

SPATIAL ANALYSIS OF DENGUE CASES IN GUADALUPE,
NUEVO LEON, MEXICO 1995-96.

Roberto Mercado H., Ildefonso Fernandez S., and Saul Lozano F.
Facultad de Ciencias Biologicas
Universidad Autonoma de Nuevo Leon, Mexico.

ABSTRACT

The spatial and temporal distributions of dengue fever cases in Guadalupe, Nuevo Leon, Mexico, were analyzed using a geographic information system (GIS). Data were obtained from the Secretary of Health of Nuevo Leon and mapped for the Municipality of Guadalupe, NL, using CARTALINX and IDRISI programs. Confirmed cases of dengue (689) occurred mostly during October (42.3%) and November (43.9%). More females (59.1%) were infected than males. Individuals 21 to 30 years of age had the highest prevalence (25.3%). Dengue cases were ranked at 5 levels: 1= 1-2 cases; 2= 3-5; 3= 6-7; 4= 8-9, and 5 \geq 9, and then mapped. The spatial distribution of 545 cases was concentrated in the southern part of city in 1995 and in the south/central part in October 1996. However, in November the concentration was in the west central region of the city. Factors like human population densities and failure of basic sanitary services contributed to the incidences and distribution of dengue cases in Guadalupe.

INTRODUCTION

The most recent outbreaks of dengue in Bangkok and Puerto Rico, usually vectored by *Aedes aegypti* (L.), indicate that infection rates are higher in young children and women than in adult males (Halstead et al. 1969, Morens et al. 1986). Similarly, children of school age in Puerto Rico showed higher attack rates by mosquitoes than other populations (Rodriguez-Figueroa et al. 1995). In 1996, a record high number of classic dengue cases occurred in Nuevo Leon. In the municipality of Guadalupe, NL, in 1995, 545 cases were officially registered. It is one of the municipalities of the state with a high incidence of dengue (SSA 1997).

The use of geographical information systems (GIS) and remote sensors have been shown to be quick and exact methods in the acquisition of data for the control of mosquitoes in two counties of Michigan (Wagner et al. 1979, Washino and Wood 1994). The satellites LANSAT 1 and 2 were used to detect the larval habitats of mosquitoes (Hayes et al. 1985). Riley (1989) presented a revision of the use of remote sensors in entomology; see also Hugh-Jones (1989) on the application of remote sensors in the study of vector transmitted illnesses.

In Israel, distances between population centers and breeding sites of species of *Anopheles* (Kitron et al. 1994) were calculated to propose systems of surveillance based on GIS. The characterization of the composition of the landscape was evaluated for the exposure risk to Lyme disease in 337 residential properties (Dister et al. 1997). They found significant association with the vegetation and areas with water. Kitron and

Kazmiecak (1997) compared surveillance measures for cases of Lyme disease in Wisconsin and their association with vegetation; they generated maps of the counties with high risk for the transmission of this disease. Becker et al. (1998) evaluated the geographical epidemiology of 7,330 cases of gonorrhea in Baltimore, Maryland, during 1994 cases were ranked in quartiles and analyzed by means of GIS. Cases of dengue (8,689) were studied in the municipality of Florida, Puerto Rico. Using GIS, Morrison et al. (1998) determined the distance among cases in intervals of time of 0-10, 11-20 and 21-30 days. They found that more than 80% of the pairs of neighbors' cases were within 500 m of one another.

Advances in the GIS technology provide new opportunities for epidemiologists to study associations among exposures in the spatial distributions of illnesses (Vine et al. 1997). Kitron (1998) reviewed the GIS, global positions, remote sensors and statistical space, and tools to analyze and to integrate spatial components in the epidemiology of illnesses transmitted by vectors. Kitron suggested surveillance and control programs based on approaches to the ecological landscape. The purpose of this study was to determine the spatial and temporal distributions of dengue fever cases in Guadalupe, Nuevo Leon, Mexico, during 1995-96 using GIS.

MATERIALS AND METHODS

This survey was conducted in the municipality of Guadalupe, Nuevo Leon, Mexico, to the east of the metropolitan area of Monterrey, population four million, with a surface area of 118,737 km² at 25° 37' 20" to 25° 44' 7" north latitude and 100° 12' 58" to 100° 16' 29" west longitude (2834190 and 2846303 N and 372051 and 386674 W in UTM). It is the second largest city in size after Monterrey in Nuevo Leon, Mexico, with 618,933 inhabitants. This corresponds to 17.4% of the state's population (INEGI 1995) with 29.34% of this population being over 12 years of age.

