Cost Analysis of Dengue in the Republic of Nicaragua
2004

Conducted by: Dengue Relief Foundation

Table of Contents

Background

Nicaragua's Natural History, Geography, and Demographics

Nicaragua has had a turbulent history plagued by both natural disasters and civil war. The Nicaraguan populous is not unaccustomed to natural disasters. The earth quake of 1972 significantly damaged the capital city of Managua; much of the damage remains un-repaired to the present day. Civil war erupted in 1979 and internal military conflict persisted throughout the 1980's (site book latin american revolution). Hurricanes, floods, tidal waves, volcanic eruptions, and severe mudslides are some of the many natural episodes that have affected the nation's ability to govern and provide effective health services for the population at large. Despite these factors the Nicaraguan people persevere to rebuild and renew their country.

Nicaragua has the distinction of maintaining the largest territorial land mass in conjunction with the least population in Central America, totaled at 5.4 million. The population is predominantly young in age with 41.5% between 0-15 years of age, 53.8% of the population is represented by those 15-60 years of age, and those over 60 represent 4.6% of the population total.(2) The median age of the country is 20.2 years old, the population growth rate is 1.97%, and the birth rate is 25.5 per 1000 of the population, further elucidating the predominance of youth in the country.(1)

Dengue Virus

The social and political history of Nicaragua have dictated the format of the current health system and more specifically how the government finances diseases of specific epidemiological concern, such as Dengue. Dengue is a virus that belongs to the

Flavivirus family. The flaviviridiae family includes other disease entities such as Yellow Fever, Japanese Encephalitis, St. Louis encephalitis, West Nile, Murray Valley, Kayanasur Forrest Disease, and tick born encephalitis (3, Morse).

The mosquito is the principal vector that transmits the Dengue virus. Species such as the *Aedes albopictus*, or asian tiger mosquito and *Aedes aegypti* mosquito, have been implicated in its transmission throughout the globe (Morse). The principal vector in Nicaragua is the *Aedes agypti* mosquito.

There are four serological types of Dengue labeled DEN-1, DEN-2, DEN-3, and, DEN4. All four of these have been documented in existence in Nicaragua. Dengue has many different clinical pictures but its two most common forms are the classic and hemorrhagic forms. Classic Dengue is marked by high fevers, headache, nausea, vomiting, and severe muscle pains. Hemorrhagic Dengue is depicted by all of the symptoms of classic dengue in addition to vascular shock, kidney damage, capillary rupture, and hemorrhage, creating petechiae and scleral bleeding (Morse).

Prior World Wide Control Efforts

From 1946 to 1963 there was no record of epidemic Dengue in Latin America. This can be attributed to the success of the Pan American Health Organization, which organized a campaign that eradicated *Aedes aegypti* from most Central and South American countries in the 1950s and 1960s (4). However, The *Aedes aegypti* eradication program was officially discontinued in the United States in 1970, and slowly discontinued elsewhere. As a result, the *Aedes aegypti* species began reinfesting countries from which it had been eradicated. (4) In 1997, the geographic distribution of

Aedes aegypti was wider than its distribution before the eradication program, and became firmly established throughout Latin America.(4) There were no special circumstances that would have allowed Nicaragua to avoid such an expansion of this vector. However, there were a multiplicity of factors, including natural and sociopolitical apsects that would allow the vector to remain within stable population pockets. This provided Dengue with a permanent residence and endemic status within the republic of Nicaragua.

Dengue in Nicaragua

Currently, the national incidence of dengue is decreasing when one compares recent trends. 1999 saw a 23.72% per 10,000 incidence, in 2000 it was 1.94% per 10,000 rising to 4.68% per 10,000 in 2001, and again decreasing to 1.94% per 10,000 in 2002. (2) However, its endemic presence provides a significant financial strain on the Nicaraguan economy.(2) Furthermore, while the incidence of dengue is declining at a national level, it is currently increasing in the capital city of Managua. In the year 2000, Managua reported 200 confirmed cases, 550 cases were reported in 2001, and nearly 1000 new cases were documented in 2004. (5) This is the perfect avenue for a renewed spread of the virus, as it invades in the highest geographical concentration of the national populus and further establishes itself as an increasing threat to outbreaks and epidemics.

