4. PREVENTION AND CONTROL STRATEGIES

The Success and Failure of the Hemispheric Eradication Program

The first *A. aegypti* programs were directed towards yellow fever. Great advances were made at the beginning of the century in Cuba and Panama to control this vector, chiefly through source reduction, oiling, and application of pyrethrins. In 1923, Brazil initiated an eradication campaign. The last urban epidemic of yellow fever in the Americas was reported in 1942, but the continued threat of the reappearance of this disease in urban areas and the increasing incidence of dengue led to continued support for vector control programs. The XI Conference of the Pan American Sanitary Bureau, held in 1942, urged infested countries to organize eradication projects based on strategies adopted by Brazil. With the discovery of the insecticidal properties of DDT, hemispheric eradication of *A. aegypti* seemed feasible.

Before the beginning of the eradication campaign, all Western Hemisphere countries, with the exception of Canada, were infested with *A. aegypti*. By 1962, 18 continental countries and several small Caribbean island countries had succeeded in eradication. The reasons for this spectacular success were the following:

- Adequate local and external funding, for well-trained personnel, equipment, and insecticides.
- Total coverage of the infested areas in time-limited programs.
- The use of DDT for perifocal spraying in and around all breeding sites.
- Streamlined, semiautonomous programs, separate from the national health programs.
- Centralized, vertically structured programs that had a military-type organization and clear lines of command, strict supervision, and a high level of discipline.

What went wrong with the eradication programs?

- Not all of the countries in the Hemisphere resolved to eradicate *A. aegypti*, and those countries that were still infested became sources of reinfestation for those countries free of the vector.
- In most of the countries that achieved eradication, *A. aegypti* programs lost political importance as the years went on, and surveillance against reinfestation gradually diminished until it was inadequate to detect small reinfestations.
- When a reinfestation was discovered, the response usually came too late, and the resources allocated to eliminate it before it became generalized and unmanageable usually were insufficient.

It is probably not feasible to attempt another hemispheric *A. aegypti* eradication campaign, for the following reasons:

- The *A. aegypti* problem is now several orders of magnitude greater than it was during the first eradication campaign. The human population in Latin America and the Caribbean is growing exponentially, with virtually all of this increase occurring in urban centers. There are now many more houses, there is more travel between urban centers within and among countries, and there are more disposable containers per household than ever before. The delivery of governmental services such as piped water and garbage collection often is inadequate in these exploding urban centers, and urban infrastructures are aging because of insufficient maintenance.
- Given the present economic crisis in Latin America and the Caribbean, very few countries have the resources to execute a vertical, paramilitary campaign with total insecticidal coverage.
- Many countries do not place high priority on *A. aegypti* programs or even on dengue control.

There are many other health problems that are considered more important and receive more resources.

- On the one hand, *A. aegypti* is now generally resistant to DDT throughout the Americas; on the other, organophosphate insecticides are more expensive and have shorter residual activity, and resistance to them is developing also.
- With time, even those well-funded and still semiautonomous programs often have become very inefficient: salaries and other monthly benefits are often not delivered to the workers on time, resulting in frequent strikes.
- Communities are less receptive to vertical disease control programs and often resist the delivery of services; there also is increasing public concern over the use of insecticides.

Current Approaches for Surveillance and Control

After the ultimate failure of the hemispheric *A. aegypti* eradication campaign, many changes have been recommended and at least partially implemented in the vector control programs.

The Change from Eradication Campaign to Control Programs

An important policy change was made in the XXXI Meeting of the Directing Council of PAHO in 1985. Where previous resolutions had insisted on the *eradication* of *A. aegypti* for all countries, resolution XXVI recognized, and for first time endorsed, the fact that some countries have programs to *control A. aegypti*.

This was an important step. The methodology used in an eradication campaign is very different from that used in control programs. Eradication involves complete and thorough coverage of the infested areas with frequent treatment cycles in order to eradicate the vector within a few years. Control is the cost-effective utilization of limited resources to reduce vector populations to levels at which they are no longer of significant public health importance.

Eradication is not merely "control done extremely well," because it is unnecessary to eliminate every breeding site in every area during a control program. For example, if treeholes, which are difficult to inspect and treat, are plentiful, but entomological surveys show they account for less than 1% of the actual mosquito production, and if resources are limited, it is not cost-effective to attempt to fill every tree hole. Time and manpower can be better spent treating or eliminating those containers, such as tires or drums, that account for most mosquito production.