Data were provided by the Central Laboratory of the Secretary of Health of the state. The data bases for the cases included years, age and sex. Cases were defined at five levels: 1-2 cases=1, 3-5=2, 5-7=3, 8-9=4, and > 9=5.

Map bases were digitized using aerial photographs with CARTALINX and taken as polygons in the geostatistics basic areas (AGEB's); ID's of polygons were assigned. The data of the dengue cases that corresponded to the months of October and November of every year were added. These maps were exported to IDRISI.

RESULTS

Of the 689 dengue cases recorded in this study, 545 were reported during 1995 and 144 were reported in 1996. Women were more affected (59.1%) than men (40.9%); the ratio of infected women/men was 1.39 and 1.67 in 1995 and 1996, respectively.

Cases of dengue were tabulated according to the year and month in which they were reported (Table 1). The months of highest dengue incidences were October and November (43.9% in both genders), corresponding with the autumn period following highest rainfalls. During the two years included in the study, only ten cases were reported during the first six months of each year; therefore, they were not considered. In July and August, there were five (0.8%) reported cases. In September, after the July-August rains, 53 (7.7%) cases were recorded, and finally the number of cases dropped to 25 (3.7%) in December. The minimum age of an infected individual was one year, while the maximum

ages were 78 and 82 years for women and men, respectively. The corresponding averages were 26.1 years for women and 32.3 years for men.

TABLE 1. Cases of Dengue Reported by Month and Year of Occurrence in 1995 and 1996 in the Municipality of Guadalupe, NL, Mexico.

Month	1995	1996	Total	(%)
Jul.	0	1	1	(0.2)
Aug.	0	4	4	(0.6)
Sep.	23	30	53	(7.7)
Oct.	248	55	303	(43.9)
Nov.	255	48	303	(43.9)
Dec.	19	6	25	(3.7)
Total	545	144	689	(100)

Cases presented by year, sex and patient age interval are given in Table 2. The greatest density of infections (25.3%) was at 21-30 years of age. It is important to note here that at ages up to 10 years, 59 and 55 cases were presented for females and males, respectively, while there were 58 female and 30 male cases for 50 year-old adults and older.

TABLE 2. Numbers of Cases of Dengue Classified by Year, Sex and Age Intervals, for the Municipality of Guadalupe, NL, Mexico.

Year	Sex	Age interval								Total	(%)
		1-10	11-20	21-30	31-40	41-50	51-60	61-70	>70		
1995	W	48	47	79	52	45	31	13	2	317	46.0%
	M	46	42	58	26	30	15	7	4	228	33.1%
1996	W	11	16	18	16	17	5	6	1	90	13.1%
	M	9	9	19	8	5	3	0	1	54	8%
Total	W	59	63	97	68	62	36	19	3	407	59.1%
	M	55	51	77	34	35	18	7	5	282	40.9%

In Fig. 3, the spatial distribution of the cases of dengue is presented for October (a) and November (b) of 1995 as well as for October (c) and November (d) of 1996. The five levels correspond to 1=1-2 cases, 2=3-5, 3=6-7, 4=8-9 and 5= >9 cases per polygon.

The level one polygon for the most part was randomly distributed over the whole municipality; nevertheless, the greatest density of cases was located in the south of the city. A greater distribution of the polygons was observed with levels 4 and 5 toward the south and southwest during 1995 and toward the center in 1996.

