Epidemiological Impact of Climatic Variation on Malaria Dynamics in a Northeastern Region of Venezuela

Laura Delgado[1], Karenia Cordova[2], Alfonso J. Rodriguez[3]

[1]Laboratory SIMEA, Tropical Zoology Institute, Faculty of Sciences and [2]Geography and Regional Development Institute, Faculty of Humanities, Central University of Venezuela (UCV), Caracas, DM, Venezuela, [3]Coordination of Environmental Sanitary Epidemiological Vigilance, General Direction of Environmental Health and Sanitary Control, Ministry of Health and Social Development (DGSACS-MSDS), Maracay, Aragua and Carúpano, Sucre, Venezuela.

E-mails: [1] laurind1@yahoo.com, [2] kareniac@cantv.net, [3] arodriguezm@saludfmv.org

ABSTRACT

Background: Malaria is a tropical infectious disease related to a complex group of biological, social and ecological factors with a wide-range of variation according to time and space. Recently, research has focused on the entomological as well as the epidemiological impact of climatic variation on malaria dynamics. For these reasons a non-conventional epidemiological study was created to evaluate the impact of climatic variation on malaria dynamics in a northeastern region of Venezuela (Sucre State, 1986-2000). The etiological agent of malaria in this region is *Plasmodium vivax*.

Methods: Malaria case records were retrieved for an epidemiological study for 15 years and this was correlated to climatic variation according to NOAA records for Venezuela in the same period to determine if climatic variation has a real impact on malaria dynamics.

Results: For a studied period 64,803 cases of malaria were reported (annual mean: 1,117±951 cases) with five relevant peaks (1988 [1,512 cases], 1990 [2,071 cases], 1991 [4,165 cases], 1997 [3,513 cases] and 2000 [5,011 cases]). We found a significant correlation (r^2>0.50, P<0.05) between the increase of malaria cases and La Nina phenomena (defined for Venezuela as a cold and wet period) in some years of the studied period. Those years with non-significant correlation between malaria and weather were explained by socio-economical and political factors (failure in control policies, people mobilization as well fails in treatment).

Discussion: Changes in climatic patterns certainly impact on biology and ecology of malaria vector in Sucre State (*Anopheles aquasalis*), explained in part in life cycle shortening due to temperature, precipitation and wet (water stage), as well as better life expectancy (earth stage) (adult phase). Then, vector population increases and this jointly with other biological and social factors prone to malaria cases increase, which was clearly observed in the present report.

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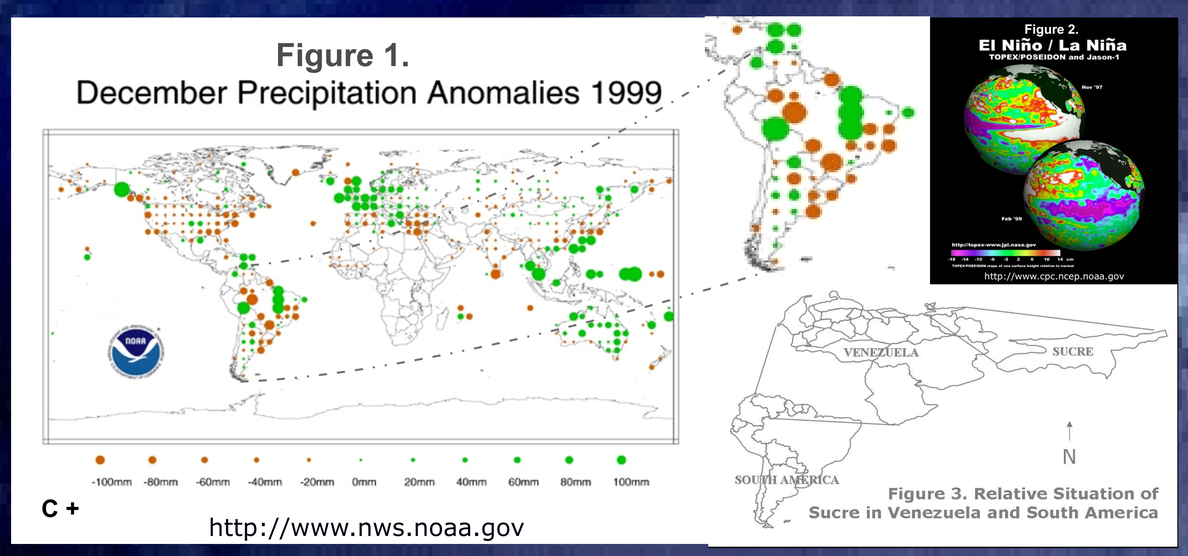
INTRODUCTION

Climatic Variability and Change

Oscillation on climatic variables around its means (predominant conditions during a given period) is known as **climatic variability**. This is presented in different time scales (intra-seasonal, seasonal, inter-annual and inter-decade) and is ubicated inside oscillations of high frequency at climatic variability scales.