The following recommendations should be followed in order to implement long-term, sustainable control programs:

Integration of Vector Control Methods

In pursuing vector control, instead of relying on a single control method, all of the potential vector control techniques are combined and integrated in the most compatible manner (see the section on "Integrated Control," beginning on page 58). Foremost in the armory of vector control methods is environmental management for the physical elimination or alteration of breeding sources (see the section on "Environmental Management," beginning on page 49). Chemical control with larvicides should be restricted to containers that cannot be controlled by any other means, and space sprays should be reserved for emergency situations (see the section on "Chemical Control," beginning on page 53). Biological and genetic control methods are mostly still experimental, or are used for application under certain special circumstances on a small scale (see the section on "Biological Control," beginning on page 56).

Integrating Aedes *Control with Control of Other Pests*

Instead of targeting only one vector, several related vector species can be included in the same program. This broader approach, known as comprehensive vector control, not only addresses several public health problems simultaneously, but it also gains better public acceptance for the program. For instance, *Aedes* control can be combined with *Culex pipiens quinquefasciatus* control, the latter species being recognized as a much greater nuisance by the public. Collection of solid waste for *Aedes* programs need not be restricted to *Aedes* production sources, but can also include items that are associated with filth, flies, and rodents.

Integration with Other Sectors and with the Community

The original eradication campaign was not sustainable, because of its costliness and isolation

from the rest of the health sector, other governmental sectors, the private sector, and the community.

Local Health Care Systems. Instead of isolating the control program from other health programs, it may be better and more efficient to integrate it with the local health care systems, by transferring responsibility, authority, resources, and knowledge from the central level to the local level (see the section on "Organization and Function of Control Activities," beginning on page 39).

Intra- and Intersectorial Collaboration. Contacts, liaisons, and cooperative activities should be promoted within the different divisions of the health sector (national malaria service, national health institute, epidemiology division, health education office, legal office), other governmental sectors (public works, water supply, sanitation, education), and the private sector (commercial enterprise, civic clubs). (See section on "Organization and Function of Control Activities," beginning on page 39).

Social Participation and Health Education. The public's involvement at the individual, family, and community levels can be promoted through the mass media, in the schools, at community meetings, and at fairs and contests (see the section on "Community Participation and Health Promotion," beginning on page 44).

Enforcement of Sanitary Legislation

Most countries have laws that prohibit unhealthy conditions in any public or private premise, but few enforce those laws regarding potential breeding sites of mosquito vectors, other insect pests, and rodents (see the section on "Legislative Support," beginning on page 47).

Prioritization of High Risk Areas

If resources are insufficient to cover all urban areas, the localities can be ranked in order of risk level by dengue incidence or *Aedes* infestation levels, so that greater attention is paid to the high risk areas. This is a dynamic process that should involve periodic revisions of the ranking.

Stratification

The important risk factors for transmission of dengue and DHF (see Tables 10 and 11) should be determined for each area, and the areas may be grouped according to common risk factors in order to apply common, selective sets of treatment strategies instead of blanket use of one method everywhere (see the section on "Epidemiologic Stratification," beginning on page 37).

Surveillance, Prevention, and Control Activities Established According to Different Epidemiologic Situations

At any given time, each country in the Americas can experience a unique situation regarding the level of infestation with *A. aegypti* (from zero infestation to very high levels) and the level of dengue transmission (from no dengue to epidemic transmission). Although, no single, uniform strategy for surveillance and control is applicable to every situation, the diverse country situations can be grouped by vector and disease characteristics, and surveillance and control activities can be described for each group.

In Table 15 seven different situations of *A. aegypti* infestation (as measured by house index) and dengue activity are presented, starting with the most favorable situation where the vector is absent and progressing to the worst case where there is an epidemic under way.

Essentially, there are three kinds of long-term dengue programs: surveillance against reinfestation by the vector; eradication programs; and "routine" control programs. "Emergency" control is the short-term response to epidemic situations.

Surveillance against Reinfestation

A few countries (Bermuda, the Cayman Islands, Chile, and Uruguay) have not been permanently reinfested by *A. aegypti* after the initial successful eradication (see Table 15, situation 1), and some others (Brazil, Cuba) have large areas free of the vector. In these cases, surveillance against reinfestation is of paramount importance. Special attention should be given to seaports, airports, cemeteries, and tire recapping facilities.