Dengue is one of the most severe socioeconomic dilemmas that persists within the republic. The debilitating aspects of the illness manifest themselves both physically and economically, such that a strain at various economic levels may be observed when combating the disease. (2) There is debilitation at the level of the working populous, where labor efforts are halted while the disease takes its course, slowing the nation's

productivity of goods and natural resources. (2) There is also a strain on the economic resources available for control of the disease. Its distribution is dependent on environmental factors and conditions that provide niches of mosquito growth and proliferation. However, there are not enough funds to provide education/prevention campaigns, insecticide, and mosquito abatement as control efforts. (2) In the face of a dwindling economy, the means for providing financial support to establish control over the disease are precarious.

Introduction

Nicaragua's Turbulent History/ Implications for Dengue

This cost analysis acts as a measure to evaluate the current financial status of Dengue relief efforts in the republic of Nicaragua. It will evaluate the avaliable resources and the efficiency of their distribution. Nicaragua has undergone changes in government that have had a direct effect on the allocation of funds toward relief efforts for Dengue. Having been overtaken by the Sandinista movement, which was a Communist regime, democracy returned to Nicaragua in 1990, and the subsequent administrations of Violeta Chamorro, Arnoldo Aleman and the current administration of Enrique Bolanos have had slightly different approaches to dengue relief efforts and fund distributions. (6) Presently the government is undergoing a process of decentralization that directly affects the methodology of how funds are distributed. (7)

MINSA Organization/ Structure

The current systematic organization of the country's health infrastructure is formulated from top down. The national Ministry of Public Health (MINSA) is the central government oversight branch. Subsequently, there is a system of integrated health care sites (SILAIS) that are partitioned nationally into a total of 17 sectors, each corresponding to one of the 17 departments into which the nation is divided. Next, each SILAIS oversees a number of municipalities that have corresponding local health centers. These centers vary in number in relation to each regional SILAIS. (7)

Decentralization of this system has been implicated as a source of discrepancy in terms of budget proposals. (7) Each branched municipality prepares its corresponding budget, which is then reviewed at the level of each SILAIS. (1,7) Furthermore, each SILAIS subsequently submits budget proposals to the central offices of MINSA. MINSA formulates a global budget and submits it to the National Assembly of Finance for approval. One of the major difficulties resides in the formulation of the budgets at the level of the municipalities and SILAIS. Specific programs, such as Dengue relief, are no longer assessed as independent entities.(7) Instead, the budget of each SILAIS and municipality is constructed purely on worker output such that the type of equipment, the number of workers and their productivity trends are assessed, rather than the needs of specific programs. This inherent flaw may proceed up the budget chain from the municipality to SILAIS to MINSA where budgets were incorrectly assessed at the point of origin.(7) As a result, some municipalities find themselves with inadequate funds for implementing relief programs midway through the fiscal year, falling short of their individual curative and eradication goals. (7) (See Appendix 1)

Choosing Intervention Methods

It would be too simplistic to think that decisions about which intervention to implement against Dengue can be made simply on the basis of the relative effectiveness of each alternative, selecting the one which most reduces the impact of the disease. (8) Such an approach would often lead to choosing expensive interventions. In the case of Nicaragua, funds may not be available or decision-makers may be reluctant to spend them on that intervention. It is appropriate to first ask whether the resources would have been better used on a different disease or in another avenue. (8) This is essentially the basis of this economic evaluation. Until now, cost-effectiveness studies of interventions to control vector-borne diseases have seldom been undertaken and are rarely done. (8) As a result it is not uncommon to find that inefficient control measures are initiated and maintained or that desirable interventions are neglected.

The Problem: Nicaragua's Economy

Nicaragua's Economy and its Impact on Dengue

With Nicaragua's turbulent political past, also comes an unstable economy. Nicaragua's financial profile has been in a continuous state of fluctuation in the last twenty years as different political parties have governed the nation. It has not been able to establish a sound financial portfolio on which to optimally attend to the needs of the people through the administration of funds to the various federal administrations,

agencies and ministries. Among these is the Ministry of Public Health, which handles all aspects of the national health care system and relies on government funding to ensure the medical well-being of the country. Some of the conditions which they combat include the infectious diseases which plague the country. Included among these are leshmaniasis, malaria, Tuberculosis, HIV/AIDS, and Dengue.