Alterations on means are known as **climatic changes** and represented change in predominant conditions; this is presented as oscillations of low frequency of weather (long last cycles: centuries, millenium, hundred thousand years). (D. Pabón. Departamento de Geografía, Universidad Nacional de Colombia, 2002)

There are well-established weather phenomena associated with the variability: ENSO, PDO, NAO, etc.



Climatic Variability and its Impact on Public Health

Climatic variability impact two important patterns:

- Precipitation or rainfall (as seen in 1999 december precipitation anomalies, Figure 1).
- Temperature (as seen in year 1999, Figure 2).

These pattern alterations are linked directly to vector-borne diseases increase.

Importance of climatic variability and Epidemiology of Malaria

Malaria is a tropical infectious disease related to a complex group of biological, social and ecological factors with a wide-range of variation according to time and space. Recently, research has focused on the entomological as well as the epidemiological impact of climatic variation on malaria dynamics.

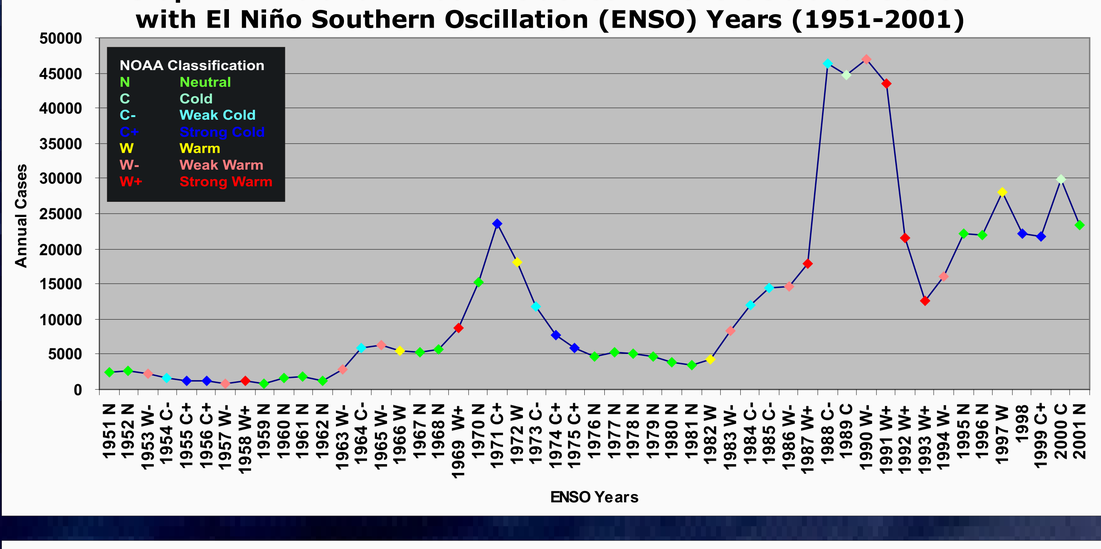
Biology of vector, life cycle and ecology of disease is significantly impacted by climatic variation, although epidemiological impact of these variations has been not studied exhaustively in Venezuela.

For these reasons a non-conventional epidemiological study was created to evaluate the impact of climatic variation on malaria dynamics in a northeastern region of Venezuela (Sucre State, 1986-2000). The etiological agent of malaria in this region is *Plasmodium vivax* and its vector *Anopheles aquasalis*. Venezuela has had a large history of malaria outbreaks in the last 50 years (Graphic 1).

