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Dengue Fever - A Public Health Problem Along the Texas-Mexico Border

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“Dengue Fever: A Public Health Problem
Along the Texas-Mexico Border”

SLIDE/LECTURE #1

Website: http://www.pitt.edu/~super1/lecture/lec1741/index.htm

My primary public health interest is the reemerging arboviral infections (e.g., dengue) that are increasing in incidence, expanding into new geographic areas, affecting new populations, and are threatening to increase in the near future, especially following a natural disaster (e.g., hurricanes). The goal of the dengue lecture series is to promote the recognition of dengue and dengue hemorrhagic fever and improve the understanding of factors involved in prevention, surveillance and control of the *Aedes aegypti* mosquito, the principal mosquito vector of dengue virus.

The purpose of these lectures is to accelerate learning and development of an effective dengue prevention and control response plan. The theme of the presentations is awareness and learning. The general nature of a dengue fever outbreak threat and the resultant need for a well-designed preparation response and recovery create a demand for services and resources that cuts across an array of responsible and affected stakeholders.

LEARNING OBJECTIVES
Upon completion of these presentations, the learner should be able to:

1. Examine and explain the growing significance of dengue and dengue hemorrhagic fever in public health.

2. Focus on effective prevention and risk reduction strategies, and how to integrate school, family, and the community into prevention programs.

3. Emphasizes the practical application of field research in the management and control of the dengue vector: *Aedes aegypti*.

4. Describe an interdisciplinary team approach to achieving success with prevention and control programs among communities and local health care workers.
Dengue is currently the most important vector-borne viral disease affecting people, in terms of both morbidity and mortality. Repeated epidemics of dengue and dengue hemorrhagic fever afflicting millions of individuals occur annually in tropical and subtropical areas of the world inhabited by the Aedes aegypti mosquito, the principal mosquito vector of dengue virus. A highly domesticated urban species, the Aedes aegypti mosquito has become adapted to living in intimate association with humans and has a worldwide distribution in the tropics including the southeastern and southern border areas of the United States.

Moreover, the ongoing resurgence of Aedes aegypti in Mexico - fomented by increased air travel, urbanization, and poor mosquito control - has led to hyperendemicity, more frequent dengue epidemics, and the emergence of dengue hemorrhagic fever/dengue shock syndrome.

Accordingly, the main purpose of this lecture is to identify and address the dominating factors influencing the resurgence of dengue fever along the U.S.-Mexico border. The lecture also will depict an arguable approach to dengue surveillance as well as describe existing efforts to prevent, control, and eradicate dengue (Aedes aegypti) with the aim of detailing potential problems that must be addressed to prevent further dengue fever outbreaks. Effective prevention and control programs will depend on improved surveillance designed to provide early warning of dengue epidemics.

Virologic surveillance should be considered the most important element in any such early warning system. Dengue virus transmission should be monitored to determine which serotypes are present, their distribution, and the type of illnesses associated with each. Effective dengue surveillance can provide an early warning capability permitting emergency mosquito control measures to be implemented and major epidemics to be averted.

The term “Dengue” was first coined and used in Zanzibar in 1727. In 1780, an outbreak of dengue appeared in Philadelphia and a physician recorded dengue fever as “breakbone fever”. This description is now generally accepted as the first clinical description of dengue.
**Aedes aegypti** is a domesticated mosquito with a short flight range, and urban spread of dengue is frequently house-to-house in a contiguous manner. The mosquito breeds in tropical or sub-tropical climates in man-made water-holding receptacles in and around human habitation, or in tree holes or plants in close proximity to human dwellings. These sturdy urban survivors are found in nearly every major city in the tropics, as well as in the sub-tropics, and they apparently prefer the blood of humans to that of other animals.

*Aedes aegypti* has four stages in its life cycle with the first three (egg, larva, and pupa) played out in water. However, in the fourth stage, the adult is a flying arthropod equipped with sucking mouthparts to feed on human or animal blood or on plant juices and it seeks an aquatic environment in which to reproduce. *Aedes aegypti* eggs are laid singly on the surface of water or in clusters called rafts.