While Dengue is now endemic to Nicaragua, it did not exist as a permanent resident until 1985, when poor mosquito control and surveillance, as well as lack of community education, fostered the ideal environment for its proliferation.(4) This potential for spread was made manifest on Oct. 28, 2002 when ProMed reported that due to an increase in the number of cases of dengue fever in Nicaragua, the Ministry of Health (MINSA) declared a nation-wide state of "dengue fever epidemic." (9) As of 24 Oct 2002, there were 1366 confirmed cases of dengue fever, 1258 of which were classic dengue fever and 108 cases of dengue hemorrhagic fever. Of the latter, there had been 7 deaths. The cities most affected by the epidemic were Nueva Segovia with 254 confirmed cases, Managua with 219 cases, Chinandega had 162 cases, and Leon reported 134 cases. Nonetheless, the majority of the cases of the hemorrhagic form had been registered in Masaya, reporting 31 cases, followed by Managua with 28 cases, Leon showing 18 cases, and Nueva Segovia with 11 cases. (9)

National Control Efforts

Attempts to control the spread of Dengue, with hopes to eventually eradicate it from the population, are focused on eliminating the *Aedes aegypti* mosquito vector. This is the only known source of disease transmission, and humans are the primary known reservoir

for the virus, though there are hypotheses that monkeys can aslo serve as reservoirs. (10) The methods used in Nicaragua to control it include spread of abatement for the larvae by workers from the department of health, and the use of insecticide composed of a diesel fuel and cypermethrin mix that is spread by fumigation units, known as Leco machines, that are mounted on the flat bed of trucks. Fumigation is also done with the use of domiciliary compressors filled with insecticide and worn as back packs by the MINSA extermination teams, to fumigate the interiors of homes. (7)

The effectiveness of these methods have been reviewed in previous studies. Results from laboratory and prefield assays in one study in Argentina, indicate that the fumigant canister CIPEIN PF-7 (Bolate) a smoke-generating formulation containing 5% beta-cypermethrin, had excellent performance as an adulticide for *Aedes aegypti* control. (11) A field trial was carried out to evaluate the effectiveness of CIPEIN PF-7 to control adult mosquitoes of *Aedes aegypti* inside houses. One fumigant canister was applied in each house, which remained closed for 1 h and was then ventilated for 15 min by opening doors and windows. Cages with adult mosquitoes and plastic cups with water containing mosquito larvae were put in various places of the houses. There was 100% initial mortality in each case after treatment with the fumigant canister. The residual effect showed 100% mortality of adults exposed 2 h for at least 3 days after treatment and 100% mortality of larvae 1 day after treatment. (11) House and Breteau indices before the treatment were 51% and 106, respectively, falling to 23% and 44 after treatment. While these methods have proven effective in studies such as this one mosquito control, the limited government funding and limited resource allocation has created a non-continuous management of Dengue relief efforts through out the nation. (11)

Dengue relief efforts in the form of fumigation/abatement use tend to occur at epidemiological peaks in incidence rather than at a steady continuous pace to avoid peaks in case volume. (7) Insufficient amounts of machinery (i.e. trucks, lecos, and hand held fumigation units), materials (i.e. abatement and insecticide) and workers are the general obstacles to reaching the goal of eradicating the mosquito population. The use of education programs inculcate a greater community awareness and understanding of prevention methods, but are limited due to budget constraints. (7) These programs emphasise the importance of identifying and removing stagnant water in and surrounding homes, as well as the role of proper daily hygiene as indespensible in controlling the spread of Dengue and diseases in general. (7) In sum, fluctuating budgets for epidemiological surveillance, the non-continuous implementation of dengue relief efforts, and poor communication among those involved within the integrated system, allow cases of the virus to go undocumented and surveillance to become less prudent such that incidence peaks may arise.

Study Design

This study concentrates its efforts on a retrospective analysis of Nicaragua's previous resource allocation and expenditures concerning dengue surveillance and treatment. The economic impact which is attributable to Dengue on the national economy can be studied at three areas of financial focus. The first is cost of preventative measures including purchases of abatement and insecticides, as well as the cost of providing salaried workers to implement these measures. Included in these costs is also the distribution of

propaganda and educational materials used to inform the public of practical measures which can be implemented to prevent the proliferation of mosquitoes and the spread of the disease. A second focus is the government incurred cost to treat a patient afflicted with dengue in either its classic or hemorrhagic forms. This area of the study looks at the different levels of treatment offered in Nicaragua, including the cost of public and private out-patient centers, public and private in-patient hospitals, as well as the cost of medications used to treat ensuing cases. Lastly, the economic impact is studied globally as an opportunity loss to the national economy due to loss of production per worker affected with dengue.

Caveat:

This manuscript will address the first study component described. A cost analysis and needs assessment of Nicaragua's primary dengue preventive measures in the form of purchases of abatement and insecticides, as well as the cost of providing salaried workers to implement these measures. This analysis was accomplished by utilizing data from the capital city of Managua. Data from the capital city is derived from a population base of over 2 million inhabitants and can be statistically extraploted to the nation of approximately 5.4 million citizens.

