegypti* Control inside Houses. *Biomédica* 29(2): 282–297.

Ostroff, S. M. 2012. Perspectives: The Role of the Traveler in Translocation of Disease. In Gary W. Brunette, ed. *CDC Health Information for International Travel 2012*. New York: Oxford University Press. http://www.nc.cdc.gov/travel/yellowbook/2012/chapter-1-introduction/perspectives-the-role-of-the-traveler-in-translocation-of-disease.htm (accessed 23 July 2012)

Pan American Health Organization (PAHO). 2011. *Sistematización de Lecciones Aprendidas en Proyectos COMBI en Dengue en la Región de las Américas*. Washington, DC.: PAHO (Title in English: *Documentation of Lessons Learned from COMBI Dengue Projects in the Region of the Americas*. Document available only in Spanish). http://new.paho.org/hq/ index.php?option=com_content&task=view&id=264&Itemid=363&lang=es

Parks, W. and L. S. Lloyd. 2004. *Planning Social Mobilization and Communication for Dengue Fever Prevention and Control: A Step-by-Step Guide*. Geneva: World Health Organization. http://whqlibdoc.who.int/publications/2004/9241591072.pdf

Setha, T., N. Chantha, and D. Socheat. 2007. Efficacy of *Bacillus thuringiensis israelensis,* Vectobac® WG and DT, Formulations against Dengue Mosquito Vectors in Cement Potable Water Jars in Cambodia. *Southeast Asian Journal of Tropical Medicine and Public Health* 38(2): 261–268.

Shediac-Rizkallah, M. C. 1998. Planning for the Sustainability of Community-Based Health Programs: Conceptual Frameworks and Future Directions for Research, Practice and Policy. *Health Education Research* 13(1): 87–108.

Spiegel, J., S. Bennett, L. Hattersley, M. H. Hayden, P. Kittayapong, S. Nalim, D. N. C. Wang, E. Zielinski-Gutiérrez, and D. Gubler. 2005. Barriers and Bridges to Prevention and Control of Dengue: The Need for a Sociological Approach. *EcoHealth* 2: 273–290. doi: 10.1007/s10393-005-8388-x.

Stanley, J., B. Clouston, and J. Binney. 2004. *Conducting Social and Economic Impact Assessment: A Practical Guide for Regional NRM Bodies in Queensland*. The State of Queensland, Department of Natural Resources, Mines and Water. http://www.regionalnrm.qld.gov.au/research_sips/sips/social_economic/pdf/impact _assessment.pdf

Stimson, G. C., C. Donoghoe, C. Fitch, and T. J. Rhodes, with A. Ball and G. Weiler. 2003. *Rapid Assessment and Response Technical Guide*. Geneva: World Health Organization (Department of Child and Adolescent Health and Development, and Department of HIV/AIDS). http://www.who.int/docstore/hiv/Core/Chapter_6.html

Suaya, J. A., D. S. Shepard, J. B. Siqueira, C. T. Martelli, L. C. S. Lum, L. H. Tan, S. Kongsin, S. Jiamton, F. Garrido, R. Montoya, B. Armien, R. Huy, L. Castillo, M. Caram, B. K. Sah, R. Sughayyar, K. R. Tyo, and S. B. Halstead. 2009. Cost of Dengue Cases in Eight Countries in the Americas and Asia: A Prospective Study. *American Journal of Tropical Medicine and Hygiene* 80(5): 846–855.

Swiss Development Cooperation. 1991. *Sustainability of Development Projects: Basic Principles and Application in Practice*. Berne: Swiss Directorate for Development Cooperation and Humanitarian Aid (SDC), Evaluation Service.

TDR/World Health Organization. 2006. *Multicountry Study of Aedes aegypti Pupal Productivity Survey Methodology: Findings and Recommendations.* Geneva: WHO. http://www.who.int/tdr/publications/documents/aedes_aegypti.pdf

US Environmental Protection Agency (EPA). 1998. *Bacillus thuringiensis* Subspecies *israelensis* Strain EG2215 (006476) Fact Sheet. October. http://www.epa.gov/oppbppd1/biopesticides/ingredients/factsheets/factsheet_006476.htm (accessed 21 March 2012)

WHO. 2002. *Mobilizing for Action: Communication-for-Behavioural-Impact (COMBI)*. WHO: Geneva. http://www.stoptb.org/assets/documents/about/cb/meetings/04/11%20COMBI%20TB%204%20pager.pdf

———. 2004. *Global Strategic Framework on IVM*. Geneva: WHO. http://whqlibdoc.who.int/hq/2004/WHO_CDS_CPE_PVC_2004_10.pdf

———. 2008. *Guidelines for Drinking-Water Quality.* 3rd ed. (incorporating the first and second addenda). Vol. 1: Recommendations. Geneva: WHO. http://www.who.int/water_sanitation_health/dwq/fulltext.pdf

———. 2011. *WHOPES-Recommended Compounds and Formulations for Control of Mosquito Larvae*. Geneva: WHO. http://www.who.int/whopes/Mosquito_Larvicides_sep_2011.pdf (accessed 21 March 2012)

———. 2012a. *Dengue Fact Sheet.* http://www.who.int/mediacentre/factsheets/fs117/en/index.html (accessed 17 March 2012)

———. 2012b. *Handbook for Integrated Vector Management*. Geneva: WHO. http://whqlibdoc.who.int/publications/2012/9789241502801_eng.pdf

———. 2012c. *WHO Pesticide Evaluation Scheme (WHOPES)*. http://www.who.int/whopes/en/ (accessed 23 March 2012)

Managing Regional Public Goods for Health
Community-Based Dengue Vector Control

The threat from dengue has grown dramatically. The World Health Organization estimates that there may be up to 100 million infections each year worldwide. Approximately 500,000 people are hospitalized, and many thousands die because of dengue each year. Controlling mosquitoes is the only available dengue prevention strategy, but dengue control activities tend to be limited to responses to outbreaks.

This report documents a promising, feasible, low-cost measure for controlling Aedes aegypti mosquitoes, the primary household-associated dengue vector. The intervention involved encouraging local communities in Cambodia and the Lao People's Democratic Republic to use small fish called guppies to devour mosquito larvae in household water containers; this was accompanied by intense communication activities. The result was significant reductions in the number of containers with mosquito larvae and of mosquito pupae per person. The approach is being considered for expansion to other areas of Cambodia and the Lao People's Democratic Republic and is also being taken to countries in the South Pacific, with a view to assessing its wider suitability.

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ISBN 978-92-9092-914-7

Asian Development Bank
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
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United Nations Avenue, Corner Taft Avenue
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