Eggs of some species of mosquitoes may be laid on moist ground subject to periodic flooding (they lay dormant until flooding occurs) when the larvae emerge to live in water; different species have adapted to exploit almost every aquatic environment. The larvae molt four times in, at least, a ten-day period, which culminates in the pupal stage. Both larva and pupa are active stages, yet unlike the larva the pupa does not feed.

The pupal stage lasts from one day to a few weeks, after which the adult emerges from the pupal skin. The emerging adults are small and fragile with one pair of narrow wings, three pairs of long, thin legs, and a slender abdomen.

Interestingly, only female mosquitoes bite and the females of most species require a blood meal before they are able to lay fertile eggs. While the primary environment of the adult mosquito is the air, they consistently mate while airborne, rarely are they encountered in large numbers far from their aquatic breeding sites suitable for egg laying.
Human mobility and intervention also can be important for their role in introducing virus into susceptible populations. Increased air travel between urban centers of the tropics has been cited as a factor responsible for the increased frequency of dengue epidemics. The geographic dissemination and endemic maintenance of dengue in Mexico's border states depends on the continued introduction of virus into susceptible human populations, spread within these populations, and low-level transmission during non-epidemic periods.

Continued dengue transmission represents a public health burden for Mexico, both in terms of costs of dengue control, as well as the potentially severe consequences of a dengue hemorrhagic fever epidemic. Resources for dengue control are limited, therefore identification of border areas that are at high risk of dengue control, as well as the potentially severe consequences of a dengue hemorrhagic fever epidemic.

The human population is growing exponentially, with virtually all of this growth occurring in urban zones. Compounding this problem, there is more population movement between urban centers within and among countries, more substandard housing, more artificial disposable containers and governmental services that are inadequate in these burgeoning urban centers.

As a result of these changes, the resurgence of Aedes aegypti (dengue fever) is presently much greater than it has been in the past. Worldwide, up to 100 million people annually are infected with dengue fever, mainly in tropical cities and urban areas, while 2.5 billion people are at risk of infection.

In most tropical countries of the world, it is difficult to determine how unhampered dengue prevention and/or control programs really are. Often, dengue (Aedes aegypti) control programs function as branches of malaria control programs and/or operate sporadically in response to real or perceived emergencies.

Moreover, given the present economic crisis, very few countries have the resources to execute an effective eradication campaign. Consequently, these countries usually do not place a high priority on Aedes aegypti eradication programs since there are many other health projects that are considered more important and thus receive more resources.
Infectious diseases account for the larger part of all deaths in the tropical areas of the world and disease, like poverty, is not distributed uniformly among people and countries. Nearly all of these deaths occur in children under the age of five.

Many of these infectious diseases that profoundly impact the health of people living in the tropics are frequently referred to as arboviral diseases. Arboviruses are enveloped, RNA-containing viruses that encompass, among others, the Flaviviruses (family Flaviviridae, genus Flavivirus) that is pathogenic in humans and includes dengue.

Conditions that contribute to the risk for becoming infected with an arboviral disease agent include biological factors related to population density, rural vs. urban living, nutritional status, climate and other environmental factors, as well as socioeconomic circumstances.

The increased disease incidence, combined with increased frequency of epidemic dengue caused by multiple virus serotypes, has increased the risk of epidemic dengue hemorrhagic fever, one of the leading causes of hospitalization and death among children in Southeast-Asia. It has also been estimated that 1 billion people in the world today lack access to adequate sanitation services and safe drinking water. Such poverty in the developing world has obvious global implications.

Dengue, dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS) are prevalent in over 100 countries and territories and threaten the health of more than 2.5 billion people, living in urban and rural areas of tropical and subtropical regions.

Annual incidence is estimated to be in the tens of millions, with an estimated 500,000 hospitalized cases of DHF/DSS, of whom the greater part are children under the age of 15 years. The average mortality rate is 5%, with some 24,000 deaths each year.
Dengue, an arboviral disease, is an arthropod-borne viral infection of humans. Arboviruses consist of a group of animal viruses that are able to reproduce in an arthropod and can be transmitted to a vertebrate host. Because of the degree of morbidity and mortality involved, dengue is considered the most important arboviral disease affecting humans.

The four dengue virus serotypes, designated 1, 2, 3, and 4, are ribonucleic acid (RNA) viruses belonging to the genus Flavivirus of the family Flaviviridae. Epidemics of dengue fever in urban communities are explosive and involve significant portions of the population. They often start during the rainy season, when the vector mosquito, Aedes aegypti, is in abundance and thriving in urban areas.