Once the previously mentioned areas of expense have been reviewed, a look at the national economy and its distribution to the area of health must be considered. The allocation of federal funding reserved for MINSA, and its further redistribution among each SILAIS and subsequent municipalities will be cross analyzed with the financial need posed by each of the three areas of financial focus for dengue prevention and treatment. How the funds are distributed compared to the cost of each of the interventions will

provide a picture as to the financial deficit experienced from the municipal to the national levels of the economy. With these comparative results the proper appropriation of funds can then be suggested based on the resulting efficacy produced by the current system of fund distribution.

Subsequently, the intervention in the form of a not for profit organization, The Dengue Relief Foundation will be described. As financial data and information regarding previous control measures is colated, a firm historical foundation will be developed. The historical financial analysis will direct the intervention and its actions. The intervention in the form of an NPO is a stable and strategically oriented funding stream. As each of the three methods of dengue control is studied an assessment will be derived as to which is the most cost effective, that is, prevents the greatest morbidity and mortality for the least expense. Once this has been extrapolated the NPO/intervention will direct funds to that specific endeavor. Next, after funds have been destributed to the most eficacious dengue control measure data will be collected to determine if indeed morbidity and mortality were reduced in direct correlation to the measure funded. Furthermore, the post-test more specifically is defined as a review period of collecting morbidity and mortality data in relation to the measure funded thereby elucidating the cost effectiveness of the measure. The non-profit organization proposes the introduction of a continuous and stable funding stream with strategic financial allocations distributed under the guidance of set quality measures. The quality measures tied to the fund distribution act as a report card to Nicaraguan officials such that funds donated must be dedicated to the proposed dengue control measure. This study will follow a quasi-experimental pre-test post-test study design format.

Methods

Research methods for this endeavor include compilation of material from the National Ministry of Public Health for epidemiological data concerning the national trends and presenting cases of Dengue in both its classical and hemorrhagic forms. The national budget is analyzed to review the influx and allocation of financial resources as they pertain to the clinical, field, and educational efforts towards the control of the spread of Dengue. The limitations of the data and study methods reside primarily in the quality and source of the data obtained. Financial data pertaining to cost for dengue preventive measures in the form of insecticide and abatement endeavors was derived from the SILAIS of Managua. The national epidemiological statistics pertaining to Dengue were derived form the national epidemiologic department at the ministry of public health MINSA. Finacial analysis and study direction were assited by Dr. Juan Jose Amador the chief of national epidemiology.

Data Analysis

MINSA Budget Allocation

The budget used towards Dengue control has to go through a series of channels before it is approved and finalized (see Appendix 1). Although there is no nationally defined Dengue prevention program, funds are distributed through out the system in the form of lump sums as budgets are approved by the National Assembly. (7) These are

allocated independently for dengue control efforts at each level of the national health system. The funds, however, are not always distributed equitably due to the system of budget proposals. Each municipality proposes a budget to the SILAIS of the district. Each of the different SILAIS then present the budget of each municipality plus their own budget to MINSA. (7) MINSA, however, is not the approving authority since they have to take all of the proposed budgets of the municipalities, each SILAIS, as well as their own, to the National Assembly by August of each year. Final approval by the Assembly is supposed to take place by January of the following year. However, the National Assembly does not always respond by the first of the new year, taking longer to approve funding appropriated for national health, thus delaying continuous Dengue control. (7)

