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CLIMATE CHANGE AND INFECTIOUS DISEASES: THE IMPLICATIONS OF EL NIÑO

CONTENTS

EXECUTIVE SUMMARY

El Niño is a natural phenomenon that causes anomalies in normal patterns of rainfall and temperature. Compared with other climate changes, El Niño events are notable for their wide geographic influence and the long duration of their extremes. The fact that El Niño events are extended climate events with large-scale effects makes them extremely important to the public health sector. The ability to project future El Niño events gives the public health sector the opportunity to prepare for and to better control transmission of disease.

At present, there are no concrete data that demonstrate that an increase or decrease in infectious diseases is consistently and reliably related to El Niño events. However, some associations from retrospective studies and preliminary data from ongoing studies suggest that El Niño events have an impact on the incidence of certain infectious diseases. The consequence of El Niño's impact on disease transmission should be considered within the context of disease ecology (epidemiological endemic levels, existing vector reservoirs, hostparasite interactions, etc.), the severity of the El Niño event, other climatic influences, and social change. The relationship between El Niño and health is complex.

For example, waterborne diseases such as leptospirosis and diarrheal infections increase during heavy rains. Thus, to the extent that an El Niño event causes heavy rains, El Niño may increase the risk of waterborne diseases. However, extreme weather events can also occur in non-El Niño years and cause outbreaks of infectious diseases, such as the outbreak of leptospirosis in Nicaragua in 1995. Alternately, some effects of El Niño may be beneficial. In 1997, the malaria incidences in Iquitos, Peru, and in Boa Vista, Brazil, decreased during an El Niño-related drought.

There is a need to develop a scientific agenda that will examine the impact of extreme events such as El NiñoSouthern Oscillation (ENSO) on human and animal health. Attention should be paid to the vulnerability of ecosystems to ENSO, how disease incidence will respond to extreme climatic events, and how health programs will adjust to climate-induced changes in morbidity and mortality.

One must look at the health impacts of ENSO from the historical contexts of disease transmission and understand the ongoing processes of change. An eco-epidemiological approach to disease prevention and control will be crucial as we continue to learn more about ENSO, anthropogenic-induced climate changes and their health impacts. PAHO will continue to monitor climate changes and infectious disease occurrences in order to identify potential risks and propose control activities.

1. Introduction

The 40th Directing Council of the Pan American Health Organization (1997) adopted Resolution CD40.R13, "Health Emergency Preparedness for Disasters Caused by El Niño," in which it resolves:

> 1.To urge countries affected by "El Niño" that have not already done so to update their contingency plans to provide an adequate response to the health problems arising from this phenomenon.
>
> 2.To request the Member States to:
>
> (a) take the necessary steps to develop effective coordination among sectors and mutual cooperation among countries in the spirit of regional integration;
>
> (b) strengthen and integrate their systems for early warning, epidemiological surveillance, and the control of communicable diseases, particularly water-borne and vector-borne diseases, and disseminate this information freely through the Internet and other modern means of communication.
>
> 3.To request the Director to:
>
> (a) strengthen technical cooperation with the Member States for emergency preparedness to enable them to deal with any emergency or disaster caused by "El Niño,“ coordinating actions in the health sector with subregional institutions such as the Hipólito Unanúe Agreement and with other multisectoral institutions;
>
> (b) ensure that the priorities of this cooperation are focused on analyzing epidemiological risk, coordinating the preparation of contingency plans, integrating responses among the countries, exchanging information for decision-making and public awareness, and training both medical and public health personnel.

There is growing concern that climate change will have broad and long-term impacts on health. Various scenarios and models have been used to project what would happen in the future if global warming continues and anthropogenic changes in the landscape increase. It is generally concluded that climate warming will greatly disrupt natural systems and increase environmental health risks (*7*). The long-term impacts on health could be drastic and irreversible.

