THE INSTITUTE FOR STRATEGIC CLARITY

Case Study: 2002-02

Mexican Secretariat of Health – Dengue

Engaged in his morning perusal of the academic medical journals, Dr. Jorge Méndez Galván looked up when a colleague dropped a Medical Alert on his desk. "An Outbreak of Dengue Detected in Guatemala" read the headline. As the Secretary of Health's advisor on epidemiology, Jorge thought about the meeting he needed to set up with the Secretary to brief him on this new development. Looking across his crowded desk at the stacks of reports and research data on epidemics he had accumulated over 20 years in the field, Jorge thought about what he would share of all the information he had. What would they do?

The coordinator of advisors to the Secretary of Health, Dr. Federico Ortiz Quesada, walked in briskly, "What's the snapshot?" Jorge replied, "Well, we have a potential epidemic with scarce financial resources. As the mosquito-transmitted disease dengue crosses Guatemala towards Mexico, the worst-case estimate of fatalities reached sixteen million people. We need to get the experts together to figure out what we want to do, now, as we have no time and no money."

As Federico left, Jorge picked up a 90-page report that summarized the post-doctoral work he had done at Johns Hopkins.

> By 1998 dengue has emerged as a major source of hospitalization and death. Dengue, a mosquito-transmitted virus, causes a high fever accompanied by significant pain in the afflicted patient. The *aedes aegypti* mosquito is the primary disease carrier. Four closely related, but antigenically distinct serotypes of dengue have been identified in the world (DEN-1, DEN-2, DEN-3, DEN-4). Dengue is of the genus *Flavivirus*. Though non-lethal in isolation, when combined the serotypes may cause dengue hemorrhagic fever/dengue shock syndrome (DHF/DSS), which is highly lethal. In Mexico, millions of people have been infected with DEN-1, to which they are now immune. If a mosquito carrying DEN-1 bites them in the future, nothing happens. If a mosquito carrying DEN-3 bites them, there is a high probability that they will develop DHF/DSS. The fatality rate for DSS can reach 44%. Over sixteen million Mexicans have had and are immune to DEN-1 or DEN-2, thus they are at risk of getting DHF/DSS, if infected with another serotype. DEN-3 had been identified in Honduras. If this serotype were to enter Mexico, the impact could be catastrophic, under the existing epidemiological control system.
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> To address the global problem of dengue, health organizations worldwide have invested heavily in researching the multiple causes and agents of transfer of this disease; yet to date there is no known vaccine or medicinal cure. Further compounding the problem, the *aedes aegypti* mosquito is very difficult to eradicate.

James L. Ritchie-Dunham prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. It is based on a case presented in detail in Managing from Clarity *(Wiley, 2001) by James L. Ritchie-Dunham and Hal T. Rabbino.*

As Jorge was reading, Dr. Javier Rosado, another adviser, walked in, "I guess you have seen the Alert …" Javier nodded. Javier noted, "As strapped as we are for resources to fight this, the devaluation of the peso leaves us with almost nothing. What are you going to recommend?" Jorge said, "While I can address the technical aspects, I will need to provide an overview of the situation within which I am providing advise. What is your assessment?"

Javier, who taught public policy at a local university, said, "Let's see. Up until last month, I would have said that we were in a fairly good position. Politically, Mexico was on very strong footing with the widely regarded presidency of Carlos Salinas. Salinas was regarded as a savvy politician, a charismatic leader and an economic visionary. Economically, the North American Free Trade Agreement linked Mexico to an extremely favorable expected economic future of opportunity and stability. There was a sense that the Mexican development model was the right one for all of South America. In addition, Mexico became a focal point for significant inflows of foreign investment capital. That was yesterday; today we have nothing and little access to more."

Jorge sighed, "I am going to read through a few summary reports I have worked up about dengue over the past years, to see what I recommend." (See Exhibit 1 for the reports on the perspectives of epidemiology, doctors, municipalities, and mosquito control programs.)

Exhibit 1

Epidemiology
The Mexican Secretariat of Health had repeatedly seen sudden outbreaks of mosquito-transmitted diseases in the tropical areas. Historically, the number of outbreaks tends to remain at zero for nine months of the year. Then beginning in April, the numbers swell up very quickly to a peak and decrease as quickly, lasting from two to three months.

The epidemic starts with the undetected entrance of a dengue-carrying sick person into a region of high mosquito density provides fertile ground for an epidemic. Due to the high mosquito density, the sick person is bitten by a female adult mosquito. This infected adult mosquito becomes contagious after a few days and bites a susceptible person. After incubating for a brief time, the infected person becomes sick. When this sick person is bitten by an adult mosquito, the cycle starts over again.

The susceptible population is affected by the inflow of new entrants, human migration from one area to another and births, and the outflow of people being infected. People are infected at a rate determined by the ratio of contagious mosquitoes to susceptible humans, the ratio of female to male mosquitoes (only female mosquitoes bite humans), the frequency with which female mosquitoes bite, and the percentage of bites that spread the virus.