Dengue Budget Breakdown

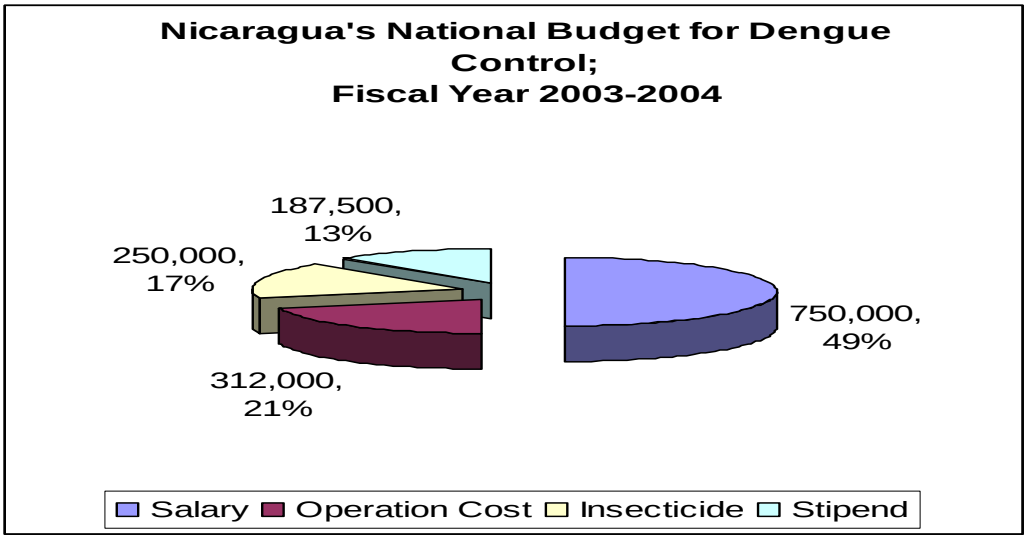
For the 2003-2004 fiscal year, the National Assembly approved a budget totaling 1.5 million dollars towards epidemiological disease control, for the nation's 5.4 million inhabitants. (7) The break down and allocation of the expenses is shown on Table 1.

Table 1: **Nicaragua's National Budget for Dengue Control Fiscal Year 2003-2004**

Item	Amount in Dollars
Salary	750,000
Operation Cost	312,000
Insecticide	250,000
Stipend	187,500
Total	1,500,000

Table 1 shows us that $750,000 of the budget is used towards worker's salaries, along with another $187,500 used towards a discretionary stipend per employee. This stipend is used as a subsidy for meals and work related travel. Operation costs for the ministry and general direction funding command $312,000 of the total budget for MINSA. These costs account for 83% of the total budget allocated for Dengue control, but have yet to include costs of insecticide or other direct control efforts. Only the remaining 17%, or $250,000, as shown in Figure 1, are distributed for purchasing insectiside. This total of 1.5 million dollars, therefore, translates into a $0.26 per capita expenditure for Dengue related control efforts in a country of 5.4 million inhabitants. See Table 1. However, as previously mentioned the budget does not remain stable from year to year. The Assembly has already informed MINSA that for the fiscal year 2004-2005, the operation/directional fund will no longer be supported by the government. This reduction in federal funds leaves a projected $0.21 budget per capita for dengue control efforts for the 2004-2005 fiscal year. (7)

Figure 1



Managua's Dengue Expenditures

Managua the capital city has a population of approximately 1.4 million inhabitants.(2) The SILAIS of Managua maintains information regarding their budget and expenditures and due to their size as the largest SILAIS in the country one can interpret and extrapolate much of the data from the this source to the nation as a whole.(7) This section will pertain to a brief analysis of the expenditures associated with dengue control and surveillance as well as a needs assessment for the SILAIS of Managua. Similar needs are demonstrated nationally.

Both insecticide and larvecide formulate a significant component of the Managua SILAIS budget as demonstrated in Table 2.0. This significant expenditure with respect to chemical control of the vector is paralleled at the national level. The expeditures relayed in Table 2.0 describe the chemical control or use of insecticide and abatement as a mehtod to contain dengue proliferation. (7,15)

Table 2.0

Expenditures related to insecticides:

Type of insecticida and larvecide	Unit of chemical	Unit price	Total Price
BTI	Liters	$ 5.50	$ 364,540.00
GRISSELEF	Liters	$ 7.50	$ 541,425.00
VECTRON	Grams	$ 20.00	$ 40,000.00
ALFA CIPERMETRINE	Liters	$ 8.00	$ 18,720.00
ABATE AL 1% (larvecide)	Kilograms	$ 1.00	$ 164,199.00
TOTAL			$1,128,884.00

The next component of the budget that is associated with dengue control is the operating cost of providing surveillance and fumigation. The integral component required to allow these efforts to take place is the use of fuel see Table 3.0. (15)

Table 3.0

Expenditures related to petroleum

Fuel type	Unit of fuel	Unit price	Total price
DIESEL	GALON	$ 2.18	$ 34,125.00
GASOLINE	GALON	$ 2.50	$ 16,250.00
KEROSENE	GALON	$ 2.18	$ 15,750.00
TOTAL			$ 66,125.00

The use of specialized equipment required to fumigate is a vital component of dengue control and provides a significant inherent cost. See Table 4.0. The use of fumigation LECO machines which are mounted on the flat bed of trucks as well as hand held devices utilized for locations inaccesible by vehicle are costly. Moreover, these machines are utilized frequently and are constantly being serviced and repaired in lieu of the fact that

there is no replacement and the life expectancy of a machine is generaly ten years with majority of the machines exceeding this critical age. (15) A needs assessment was accomplished as to the number of acres that are left unfumigated and the number of acres that are currently fumigated with each type of machine. This allowed one to extrapolate the number of each respective machine required to accomplish the task of improved fumigation coverage see Table 5.0. (15)