According to the World Health Organization “arboviruses are viruses that are maintained in nature principally, or to an important extent, through biological transmission between susceptible vertebrate hosts by hematophagous arthropods or through transovarial and possibly venereal transmission in arthropods; the virus multiply and produce viraemia in the vertebrates, multiply in the tissues of arthropods, and are passed on to new vertebrates by the bites of arthropods after a period of extrinsic incubation.” Vertical (transovarial) and venereal transmission in arthropods may serve as basic long-term maintenance mechanisms for some arboviruses.

Some researchers consider vertical transmission to be a survival mechanism developed by the virus to resist adverse climatic conditions that may affect its arthropod host. Vertical transmission involves the direct transfer of infection from a parent organism to his, her, or its offspring.

In contrast, horizontal biological transmission involves ingestion of the virus in the blood of a viremic vertebrate, multiplication of the virus in the midgut of the mosquito, dissemination of the virus to the hemocoel, infection of the salivary glands, and transmission of the virus to a susceptible vertebrate host by the mosquito's bite. The virus can also be transmitted either horizontally by arthropods infected vertically, or mechanically by arthropods that obtain a partial blood meal from an infected host and then continue they’re feeding on a susceptible one.
Changes in global and local temperatures and rainfall could expand the geographical distribution of the *Aedes aegypti* mosquito, affect its behavior, and increase the rate of development, thus increasing the risk of transmission of dengue.

Additionally, extreme weather conditions, such as heat and heavy flooding, can produce the right environmental conditions for an outbreak. Major upsurges of dengue, in some nations such as Colombia in 1995, follow periods of heavy rains.

It has been noted in the literature that in addition to climatic and environmental disruptions and changes, the movement of people, arthropod-vector, plants, and other particulars can increase exposure to dengue.

The phrase “Viral Traffic” has been coined to describe the movement of viruses to new species or new individuals often through human acts -- in other words, viral traffic is enhanced by human traffic. Some emerging and re-emerging infections are caused by pathogens already present in the environment, but viral traffic and human traffic awaken them from their dormancy.

Thus, prospects for reversing the recent trend of increased epidemic activity and geographic expansion of dengue are not promising. New dengue virus strains and serotypes will likely continue to be introduced into many areas where the population densities of *Aedes aegypti* are at high levels.

However, the transmission dynamics of dengue virus are determined by the interaction of the environment, the agent, the host population, and the vector that exist together in a specific habitat. The magnitude and intensity of that interaction will define the dengue transmission in a community, region, or country.
In the Americas, dengue fever intensified as a public health problem during the 1980s -- between 1980 and 1990 more than one million dengue cases were reported. Also, during those years, an increase in cases of the potentially fatal forms of dengue, dengue hemorrhagic fever and dengue shock syndrome, was observed in various countries of the Americas.

Dengue is primarily an urban disease of the tropics, and the viruses that cause it are maintained in a cycle that involves humans and *Aedes aegypti*. One of four closely related, but antigenically distinct, virus serotypes, DEN-1, DEN-2, DEN-3, and DEN-4, of the genus Flavivirus, cause dengue and dengue hemorrhagic fever.

Primary infection with any serotype may lead to acute illness defined as fever with two or more of the following symptoms: headache, bodily pain, rash, and hemorrhagic manifestations. Fever and other symptoms may subside after 3 or 4 days, and the patient may recover completely, or the fever may return with a rash within 1 to 3 days. Moreover, infection with one of these serotypes does not provide cross-protective immunity, so persons living in a dengue-endemic area can have four dengue infections during their lifetimes.

Infection with a dengue virus serotype can produce a spectrum of clinical illness, ranging from a nonspecific viral syndrome to severe and fatal hemorrhagic disease. Secondary exposure to the same serotype generally does not produce illness because of pre-existing antibodies.

However, secondary exposure to a different serotype may lead to another dengue fever episode, and the patient may be at risk for more serious forms of infection, dengue hemorrhagic fever or dengue shock syndrome.