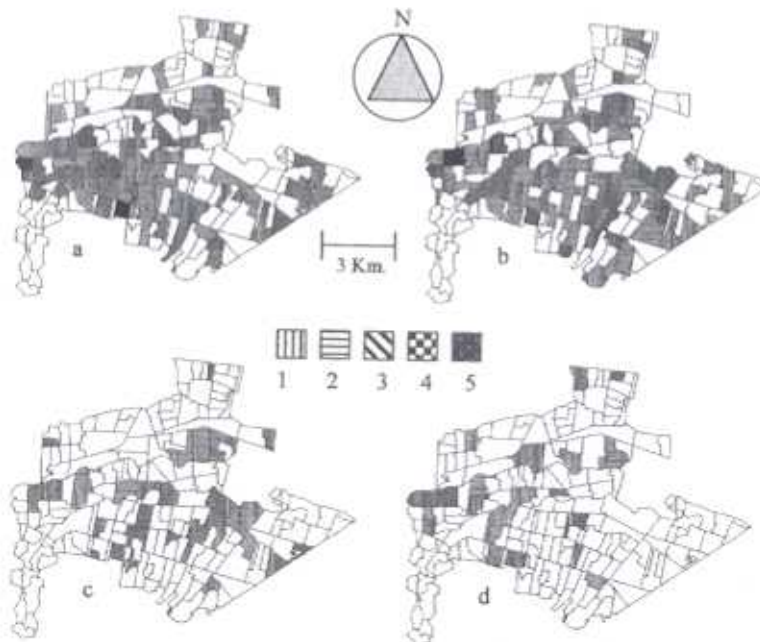


FIG. 3. Spatial distribution of the cases of dengue during a) October, b) November of 1995 and c) October, d) November of 1996 in the municipality of Guadalupe, N. L., Mexico. (Categories: 1=1-2, 2=3-5, 3=6-7, 4=8-9 and 5 \geq 9 cases)

DISCUSSION

In northeastern Mexico, the months of higher temperatures are July and August, and those with more rain are August and September. In the current study, October and November were the months of higher dengue incidence in the state of Nuevo Leon, agreeing with data published by Ram-Shobha et al. (1998) for the dengue outbreak in India. Months of the year with higher rainfall and temperatures may trigger conditions for larval habitats, increasing in towns where water is stored (Gubler and Trent 1994). The higher temperatures may produce small females that are forced to take increased numbers of blood meals and therefore are contributing with higher vector bite frequency (Focks et al., 1995).

Age and sex are two factors that influence infection rates in humans. It was found that 59.1% of the total dengue cases were reported in women, and this agrees with studies by Halstead et al. (1969) and Morens et al. (1986). However, 7.9% of cases occurred in

10 years-old girls, which does not agree with data published by Rodriguez-Figueroa et al. (1995) who established that children of school-age presented higher rates of attack by mosquitoes than other groups. Of the total cases, 12.1% were reported for people older than 50 years of age. Most cases by age group were in the 21-30 years-old bracket, with 25.1% of infections in Guadalupe occurring in this age group.

A total of 183 polygons were drawn in the Municipality of Guadalupe, Nuevo Leon, and they agree with the basic geographical units used by the National Institute of Geography and Statistics of Mexico for the handling of demographic data.

The most populated area in the municipality is in the south, where the neighborhoods are relatively new, and some lack appropriate sanitary services. Also people store water in barrels used by *Ae. aegypti* as breeding sites and this agrees with results of Gubler (1994), as far as environmental factors that lead to universal incidences of dengue transmission.

The map bases, generated by the digitalization of the polygons, were exported to the package IDRISI for their spatial analyses. Most of the cases found in 1995 were distributed spatially toward the south and the west of the municipality (Fig. 3). The polygons in the southern part of the city, where there are recently formed neighborhoods, were at the city limits. To the west, there are neighborhoods with businesses and industries near the long-established colonies of Monterrey, Nuevo Leon, that have well-kept neighborhoods.

The spatial distribution of the dengue cases in 1996 (Fig. 3) changed from the south-central part of the city in October to west-central in November, and these two months had the highest dengue incidences in both years of this study. The linear TREND analysis indicates a clear tendency toward the southern portion of the municipality in October and November of 1995, while in 1996, the trend was toward the central part of the city.

In conclusion, GIS is a tool which can be used to efficiently and effectively determine the spatial distribution of dengue cases and to produce risk maps for this disease. Concentrating efforts on those areas demonstrated to be at high risk can effect economies.

ACKNOWLEDGMENT

We thank the Central Laboratory of the Secretary of Health of the state of Nuevo Leon.