After recovering from the first serotype, the people become immune to it and susceptible to DHF/DSS when exposed to a second serotype. The dynamics are the same for the second serotype, until they get sick, when the probability of death from the first serotype is negligible. With the second serotype the probability of death from DHF/DSS increases to 15%.

Doctors
Doctors serve the population in maintaining its health. Sick people want special attention, so they can get better and return to their families. Doctors, on the other hand, have too many patients to give significant individualized care, especially with limited medical resources. Additionally, though doctors want to assist and cure everyone, even when the people feel bad, they do not come immediately. In epidemics, doctors report incidences to the secretariat as soon as they identify them. However, they always give us fewer resources for detection than we need. As stated before, early detection and isolation of sick people represent key determinants in controlling the epidemic. In Mexico with slow medical reporting mechanisms in the poor rural areas, the epidemic can be well on its way before it is detected. This is further frustrated by inadequate training of medical staff in rural areas as to disease detection, and the lack of laboratory testing facilities, as well as the need for the patient to be seen twice to determine positively that it is dengue. Earlier detection, such as the 4-hour immediate dangerous disease alert system in the United States of America, would allow quick responses to outbreaks, but these systems are very expensive and require extensive training.

Municipalities
Municipal governments have very limited budgets for medical services. Their job is to fulfill the basic service needs of the population and to maintain a healthy political environment, however,

there are not enough financial resources for all their needs. For example, the towns do not have appropriate running water and refuse pick up services

Human living conditions contribute to the mosquito growth dynamic. In the tropical regions where dengue is most prevalent, many people still have no access to running, sanitized water, and store water in stagnating receptacles. Inadequate refuse collection systems lead to piling up of refuse, such as tires and cans, typical of many homes in these regions. These receptacles provide ample refuge from the changing ecological conditions, ideal for the mosquito to lay eggs.

Mosquito Control Programs

The population dynamics of the mosquito are crucial in the epidemic. Basically, as more adult mosquitoes lay more larvae, the larvae become more adult mosquitoes, creating exponential growth. One female can, in one summer, leave behind a few billion descendants. For example, in Mérida, studies show that the mosquito lives up to thirty to sixty days, depending on climatic changes and food availability. If a 25-day old mosquito bites an infected human, the mosquito would acquire the virus and incubate it for the next 7 days before it can pass the virus to a human. This mosquito would most probably die of "old-age" before infecting a human. This fast growth, fast death cycle results in a relatively stable mosquito population, during the warm months in Mérida from April to October. However, in the colder months the mosquito population shrinks significantly, due to the higher death rate from ecological conditions. The population remains relatively low until the entrance of the warmer months. The reinforcing growth implicit in the mosquito population is relatively offset by natural and human "controls." Ecological conditions, such as high winds and temperature changes, control the growth of the mosquito population, by killing most of the population every day.

To control the epidemic, health officials can use mosquito control, refuse removal, and disease detection. Mosquito control programs attack the adult mosquito population by fumigating and the larvae population by dispersing larvicides in positive receptacles, killing the larvae in the receptacle. Refuse removal programs educate people to remove the rubbish from their houses in which the mosquitoes lay their larvae. Disease detection programs educate medical personnel to send in laboratory tests for patients with suspicious symptoms to reputable laboratories, and then to notify authorities of dengue cases in a timely fashion.

The number of adult mosquitoes killed by fumigation programs is determined by the fumigation effect, how well the fumigation program works, and when the program is initiated. The adult mosquito population killed by climate variation depends on seasonal variation in temperature and wind speeds. The number of positive receptacles per house is affected by the inflows of new receptacles and receptacles no longer controlled by larvicides, and by the outflows of removing receptacles and protecting receptacles. New receptacles represent the increasing amount of garbage that collects in the house and near it. Receptacles are no longer controlled by larvicides after the larvicide effect diminishes. Receptacles are removed by the impact of the Educational programs teaching people to keep their homes clean. Receptacles are also protected by larvicide. The number of controlled receptacles is affected by the inflow of receptacles being controlled by larvicide, and by the outflows of receptacles no longer being controlled by larvicides, and those that are removed as a result of education programs. This model shows that larvicide programs

may be helpful for large water systems such as septic tanks, but the strongest effects come from picking up the garbage and from creating less garbage. Though seemingly obvious, consumer products are increasingly more "disposable" and refuse-collection infrastructures weaker. Initial attempts at educating the people to remove these positive receptacles have met with some success and are relatively inexpensive.

The low efficiency of these expensive equipment and labor-intensive larvae and mosquito control programs, as low as 15-20% eradication, indicates that controlling the mosquito population is non-trivial, as evidenced historically. Larvicides are also largely unsuccessful as they require the brigades to find all possible places for the mosquito to lay eggs. A few studies have indicated that brigades identify approximately 20% of the positive receptacles in a home. Whereas larvicide strategies render positive receptacles "controlled" for an assumed six months, educational strategies remove positive receptacles from the system. The larvicide and educational strategies combine to affect the number of positive receptacles where female adult mosquitoes lay eggs.