Furthermore, dengue virus infection may also cause a nonspecific febrile illness that can be easily confused with measles or influenza. Therefore, a proper laboratory test is essential for a correct differential diagnosis and to public health surveillance reporting.
Mosquitoes can be vectors of disease carrying pathogens from one host to another and many pathogens must pass certain stages of their life history within mosquitoes. Moreover, most viruses exhibit a latent period after penetrating the mosquito, and until the incubation period is over no transmission is possible.

*Aedes aegypti* mosquitoes are apparently unaffected by infection with the dengue virus and dengue fever will not shorten its life span nor will it alter its behavior in any detectable manner. However, environmental hazards can determine whether *Aedes aegypti* will survive long enough to pass-on the dengue virus it carries.

Among the determinants of dengue transmission are the environmental or geographical areas where the vector develops and contacts the host population. As compiled from the literature, these geographical and climatological parameters may be used to stratify the areas where the expected transmission may be endemic, epidemic, or sporadic.

Consider the following:

1. Dengue is mainly transmitted in the tropical and sub-tropical regions of the Americas that lie between 45 degrees North and 35 degrees South Latitudes.

2. Elevation is a limiting factor for vector and virus development. At lower elevations, mean annual temperature, humidity, and rainfall are the conditions that affect vector survival and reproduction.

3. Temperature also affects viral replication in the vector:
   - ambient temperature range: 15 - 40 degrees C
   - relative humidity: moderate to high.
Dengue is a rapidly expanding disease problem and epidemics worldwide have become larger and more frequent. Incidence of the severe and fatal form of the disease, dengue hemorrhagic fever, has increased dramatically in Asia and has moved into the Americas, including the United States-Mexico border region.

Two factors are primarily responsible for this change in epidemiology: increased air travel and a total lack of effective mosquito control in tropical and sub-tropical urban centers. Important risk factors for dengue hemorrhagic fever include the strain and serotype of the virus involved, as well as the age, immune status, and genetic predisposition of the patient.

The only option presently available to prevent the dengue problem from becoming progressively worse is to reduce incidence of disease, and the only way to achieve that is to control *Aedes aegypti*.

Unfortunately, the conventional methods that have been used are not very effective. Keep in mind, that without the development of effective vaccines, the prospects of a very real crisis exist that has not been appropriately addressed.

### GLOBAL INCIDENCE OF DENGUE HEMORRHAGIC FEVER

<table>
<thead>
<tr>
<th>Years</th>
<th>Cases</th>
<th>Cases Per Year</th>
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<td>1956-80</td>
<td>715,283</td>
<td>29,803</td>
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<tr>
<td>1981-85</td>
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<td>1986-90</td>
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*Source: Duane J. Gubler, Virus Information Exchange Newsletter, No.8, 1991.*
DENGUE MORBITITY AND MORTALITY DATA

For the sake of brevity, reciting that the incidence of dengue fever and dengue hemorrhagic fever, an acute febrile illness transmitted by the *Aedes aegypti* mosquito, is on the rise can succinctly summarize this graph.

Hundreds of thousands of dengue cases are reported worldwide each year. Given the difficulty in obtaining full reporting, the actual number of human infections is probably much higher than the number reported.

Dengue is usually a nonspecific febrile illness that resolves with supportive therapy but the clinical spectrum ranges from asymptomatic infection through severe hemorrhage and sudden fatal shock.

The pathophysiology of the severe forms of dengue may be related to sequential infection with different serotypes, variations in virus virulence, interaction of the virus with environmental and host factors or a combination of these factors.

In the recent past, dengue transmission has increased in most countries of the Americas and epidemics are occurring at more frequent intervals. Along with the increased incidence of dengue fever has been the emergence of dengue hemorrhagic fever, with a major epidemic in Cuba (1981) and a smaller epidemic in Mexico (1984). Moreover, there has been an increased occurrence of dengue hemorrhagic fever cases throughout this region.
Arthropod-borne disease control requires local and regional efforts that often cover wide areas. The response to disease diffusion from south of the border involves applying counter-measures in directly threatened areas.

The type, number, and intensity of such counter-measures are determined by the perceived degree of threat, and can affect a zone extending far from the border itself. Presently, there is no significant obstacle to arthropod-borne disease diffusion in the gradual environmental and climatic transition along the U.S.-Mexico border.