REFERENCES

- Becker, K., E. G. Gretory, E. B. Wayne, and J. M. Zenilman. 1998. Geographic epidemiology of gonorrhea in Baltimore, Maryland, using a geographic information system. *Amer. J. Epid.* 147: 709-716.
- Dister, S., D. Fish, S. Bros, D. Frank, and B. Wood. 1997. Landscape characterization of peridomestic risk for Lyme disease using satellite imagery. *Amer. J. Trop. Med. Hyg.* 57:687-692.
- Focks, D., E. Daniels, D. G. Haile, and J. E. Keesling. 1995. A simulation model of the epidemiology of urban dengue fever: Literature analysis, model development, preliminary validation and examples of simulation results. *Amer. J. Trop. Med. Hyg.* 53: 489-506.

- Gubler, D. J., and D. W. Trent. 1994. Emergence of epidemic dengue/dengue hemorrhagic fever as a public health problem in the Americas. *Infect. Agents Dis.* 2:383-393.
- Halstead, S.B., J. E. Scanlon, P. Umpaivit, and S. Udomsakdi. 1969. Dengue and chikungunya virus infection in man in Thailand, 1962-1964. IV. Epidemiologic studies in the Bangkok metropolitan area. *Amer. J. Trop. Med. Hyg.* 18: 997-1021.
- Hayes, R.O., E. L. Maxwell, C. J. Mitchel, and T. L. Woodzick. 1985. Detection, identification and classification of mosquito larval habitats using remote sensing scanners in earth-orbiting satellites. *Bull. WHO.* 63: 361-374.
- Hugh-Jones, M. 1989. Applications of remote sensing to the identification of the habitats of parasites and disease vectors. *Parasit. Today* 5: 244-251.
- Instituto Nacional de Estadística Geografía e Informática (INEGI, 1995). Dirección Regional del Noreste. Monterrey, NL.
- Kitron, U. 1998. Landscape ecology and epidemiology of vector-borne disease: Tools for spatial analysis. *J. Med. Entomol.* 35: 435-445.
- Kitron, U., and J. J. Kazmierczak. 1997. Spatial analysis of the distribution of Lyme disease in Wisconsin. *Amer. J. Epidemiol.* 145: 558-566.
- Kitron, U., H. P. Pener, C. Costin, L. Orshan, Z. Greenber, and U. Shalom. 1994. Geographic information system in malaria surveillance: Mosquito breeding and imported cases in Israel, 1992. *Amer. J. Trop. Med. Hyg.* 50: 550-556.
- Morens, D. M., J. G. Rigau-Perez, R. H. Lopez-Correa, C. G. Moore, E. E. Ruiz-Tiben, G. E. Salther, J. Chiriboga, D. A. Eliason, A. Casta-Velez, J. P. Woodall, and Dengue Outbreak Investigation Group. 1986. Dengue in Puerto Rico, 1977: Public Health response to characterize and control an epidemic of multiple serotypes. *Amer. J. Trop. Med. Hyg.* 35: 197-211.
- Morrison, A. C., A. Getis, M. Santiago, J. G. Rigau-Perez, and P. Reiter. 1998. Exploratory space-time analysis of reported dengue cases during an outbreak in Florida, Puerto Rico, 1991-1992. *Amer. J. Trop. Med. Hyg.* 58: 287-298.
- Ram Soba, D. 1998. Incidence of dengue fever in relation to climatic factors in Ludhiana, Punjab. *Indian J. Med. Res.* 108:128-33.
- Riley, J.R. 1989. Remote sensing in entomology. *Ann. Rev. Entomol.* 34:247-271.
- Rodriguez-Figueroa, L., J. G. Rigau-Perez, E. L. Suarez, and P. Reiter. 1995. Risk factors for dengue infection during an outbreak in Yanes, Puerto Rico in 1991. *Amer. J. Trop. Med. Hyg.* 52: 496-505.
- Secretaría de Salud y Asistencia (SSA). 1997. Sistema Nacional de Vigilancia Epidemiológica. 26: 8.
- Vine, M. F., D. Degnan, and C. Hanchette. 1997. Geographic information systems: their in environmental epidemiology research. *Environ. Health Perspectives.* 105: 598-605.
- Wagner V.E., R. Hill-Rowley, S. A. Narlok, and H. D. Newson. 1979. Remote sensing: A rapid and accurate method of data acquisition for a newly formed mosquito control district. *Mosquito News.* 39: 2283-287.
- Washino R. K., and B. L. Wood. 1994. Application of remote sensing to arthropod vector surveillance and control. *Amer. J. Trop. Med. Hyg.* 50: 134-144.