Examples of observed climate changes include an increase in global temperatures ranging from 0.3° C to 0.6° C, a diurnal temperature range decrease, the global retreat of major glaciers, and an increase or decrease in precipitation in certain regions of the world (*8*).
The impacts of human-induced climate changes are presently being studied and debated by many scientific and health professionals. There are also naturally induced changes in atmospheric and oceanic circulation patterns caused by El Niño and the Southern Oscillation. Since 1976 these shifts have shown a bias toward warmer climatic events. It is projected that there could be an increase in the severity of El Niño events in the future.

Public interest and concern over El Niño is increasing. Traditionally, meteorological changes and environmental impacts of the phenomenon have been the focus of ENSO-related press. Since the severe ENSO event of 1982-1983, major social and economic consequences have been reported as additional effects of the phenomenon. Table 1 reflects significant concern following the ENSO event of 1982-1983.

Table 1. Effects of the 1982-1983 ENSO (in US$)

Location	Anomaly	Major Social Impacts	Costs
U.S. Mountain and Pacific States	Storms	45 dead	$1.1 billion
U.S. Gulf States	Flooding	50 dead	$1.1 billion
Hawaii	Hurricane	1 dead	$230 million
Northeastern United States	Storms	66 dead	NA
Cuba	Flooding	15 dead	$170 million
Mexico and Central America	Drought	NA	$600 million
Ecuador and Northern Peru	Flooding	600 dead	$650 million
Southern Peru and Western Bolivia	Drought	NA	$240 million
Southern Brazil, Northern Argentina, and Eastern Paraguay	Flooding	170 dead	$3 billion
Bolivia	Flooding	50 dead	$300 million
Tahiti	Hurricane	1 dead	$50 million
Australia	Drought, Fires	71 dead, 8000 homeless	$2.5 billion
Indonesia	Drought	340 dead	$500 million
Philippines	Drought	NA	$450 million
Southern China	Wet weather	600 dead	$600 million
Southern India and Sri Lanka	Drought	NA	$150 million
Middle East, chiefly Lebanon	Cold, snow	65 dead	$50 million
Southern Africa	Drought	Disease, starvation	$1 billion
Iberian Peninsula and Northern Africa	Drought	NA	$200 million
Western Europe	Flooding	25 dead	$200 million

Source: New York Times, 2 August 1983

As El Niño continues to receive greater attention, public demand for understanding it grows. El Niño is second only to seasonal changes in its impact on world climate. This paper reviews what is known about El Niño and health, explores the health impact of El Niño and the Southern Oscillation, and then discusses the steps PAHO can take to assist Member States as they confront the problems of changing climate and El Niño.

1.1 *El Niño and the Southern Oscillation*

In the 1920s, Sir Gilbert Walker observed a “seesaw” relationship among barometric pressures in the southern Pacific Ocean—when the pressure was high in the western Pacific, it was low in the eastern Pacific, and vice versa, causing dramatic shifts in surface wind direction and velocity. He named the occurrence the Southern Oscillation. Later, as other scientists learned more about wind patterns and ocean temperatures in that region, they were able to link Walker’s pressure seesaw with the periodic strong, warm ocean current along the coasts of Peru and Ecuador known as El Niño. More importantly, they discovered that El Niño and the Southern Oscillation—collectively known as ENSO—were a weather phenomenon responsible for monsoon rains, droughts, and other climatic changes across much of the globe, including the equatorial Pacific, the United States, Canada, Latin America, and Africa.

During an El Niño event, rain falls in the eastern Pacific while the western Pacific is dry. Normally, monsoons occur in the western Pacific while the eastern Pacific is dry. Unlike annual weather patterns, which are predictable, El Niño events reoccur at irregular intervals every 2-7 years and are never the same (Table 2). They typically begin around Christmas and last 12-18 months. The most severe ENSO event recorded was in 1982-1983. Since then another occurred in 1986-1987 and there was an extended ENSO event from 1990-1995. We are presently undergoing an ENSO event that is expected to last into 1998.