Previously distance and widely dispersed population provided barriers, however, the potential for disease diffusion has increased over time. It may be that the key question is: How receptive is the present environment to introduced arthropod-borne viral disease? Bear in mind that human mobility and intervention can alter disease transmission potential. Moreover, diffusion of arthropod-borne disease is the realization of potential ecological pathways for transmission. Disease control seeks to eliminate or at least minimize these pathways, thus preventing diffusion.

Dengue is emerging as a major public health problem in most areas along the U.S.-Mexico border. This is attributable to the fact that in recent years the epidemiology of dengue in the Americas has changed dramatically. Over the past two decades epidemics caused by all four dengue virus serotypes have occurred with increasing frequency.

The increased disease incidence, combined with increased frequency of epidemic dengue caused by multiple virus serotypes, has increased the risk of epidemic dengue hemorrhagic fever, one of the leading causes of hospitalization and death among children in Southeast-Asia.

Examination of the difficulties hindering the eradication of *Aedes aegypti* has revealed many political, economic, and social problems that, although prevalent for many years, are reaching such proportions in some countries as to negate the effectiveness of the measures taken to prevent, control and eradicate dengue and the vector mosquito, *Aedes aegypti*. 
Aedes albopictus, a potential and likely vector of dengue, has been introduced in the American gulf states of Texas, Louisiana, and Florida and in the U.S.-Mexico Border States.

There is evidence that Aedes albopictus could spread further south since Aedes albopictus breeds on the edge of forests and has adapted to the domestic environment throughout several areas of its geographical range thus, making it harder to control.

One of the most important differences between the North American population of Aedes albopictus and Aedes aegypti is their latitudinal distribution.

While Aedes aegypti populations are limited to the southern portion of the United States due mainly to their inability to tolerate very low temperatures, Aedes albopictus populations have evolved a photoperiod-induced egg diapause, which may allow them to colonize temperate and northern latitudes.

In addition, temperate strains of Aedes albopictus, such as the North American ones, show egg-cold hardiness, which enables the species to survive the sub-optimal winter temperature found in the northern latitudes of the United States.
One should consider that, in the absence of an effective vaccine against all four virus serotypes of dengue, only countries relatively free of *Aedes aegypti* can do anything to safeguard their communities from this pestilence.

Furthermore, *Aedes albopictus*, a potential vector of dengue, has been introduced in the American gulf states of Texas, Louisiana, and Florida and in the U.S.-Mexico Border States.

There is evidence that *Aedes albopictus* could spread further south since *Aedes albopictus* breeds on the edge of forests and has adapted to the domestic environment throughout several areas of its geographical range -- thus, making it harder to control.
The distribution of *Aedes albopictus* and that of *Aedes aegypti* can overlap in the same urban environment, *Aedes albopictus* is more commonly found in suburban and rural areas where open, vegetated spaces are prevalent.

Studies have shown that *Aedes albopictus* was the most abundant species in suburban environments, which were characterized by open areas with plentiful vegetation, surrounded by buildings. By contrast, in more urbanized sections of a city, *Aedes aegypti* appears to remain the dominant species. Interestingly, *Aedes albopictus* have shown a much greater propensity for using nature's water-holding containers than *Aedes aegypti*.

Recent outbreaks of dengue in nearby Caribbean and Central and South American countries may increase the likelihood of future autochthonous transmission in Texas. Mosquito vectors are widely distributed in the state, and travelers returning from dengue-endemic areas place at risk the resident population, which has minimal immunity to dengue viruses.

Because physicians' awareness of dengue is low and specialized laboratory diagnostic methods are not available locally, low-level dengue transmission may go undetected. In response to an outbreak of dengue in Mexico in 1995, the Texas Department of Health initiated an active surveillance program that detected 29 confirmed cases, including seven in persons with no recent history of travel outside Texas.

In 1977, outbreaks caused by dengue virus-type 1 occurred throughout the Caribbean, and in 1978 dengue was reported in Southern Mexico. Dengue reappeared in Mexico in 1979, and in the spring of 1980, when dengue virus-type 1 was isolated from a patient in Merida, it became apparent that dengue-1 might reach the United States-Mexico border. The region of the United States with the most immediate risk of dengue introduction was believed to be South Texas, in particular the Lower Rio Grande Valley area, where large numbers of travelers move across the border from Mexico.
Because dengue is primarily an urban disease, inadequate systems for collecting and storing solid waste and failure to remove discarded items such as junk cars, tires, and oil drums as well as small discarded containers have been associated with an increased risk of dengue transmission.