Seaports. Maritime ports have been an introduction site for both *A. aegypti* and *A. albopictus* in Asia, the South Pacific, and North America. Ports receiving vessels from infested areas should have programs to inspect vessels, and to institute source reduction measures for shipboard foci and potential foci. Tires and tarps used to cover cargo and cargo containers, and water storage tanks and drums are some of the common shipboard foci for

Table 15. Surveillance and control activities according to status of *Aedes aegypti* and dengue.

Situation			Program Status	Type of surveillance recommended		Type of control recommended	
Aedes aegypti	Dengue virus	Examples		Vector	Disease	Routine[a]	Emergency
Eradicated	Absent	Uruguay, 1993	Surveillance	++ (against reinfestation)		(+)	
Low (<0.1%)	Absent	Cuba, 1993	Eradication	++ (against reinfestation)		+	
Medium (0.1–5%)	Absent	Panama, 1992	Control	++	++	+	
High (>5%)	Absent	Bolivia, 1986 Ecuador, 1987 Paraguay, 1988 Panama, 1989	Control	+ (only to evaluate control program)	++	+++	
High (>5%)	Endemic	Puerto Rico, 1993 Ecuador, 1993 Guatemala, 1993 Venezuela, 1993 and most other countries	Control	+ (only to evaluate control program)	++	++	
High (> 5%)	Increasing	Puerto Rico, 1986	Alert	+ (only to evaluate control program)	++	+++	++
High (>5%)	Epidemic	Brazil, 1986 Bolivia, 1987 Ecuador, 1988 Paraguay, 1989	Emergency	+ (only to evaluate control program)	++	++	+++

(+): Optional +: Necessary ++: Important +++: Very important.
[a]Routine control: Long-term source reduction campaigns with some larviciding and perifocal treatment.

A. aegypti. Surveillance and source reduction also should be conducted at the entire port facility, its buildings and grounds, and the immediate surrounding area.

Airports. Airports also represent potentially important locales for the introduction of urban *Aedes* vectors, although it is usually the virus-infected human host entering a country at airports or seaports that represents the greater public health risk.

Cemeteries. Cemeteries act as important *Aedes* foci where flowers, live or artificial, are placed in vases and other containers.

Tire Recapping Facilities. Tire recapping facilities located at or near international seaports and airports are important potential key sites for the introduction of urban *Aedes* vectors. Periodic inspections for foci should be implemented at these facilities and include covering tire piles with tarp or placing tires under rain shelter.

The importance of maintaining a vector surveillance program in areas that are free of *A. aegypti* must be stressed. A good surveillance program designed to avoid reinfestation is much less costly than an eradication or control program set up after reinfestation has occurred.

Present-day Eradication Programs

Eradication is still technically feasible in certain circumstances and areas in the Americas. For example, the present infestation in Cuba is limited to a small area of Havana, and intensified efforts should soon succeed (Table 15, situation 2). However, the benefits of success will only be realized if long-term vigilance against reinfestation is maintained, which has not been the case in most past programs.

Guidelines for the execution and verification of eradication are given in the "Guide for Reports on the *Aedes aegypti* Eradication Campaign in the Americas."

Routine Control

The long-term activities aimed against the immature mosquito population are called *routine* control, and the principal method employed is source reduction. There is no need for space spraying, and larvicides need only be used in those containers that cannot be removed, destroyed, discarded, permanently drained, covered, or otherwise managed. To ensure sustainability, all sectors

of the community should be brought into the program. Table 15 shows the different epidemiologic scenarios where "routine" control is applicable.

As *Aedes* infestation increases (situation 3), vector surveillance becomes important for prioritizing and stratifying areas for intervention and for monitoring the effect of control efforts; disease surveillance now becomes necessary in order to detect the introduction and transmission of dengue virus.

When the *Aedes* infestation is high (shown in Table 15 as house index > 5%; however, this figure is arbitrary, because there is no known threshold level of house infestation below which it can be assured that there will be no outbreak of dengue) and if dengue is endemic (situation 5), routine control operations obviously are failing. Disease surveillance now gathers paramount importance in the effort to detect an increase in numbers of cases from the normal endemic level or the introduction of a new dengue serotype. Emergency preparations should be initiated: the medical community should be informed of dengue and DHF/DSS symptoms and the treatment of cases, a contingency hospitalization plan should be developed, and preparations for emergency vector control should be made.