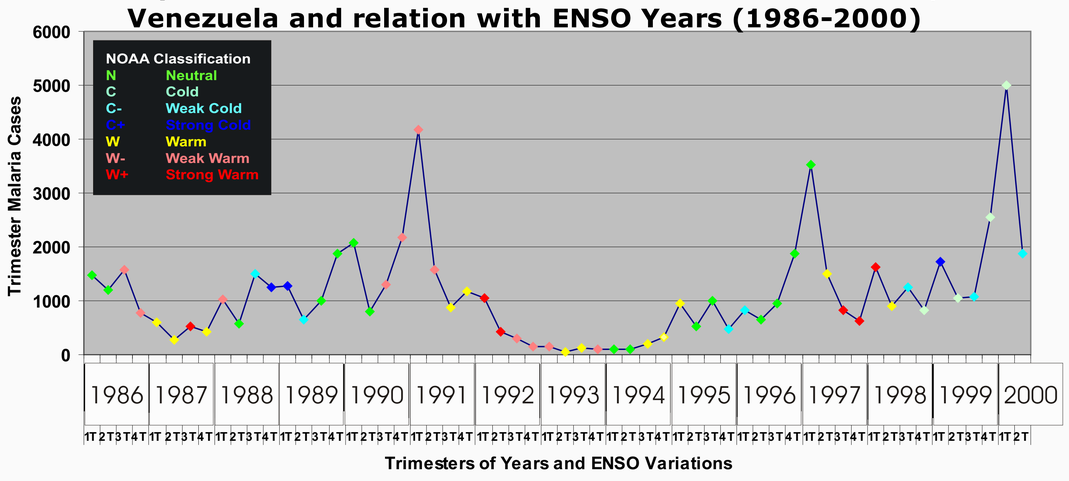
METHODS

Malaria case records were retrieved for an epidemiological study for 15 years (1986-2000) in Sucre State, Venezuela, and this was correlated (r^2) to climatic variation according to NOAA (National Oceanic and Atmospheric Administration, US) records for Venezuela in the same period to determine if climatic variation has a real impact on malaria epidemiology dynamics.

Graphic 1. Malaria Annual Incidence in Venezuela and relation with El Niño Southern Oscillation (ENSO) Years (1951-2001)



Graphic 2. Trimester Incidence of Malaria in Sucre State, Venezuela and relation with ENSO Years (1986-2000)