Consequently, the options available for prevention and control of epidemic dengue are rather limited and they include the following: *Aedes aegypti* eradication; effective public sanitation/insecticide application; regulation of commercial travel/migration; preventive measures keyed to improved surveillance; and routine mosquito control efforts. Yet,

**The emphasis should be on disease prevention rather than mosquito control and should serve to:**

1. Establish guidelines for the prevention and control of dengue.

2. Emphasize the fact that dengue is primarily a problem of poor public/domestic sanitation, inadequate water treatment, high levels of poverty/unsatisfactory living conditions, and the presence of appropriate vectors and/or reservoirs;

3. Escalate the development and use of effective vaccines against all four serotypes of dengue;

4. Develop directions for appropriate communication links with the community and encourage participation in a community-based intervention programs for the prevention and control of epidemic dengue;

5. Transfer the responsibility and capability for the prevention and control of epidemic dengue to the community as well as promote training programs for participants;

6. Facilitate the evaluation of the effectiveness of a community-based intervention program for the control of epidemic dengue; and

7. Provide guidelines for basic logistical support.
Among other major public health problems in the Americas, particularly along the United States-Mexico border region, are widespread apathy about dengue infection, including dengue hemorrhagic fever/dengue shock syndrome, and environmental management.

Environmental management should focus on those man-made containers and natural breeding sites that produce the greatest number of adult *Aedes aegypti* in each community. While working for the control of man-made and natural breeding sites of dengue vectors, public health workers should simultaneously work to modify human behavior through health education and public health communication, in order to reduce the number of breeding sites produced by the community.

Arguably, in the absence of a vaccine and effective antimicrobials, mosquito control measures should become the backbone of a dengue prevention and control program. The program must emphasize that mosquito control is a responsibility of everyone in the community, not just of those in government. Entire families must be educated and encouraged to become involved in vector elimination.

Such education programs are essential for controlling *Aedes aegypti* breeding sites in both private areas and in public places, the environmental handling of which must consider both local customs and the need to have residents support any measures taken. Inevitably, prevention of epidemic dengue and dengue hemorrhagic fever/dengue shock syndrome will depend upon effective, long-term mosquito control. To be cost-effective and sustainable, such control must be achieved through integrated community-based action.

Yet, one cannot help but to take into account that disease control has historically been a responsibility of government. With a disease like dengue, however, most governments do not have the resources to maintain effective control. Hence, the program developed must be integrated to provide government support for the community-based efforts.
To develop effective community participation, the program should seek to inform the people of South Texas about the potential dangers and consequences of epidemic dengue hemorrhagic fever/dengue shock syndrome, the fact that major epidemics can be prevented, and the fact that it is their responsibility to see that preventive measures are effective.

Ultimately, the information that must be communicated to the people along the Texas-Mexico border is:

* Dengue fever is now endemic in Mexico, particularly along the Mexican Gulf coastal plain in the state of Tamaulipas;

* South Texas, particularly the Lower Rio Grande Valley, is at high risk of epidemic dengue because of the high *Aedes aegypti* densities along the Texas-Mexico border and the Mexican Gulf coastal plain;

* The majority of dengue transmission occurs in and around the house because people usually accumulate excessive trash around their homes, thereby creating mosquito breeding places;

* Control must be a community effort, because only the people involved can effectively clean-up the areas around their own homes to prevent mosquitoes from breeding and flying from house to house;

* Insecticide spraying should only be used in emergency situations; it is the responsibility of the people, not the government, to prevent epidemic dengue.
Clearly, this proactive approach to *Aedes aegypti* control has been to identify and involve all segments of the community. The rationale being that only a program planned, directed, and financed by the community will be truly community-based and sustainable.

Finally, it is important to note that the people living and working along the United States-Mexico border must be educated to a point where they accept their responsibility for playing the principal role in the prevention and control of epidemic dengue and dengue hemorrhagic fever/dengue shock syndrome.