Table 4.0

Expenditures Related to Fumigation Equipment

Type of equipment	Need	In function	Deficit	Specifed type of machine	Unit price	Total price
LECO Machine	20	6	14	LECO	$14,000.00	$196,000.00
SWINFOG Machine	20	5	15	SWINFOG	$2,000.00	$30,000.00
Back pack fumigation Device	20	5	15	Back Pack fumigation device	$600.00	$9,000.00
TOTAL						235,000.00

As described earlier the requirement of fuel as well as vehicles is essential to a proper dengue control effort. Taking into account the number of acres one vehicle covers and extrapolating this figure into the total acres left to be covered one can estimate the need for vehicles corresponding to the SILAIS of Managua. (15)

Table 5.0

Needs Assessment Pertaining to Vehicles

Vehicle type	Needs assessment	Currently functioning	Deficit	Unit price	Total Price
Truck 4x4	20	6	14	$36,000.00	$ 504,000.00
Motorcycle	19	7	12	$ 4,500.00	$ 54,000.00
TOTAL					**$ 558,000.00**

Maintenance of the vehicles utilized for control is absolutely essential as the six vehicles in current use are detriorating due to the extreme conditions and constant use of the vehicles. See Table 6.0 (15)

Table 6.0

Vehicle Maintenance Cost

Type of accesory	Unit of measure	Unit price	PRECIOS TOTAL
Oil # 40	20 barrels	$ 237.50	$ 4,750.00
Oil #140	Barrel	$ 375.00	$ 375.00
Oil double change	24 Liters	$ 2.80	$ 675.00
Oil filters	144 Units	$ 9.37	$ 1,350.00
Air filters	24 Units	$ 12.50	$ 300.00
Break fluid	60 Liters	$ 1.87	$ 112.50
Spark plugs	400 Units	$ 1.56	$ 625.00
Tires (truck)	96 Units	$ 93.75	$ 9,000.00
Tires (Motorcycle)	38 Units	$ 21.87	$ 831.25

One must also include in the transportation budget the remaining funds that are saved should a vehicle become unsalvagable. The budget stipulates a $22,500.00 replacement fund for vehicles rendered unusable. (15)

Continuing the dengue control cost analysis for the Managua SILAIS, one must inlcude the yearly budgeted funds dedicated to the worker's stipend. The stipend includes 3 meals a day and travel expenses with respect to distant locations within the designated mosquito control area. The yearly stipend for all workers in the SILAIS is valued at $228,000.00 on the yearly budget. (15)

The SILAIS of Managua also stipulates a miscellaneous fund for extraneous circumstances associated with equipment parts totaled at $93.75.

In sum, the total budget for vector control pertaining to Dengue arrives at a grand total of $2,306,227.75 (15) Furthermore, one must elucidate that this sum extrapolates the requirement to control all mosquito vector mediated disease of which dengue demonstrates the most sizeable fraction. In addition, it is also important to note that included within this total sum amount is the current needs assessment. (15)

Therefore, should this entire budget be overlayed to the nation one would gather that US$ 0.40 is spent per capita. However, one must keep in mind the aforementioned limiations of this value and compare it to the previous dengue control expenditure value speculated at US$ 0.26 per capita. In brief, one might suggest that a possible range of per capita spending from US$ 0.26 to 0.40 is described for the majority of dengue related control efforts.

In further review, it was also assessed that the SILAIS of Managua spends a modest sum on education and prevention which may be described in Table 7.0 below. (15)

Table 7.0

Education and Prevention Campaign

Education and promotion	$US
Radio and television campaign	$32,250.00
Brochures and design cost	$18,000.00
Total expense	$50,250.00

However, despite these added sums it still remains that a viable reference range from US$0.26 to US$0.40 is demonstrated as per capita spending for dengue related control initiatives that pertain to government driven chemical and educational efforts.

Medical cost a component of direct cost

Next, the financial considerations with respect to medical treatment of those afflicted with Dengue can vary depending on the severity and viral serotype. However, some generalizations as to medical treatment provide a rather cursory estimate that may be summed to the previous expenditures.