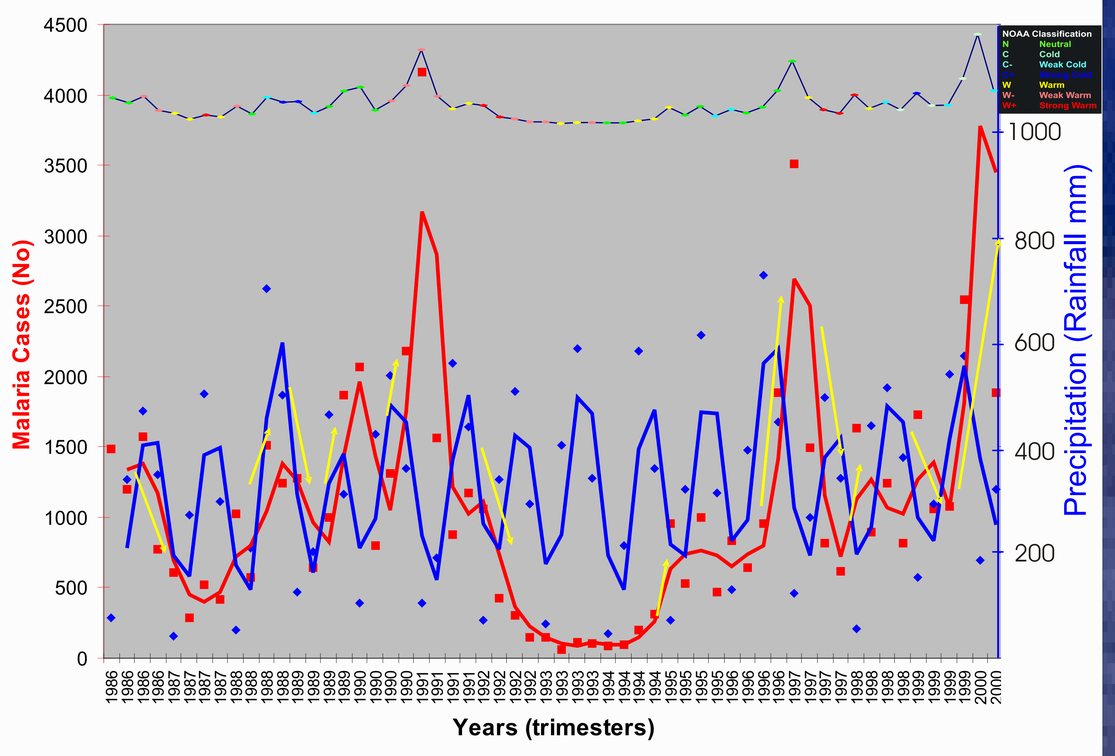


NOAA Classification: Cold & Warm Episodes by Season. http:// www.nws.noaa.gov

RESULTS

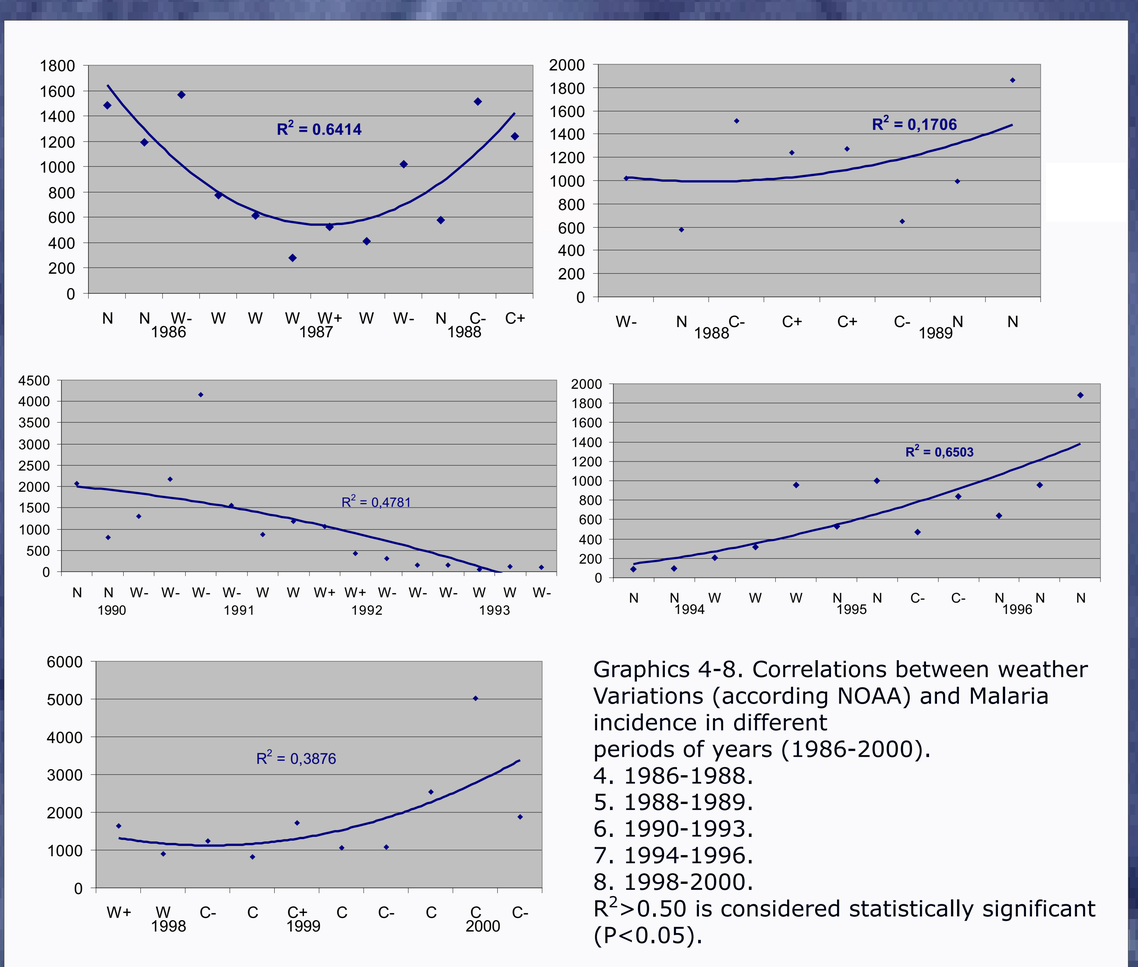
For a studied period 64,803 cases of malaria were reported (annual mean: 1,117±951 cases) with five relevant peaks (1988 [1,512 cases], 1990 [2,071 cases], 1991 [4,165 cases], 1997 [3,513 cases] and 2000 [5,011 cases]) (Graphic 2). We found a significant correlation (r^2>0.50, P<0.05) between the increase of malaria cases and La Nina phenomena (defined for Venezuela as a cold and wet period) in some years of the studied period (Graphic 4-8). Those years with non-significant correlation between malaria and weather were explained by socio-economical and political factors (failure in control policies, people mobilization as well fails in treatment).