An examination of factors contributing to the resurgence of dengue (e.g., poor public sanitation, inadequate water treatment, and high levels of poverty associated with unsatisfactory living conditions and the presence of appropriate vectors and/or reservoirs) can illustrate how factors on one side of the border relate to and influence those of the other side and ultimately, both nations.

The Texas-Mexico border is particularly appropriate for such analysis of the effects of economic, social, behavioral, and ecological factors affecting disease transmission as well as the development of innovative interventions to control or prevent dengue.

However, the emphasis should be on disease prevention (e.g., development of a vaccine) rather than mosquito control -- one must take into account that there are significant health risks in the absence of adequate protective measures and eradication programs.
A countrywide dengue surveillance and control program is essential in order to reduce response time and minimize morbidity and mortality. Except in those countries where *Aedes aegypti* eradication might still be achievable, the program strategy should be changed from one of eradication to one of control that is based on the actions outlined below:

* The distribution of *Aedes aegypti* must be determined in all regions of a country, especially in the urban areas. The status of *Aedes albopictus*, a second very efficient vector already present in the southern border regions of the state of Texas, should also be determined by intensifying surveillance programs to prevent the spread of this potential vector of dengue virus.

* Emphasizing environmental management as the main vector control tool. The prudent use of insecticides should only be undertaken when physical methods are impractical and biological control methods should only be pursued if appropriate. The prudent use of insecticide should include both space spraying for rapid/temporary reduction of infected adult mosquitoes and source reduction for permanent control, plus monitoring vector susceptibility to the insecticides to be used during these periods.

* Continuing to monitor the vector population through appropriate statistical sampling procedures, in order to target control efforts and evaluate control interventions as well as encouraging and incorporating the community's full participation in the design, execution, and evaluation of prevention and control activities.

* Developing a laboratory-based surveillance network within individual countries or among neighboring countries. Viral isolation capability also should be developed where possible.

* Promoting the public health and medical education of health care personnel in the recognition, management, and treatment of dengue and dengue hemorrhagic fever/dengue shock syndrome.
A surveillance system must be simple, yet comprehensive, in its structure and in its operation and flexible enough to allow the incorporation of new data. Dengue prevention and control programs must be in line with more effective surveillance as an early warning system that can predict epidemic dengue, and combining this with mosquito control measures - including community-based measures - to reduce *Aedes aegypti* densities.

An effective dengue surveillance system must address the disease from both a clinical and an entomological perspective as well as consider the virologic, epidemiologic, and serologic aspects that are useful in an active surveillance system.

Surveillance for dengue and dengue hemorrhagic fever/dengue shock syndrome can be either active or passive. Currently, most surveillance for these diseases has been passive - that is, it has depended upon case reports from the medical community that have recognized dengue-like illnesses. In most tropical countries where dengue transmission is reported, the surveillance system is of the passive type, with health authorities waiting until transmission is recognized by the medical services and detected through the routine reporting system.

This type of surveillance is typically very insensitive because of the low index of suspicion on the part of the physicians and the difficulties inherent in clinical differential diagnosis. Additionally, many patients treat themselves at home and do not seek medical treatment. Thus, by the time dengue cases are detected and reported by the medical community in a passive surveillance system, substantial transmission has already occurred and even may have peaked. By then it is generally too late to have much impact upon epidemic transmission, even though intensive mosquito control measures may be implemented.

The alternative strategy is active surveillance, which entails actively monitoring dengue infections in the community at all times.
The intent of an effective surveillance system is to provide early and precise information to public health officials on four aspects of increased dengue activity:

**Time; Location; Virus Serotype; and Disease Severity.**

The purpose would be to reduce transmission, thereby reducing the probability of dengue hemorrhagic fever/dengue shock syndrome. It should, therefore, be a proactive surveillance system that will allow for early detection of dengue cases and thus will improve the capacity of public health officials to prevent and control the spread of dengue.

The most significant characteristic of this type of surveillance is its predictive capability. Analysis of trends of reported cases, the establishment of sentinel clinics, the confirmation of dengue cases by the laboratory, and the rapid identification of the serotypes involved in transmission, provide the necessary information to predict dengue transmission and guide implementation of control measures well in advance of peak transmission. Proactive clinical surveillance must be linked to entomologic surveillance, in order to identify dengue transmission in time and place.