The daily cost of a pediatric intensive care bed or neonatal intensive care bed totals approximately $88.40 respectively. The cost for a general pediatric ward bed in Nicaragua can be estimated to cost $22.00 per day. Similarly for an adult general ward bed $22.00 to $30.00 can be expected. (14)

Most cases of dengue can be treated by supportive care with use of IV fluids, namely lactated ringers, and acetamenophen. (14) A patient may remain in the hospital any where from three to fours days after being afflicted with dengue. Therefore cost may range from $360.00 for a pediatric ICU visit to $120.00 for an adult visit. (14)

The financial analysis of dengue can be accomplished by reviewing direct costs such as those demonstrated above which include but are not limited to epidemic control measures, educational efforts, and medical care costs.

Results and Discussion

Education vs. Chemical Control

It is evident that Nicaragua is in a perpetual struggle to protect its citizens from the debilitating effects of Dengue. Interestingly the Nicaraguan economy as well as its citizens has experienced significant financial hardship with respect to treating and controling the disease. The financial strain is not unique to Nicaragua as many countries graple with similar circumstances. (16) In 1998 Vietnam experienced an epidemic of dengue with 234,866 cases and 383 deaths with direct costs totaling US$ 2 million approximately US$ 9 per case. The Vietnamese government then spent another US$ 1 million on vector erradication programs. This is most certainly a significant financial strain on a country with a per capita gross national product of US$ 365. (16) Nicaragua who ranks in the top five countries with increased mortality due to hemorrhagic dengue has a gross national product of US$ 830 per capita significantly greater than that of

Vietnam but inadequate none the less to combat the endemic burden of disease.(16) Other countries that possess even greater wealth have attempted to erradicate the mosquito vector, *Aedes aegypti*, but to no avail. It would appear that solely treating the effects of the disease medically and chemically controling the vector are insufficient initiatives for dengue control. Brazil has had annual expenditures which have exceeded US$ 600 million comprising 1.6% of the total health budget. (16) In addition, Brazil has been known to spend US$ 7 per capita on dengue related control efforts a siginificant difference from that of Nicaragua currently in a range of US$ 0.26 to 0.40 and most likely dropping to US$ 0.21. (7,16)

This being said the argument persists that perhaps chemical control or the use of insecticide and abatement programs may not be sufficient as even the most opulent of dengue infested countries are unable to maintain control of endemic disease. In Thailand, despite annual expenditures exceeding US$ 11 million the country suffered one of the largest Dengue Hemorrghagic Fever outbreaks in its history. (16) Therefore, as one analyzes the exorbitant operational costs of mounting a dengue control effort by targeting the mosquito vector one may begin to entertain other avenues that may be utilized in conjunction with chemical control to bolster dengue erradication.

Recommendations and a Look to the Future

The introduction of a stable funding stream with strategic allocation of funds is necessary to improve dengue control efforts in Nicaragua. It was evident that the

Nicaraguan government did not have sufficient funds to mount an effective national education campaign to bolster or complement their mosquito abatement/insecticide program. The education programs that are currently in effect are nothing more than pilot programs that are financially supported by external donor support from groups such as the Pan American Health Organization, World Health Organization, and World Bank.

The recommendation we propose requires an initiative to introduce a stable funding stream to assist dengue education pilot programs to become mainstream nationally. The Dengue Relief Foundation (DRF) is a nonprofit organization developed for this express purpose, that is to procure financial support and provide monetary assistance to specific educational pilot programs. Currently the educational pilot program chosen as a target for assistance is called project COMBI. The program specializes in motivating community leaders to spear head change in their local communities. Dengue education is taught by local community activists that travel door to door providing information that allows for the erradication or control of vector breeding grounds. It is thought that behavioral change is best accomplished by utilizing community leaders to teach their community members rather than hiring external entities to accomplish the task.

When one looks forward with respect to Dengue control it is often mentioned that a vaccine or the development of immunological resistance would be truly ideal. Recently, a conference in which the Pharmacoeconomics Working Group estimated the costs imposed by the burden of dengue illness and the allure of the dengue vaccine market. The conference concluded that a price dose of US$ 5.00 per dose and total vaccination cost of US$ 16.10 would most likely be the value of such an initiative. (16) However, the gross

per capita of the vaccination program would be US$ 0.30 with a net cost of US$ 0.17 because of health care cost savings due to less Dengue Hemorrhagic Fever cases. The Disability Adjusted Life Year saved from use of a dengue vaccine was totaled at US$ 389.00. (16) Vaccine producers would stand to make a revenue of approximately US$ 123 million per year. (16) There is currently work being conducted in Nicaragua to begin a vaccination pilot program that would allow for preliminary results and data to be obtained regarding its clincial as well as cost effectiveness. The research is being conducted by Eva Harris and her research team from UC Berkley.