Graphic 3. Relation between Malaria dynamics and weather variations, Sucre State, Venezuela, 1986-2000.



Legend:
Upper line: ENSO Weather Variations
Red line: Malaria cases by trimester/year incidence
Blue line: Precipitation (rainfall) by trimester/year
Yellow arrows: Possible connections between malaria incidence and rainfall

NOAA Classification: Cold & Warm Episodes by Season - http://www.nws.noaa.gov



Graphics 4-8. Correlations between weather Variations (according NOAA) and Malaria incidence in different periods of years (1986-2000).
4. 1986-1988.
5. 1988-1989.
6. 1990-1993.
7. 1994-1996.
8. 1998-2000.

R^2>0.50 is considered statistically significant (P<0.05).

DISCUSSION

We found significant correlations between malaria incidence and weather variations in this series, for some bi- and tri-annual periods. Certainly, ecological factors are predominant in some years in relation with predispose conditions for vector development, especially in an area with many ecological conditions appropriated for *Anopheles* life cycle.

In the periods 1986-1988 and 1984-1996 we observed a strong relation between malaria incidence and weather variations (predominant factor).

Periods 1988-1989, 1990-1993 and 1998-2000 showed a trend (non significant) indicating importance of other factors.

Changes in climatic patterns certainly impact on biology and ecology of malaria vector in Sucre State (*Anopeheles aquasalis*), explained in part in life cycle shortening due to temperature, precipitation and wet (water stage), as well as better life expectancy (earth stage) (adult phase). Then, vector population increases and this jointly with other biological and social factors prone to malaria cases increase, which was clearly observed in the present report.

REFERENCES

1. Kovats RS *et al*. El Nino and health. Lance 2003;362:1481-9.
2. Singh N. Sharma VP. Patterns of rainfall and malaria in Madhyia Pradesh, central India. Ann Trop Med Parasitol 2002;96:349-59.
3. Gagnon AS *et al*. The El Niño southern oscillation and malaria epidemics in South America. Int J Biometeorol 2002;46:81-9.
4. Poveda G *et al*. Coupling between annual and ENSO timescales in the malaria-climate association in Colombia. Environ Health Perspect 2001;109:489-93.
5. Kovats RS. El Niño and human health. Bull World Health Organ 2000;78:1127-35.
6. El Niño and associated outbreaks of severe malaria in highland populations in Irian Jaya, Indonesia: a review and epidemiological perspective. Southeast Asian J Trop Med Public Health 1999;30:608-19.
7. Lindsay SW *et al*. Effect 1998-98 El Niño on highland malaria in Tanzania. Lancet 2000;18:989-90.
8. Lindblade KA *et al*. Highland malaria in Uganda: prospective analysis of an epidemic associated with El Niño. Trans R Soc Trop Med Hyg 1999;93:480-7.
9. Kilian AH *et al*. Rainfall pattern, El Niño and Malaria in Uganda. Trans R Soc Trop Med Hyg 1999;93:22-3.
10. Patz JA *et al*. Prediction key malaria transmission factors, biting and entomological inoculation rates, using modelled soil moisture in Kenya. Trop Med Int Health 1998;3:818-27.
11. El Niño and its impact on health. Epidemiol Bull 1998;19:9-13.
12. Bouma MJ *et al*. Predicting high-risk years for malaria in Colombia using parameters of El Niño Southern Oscillation. Trop Med Int Health 1997;2:1122-7.
13. Bouma MJ, Dye C. Cycles of malaria associated with El Niño in Venezuela. JAMA 1997;278:1772-4.
14. Bouma MJ, van der Kaay HJ. The El Niño Southern Oscillation and the historic malaria epidemics on the Indian subcontinent and Sri Lanka: an early warning system for future epidemics? Trop Med Int Health 1996;1:86-96.
15. Bouma MJ, van der Kaay HJ. Epidemic malaria in India and the El Niño southern oscillation. Lancet 1994;344:1638-9.

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