If effectively applied at this stage, mosquito control measures might abort an incipient epidemic. Vigilance would have to be maintained for some time, however, to ensure that the epidemic was not simply delayed. To achieve this type of predictive capability for epidemic dengue, the active surveillance system must be laboratory-based and must use rapid and sensitive laboratory diagnostic methods.

A laboratory-based surveillance system of this type will provide information on the onset, location, infecting virus serotype, and severity of the disease. It also will allow prompt reporting of results to submitting clinics and health care personnel and the ability to obtain further information, if necessary, on cases of severe disease or of public health importance.

Thus, a good diagnostic laboratory is essential to an effective active surveillance system.
In summary, an effective dengue surveillance system must address the disease from both a clinical and an entomological perspective as well as consider the virologic, epidemiologic, and serologic aspects that are useful in an active surveillance system:

**Clinical Surveillance:** surveillance for viral syndromes with a fatal outcome may be more effective in providing an early warning of epidemic activity;

**Entomologic Surveillance:** surveillance which deals with dengue's mosquito vectors, requires knowledge of the species present, species associations, species distributions, the types and productivity of larval habitats, seasonal changes in population densities, and behavior of the principal vector involved;

**Epidemiologic Surveillance:** the aim of epidemiologic surveillance is to monitor disease activity for dengue-like illness and/or dengue hemorrhagic fever/dengue shock syndrome.

**Serologic Surveillance:** When used in conjunction with epidemiologic case reporting, routine serologic surveillance data are very useful in determining what proportion of cases actually involves dengue.

There are three epidemiologic situations where different levels of surveillance are recommended:

1. Countries where no dengue transmission has been detected, but where *Aedes aegypti* is present.

2. *Aedes aegypti* is present, dengue is endemic, and seasonal increases in transmission occur.

3. Areas where epidemic dengue is occurring.
Virologic surveillance should have the following objectives:

1. Monitor the endemic dengue viruses transmitted in the area during inter-epidemic periods.
2. Monitor the geographic distribution and movement of all dengue virus serotypes.
3. Monitor types of illness associated with dengue infection in the endemic area.

For maximum efficiency, the surveillance system must be adaptable to changes in disease incidence. As *Aedes aegypti* infestation increases, 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.

Nevertheless, the aim of active virologic surveillance, the most important element, is to monitor dengue transmission, giving emphasis to periods of sporadic or silent transmission, so as to quickly detect introduction of new virus strains or serotypes. Other important components are surveillance for increased fever activity and for viral syndromes with fatal outcomes. Individually, none of these components is necessarily very sensitive, but collectively the three together provide the most sensitive data obtainable for predicting epidemic dengue.

Furthermore, when used in conjunction with entomologic data they provide the basis for action by a rapid response emergency vector control unit seeking to control an incipient epidemic before it spreads. However, it must be emphasized that effective surveillance for dengue, dengue hemorrhagic fever and dengue shock syndrome is not possible without a diagnostic laboratory that can perform serologic and virologic diagnostic tests that are both rapid and sensitive. This is a major problem in many dengue-endemic countries.
There is no specific treatment for dengue fever. Moreover, vaccine development is difficult since any of four different dengue serotypes may cause the disease, and because protection against only one or two of these serotypes might actually increase the risk of more serious disease. Nevertheless, progress is being made in the development of vaccines that may protect against all four serotypes.

At present, the only method of controlling or preventing dengue and dengue hemorrhagic fever is to combat the vector mosquito which, in Asia and America, breeds primarily in man-made containers such as bottles, cans, used tires and other items that retain water. In Africa, however, it breeds both in artificial containers as well as in natural habitats.

Control of dengue at the present time is dependent on control of the principal vector, Aedes Aegypti.

Efforts to achieve such control must now be focused on community education and action towards eliminating this mosquito's breeding sites near human dwellings.

As a result of the continued infestation of the South Texas/Lower Rio Grande Valley with Aedes Aegypti, indigenous transmission along the United States-Mexico border remains a public health concern for both governments.

Yet, the political boundary that artificially separates the two nations belies the true interdependence, both economic and social, on either side.

Ultimately, it is this political boundary that determines in the end how any or all concerns about public health along the United States-Mexico border must be addressed -- with diplomacy and cooperation through the international political process.