In sum, it would seem that education and possible vaccine initiatives may prove to be viable options to alleviate the current endemic disease burden due to dengue in Nicaragua. The intervention proposed by this analysis demonstrates that education is poorly funded by the government if not at all and a stable funding stream dedicated to such an initiative may prove beneficial over the long term. Similarly, it may be a future opprtunity for nonprofit organizations such as the Dengue Relief Foundation to support vaccine initiatives once siginificant data has been collected with respect to its clinical and cost effectiveness.

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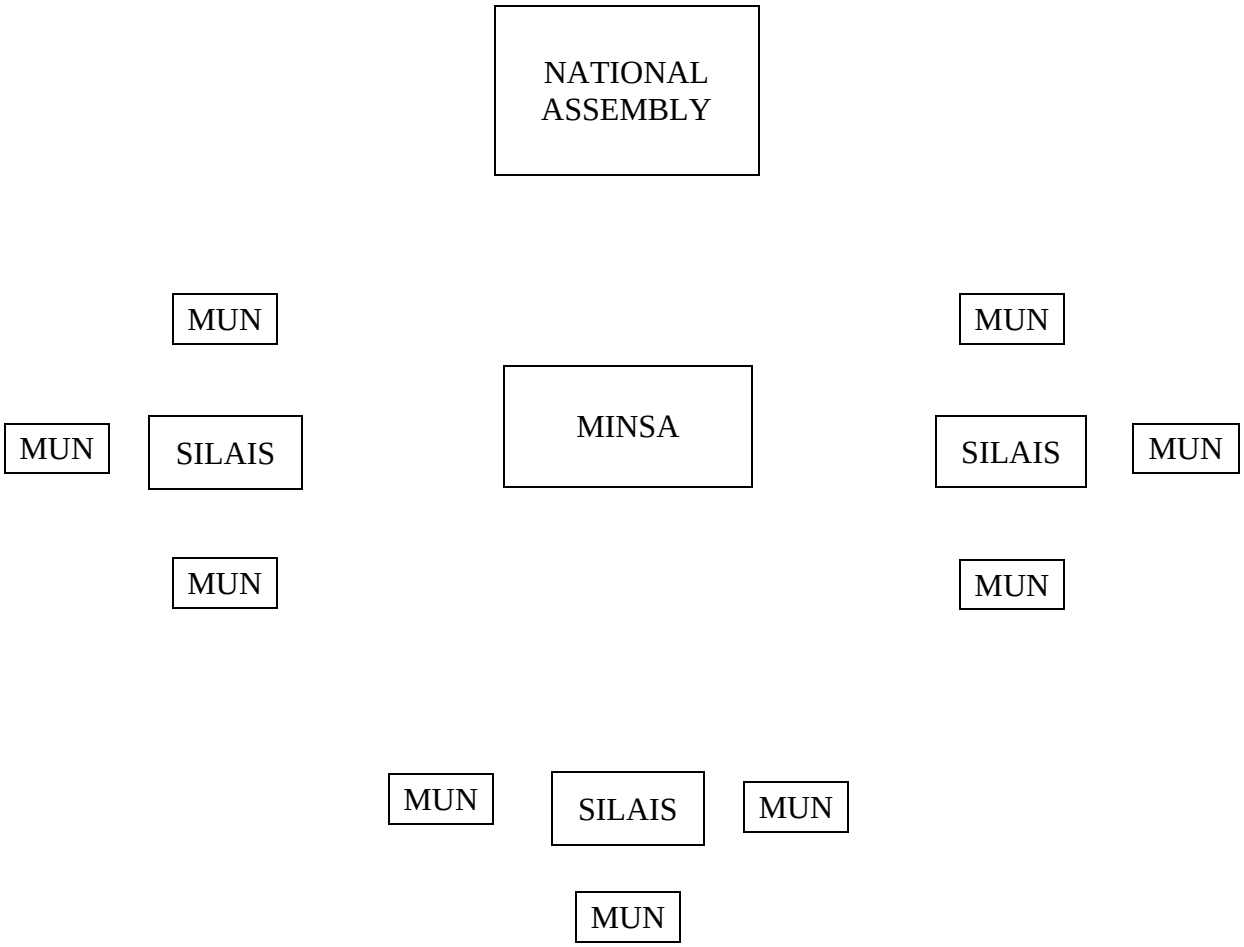
Appendix 1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