Emergency Response

Emergency control is the intense, short-term activity directed at a rapid reduction of the adult mosquito population, in order to suppress dengue transmission in an epidemic situation or when an epidemic appears to be imminent. Space sprays are the fastest available emergency method, but as epidemics may continue for several weeks, intensification of *routine* larval control measures such as source reduction and larviciding probably also helps to suppress them (see the chapter on "Emergency Preparation and Response," beginning on page 59).

Epidemiologic Stratification

The traditional model of health intervention considered the study of the dynamics of dengue incidence and the understanding of risk factors for the disease as matters of minor importance, since it believed that single, "magic bullet" interventions were to be used for all situations and conditions of dengue outbreaks.

By using a nontraditional socioepidemiologic approach to dengue transmission, which is based on epidemiologic stratification, health professionals are better equipped to assess the short- and long-term impacts of various control strategies, including social participation and reduction/elimination of major dengue risk factors. This approach represents a substantial departure from traditional control interventions.

Epidemiologic Stratification of Dengue Risk

The epidemiologic stratification of a disease such as dengue is a dynamic and ongoing process involving research, diagnosis, analysis, and the interpretation of information that serves as the basis for a comprehensive, methodological classification of geoecological areas and population groups according to dengue *risk factors*.

A *risk stratum* is an aggregate of individuals and social groups that are located in well-defined geographical areas and that share a similar hierarchy of principal risk factors. Consequently, measures or interventions that are undertaken in order to modify these risk factors will be similar within each stratum. For example, for areas where the principal breeding sites are discarded containers, emphasis should be placed on the elimination of solid waste. In other areas where water storage containers provide most of the breeding sites, mosquito-proofing the water containers could be a short-term remedy, and provision of piped water supply might be the long-term solution.

The main feature of the socioepidemiologic approach is an epidemiologic study of the risk factors for specific individuals and social groups that are responsible for the incidence of dengue at the local level. The known risk factors for dengue transmission were discussed in the section on "Risk Factors for Dengue and Dengue Hemorrhagic Fever," beginning on page 19, (see also Tables 10 and 11), and use such critical parameters as socioeconomic conditions, vector biology, and the health program's ability to respond to prevention and control needs.

The establishment of risk profiles and ecological profiles for dengue transmission can be of great value for planning targeted source reduction and environmental management activities, as well as for organizing epidemic intervention measures.

The stratification process currently used in dengue programs in the Americas consists of classifying localities or neighborhoods according to a

set of *assumed* risk factors, usually without conducting previous studies to determine which are the most important factors and what each one's relative importance is. The assumed risk factors most commonly used by the country programs for their classification are: elevation, mean annual temperature, population density, history of infestation with *A. aegypti*, house index, breteau index, economic importance, proximity to positive localities, proximity to ports and international borders, and current dengue transmission.

Once the localities or neighborhoods have been classified, they are ranked according to level of risk. Number, intensity, and frequency of different control measures are greatest in the localities of highest risk. If resources are limited, higher-risk localities are treated first. For example, in Mexico localities are classified according to three ranges of elevation (0 to 600 m, > 600 to 1200 m, and > 1200 to 1800 m), three population sizes (> 2500 to 20,000, > 20,000 to 50,000, and > 50,000) and three mean annual temperatures (< 20°C, 20°C to 25°C, and > 25°C). Localities with the lowest elevation, highest population size, and highest temperatures receive the most frequent interventions and the most epidemiologic and entomological surveillance.

In summary, risk stratification and the socio-epidemiologic risk approach provides a rationale for dengue prevention and control activities at the local and regional levels. The purpose of this approach is to establish an epidemiologic hierarchy of possible specific measures or interventions that may be used to prevent dengue transmission by *eliminating or reducing the underlying risk factors* through primary prevention measures and appropriate vector control. Proposed specific interventions are based on the local epidemiologic situation and its principal risk factors. The approach is based on the study of epidemiologic, socioeconomic, and environmental parameters, including the managerial capability of local health care programs and the logistic and financial constraints of countries prone to dengue activity.