The sister of El Niño, La Niña, is the cold phase of ENSO and describes the situation when there are cold eastern and central equatorial Pacific sea surface temperatures. In the western Pacific, a La Niña event increases precipitation.

1.2 *Forecasting El Niño*

There has been considerable progress in forecasting ENSO events**.** Atmosphere-ocean forecast models have been developed which can predict El Niño from four months to a year in advance. The warming of the surface of the sea in the tropical Pacific was predicted one year before the ENSO phenomenon of 1986-1987. The ability to reliably link sea surface temperature data with changing climate conditions in a variety of locations will facilitate prediction of both the occurrence and effects (flooding vs. drought) of El Niño events.

Table 2. El Niño and La Niña Years (generally from October to September)

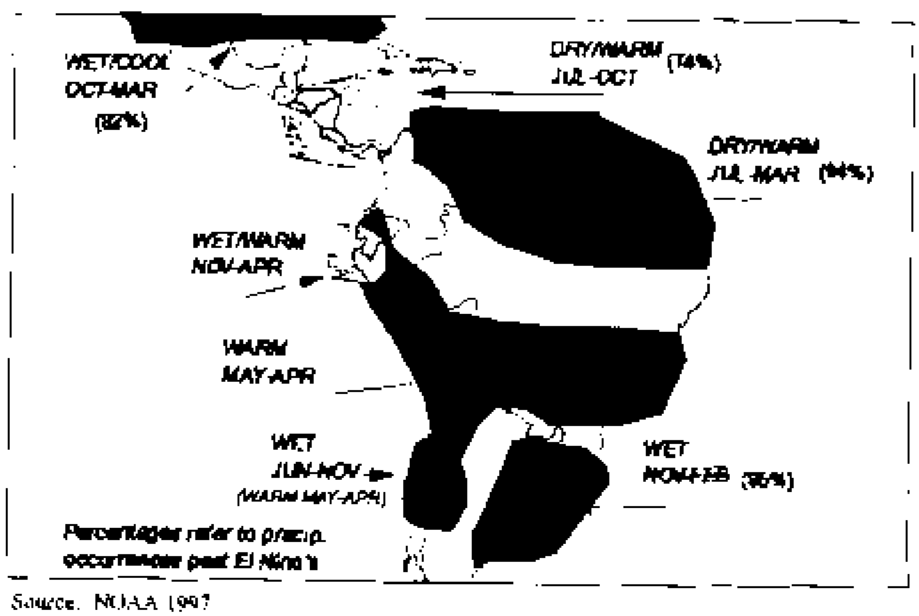
El-Niño Years	La Niña Years
1900-1901	1903-1904
1902-1903	1906-1907
1905-1906	1908-1909
1911-1912	1916-1917
1914-1915	1920-1921
1918-1919	1924-1925
1923-1924	1928-1929
1925-1926	1931-1932
1930-1931	1938-1939
1932-1933	1942-1943
1939-1940	1949-1950
1940-1941	1954-1955
1941-1942	1964-1965
1946-1947	1970-1971
1951-1952	1973-1974
1953-1954	1975-1976
1957-1958	1988-1989
1963-1964	
1965-1966	
1969-1970	
1972-1973	
1976-1977	
1982-1983	
1986-1987	
1991-1992	
1993-1994	
1995?	

At present, climate forecasts related to upcoming rainy seasons (on the pacific coast of South America) are based on the wind and water temperatures in the tropical Pacific region and the output of numerical prediction models. Four forecast possibilities exist: (1) near normal conditions; (2) a weak El Niño with slightly wetter than normal growing seasons; (3) a full-blown El Niño with flooding; or (4) cooler than normal waters offshore, with higher than normal chance of drought (*13*).

1.3 *El Niño in the Americas*

In the Americas there are several general changes in precipitation patterns associated with ENSO events (*15*). In North America there is generally greater than normal precipitation in the Gulf and northern Mexico regions from October to March (Figure 1). In the Great Basin of the United States there is greater than normal precipitation from April to October.

Figure 1. Potential Impacts of El Niño on Mexico and on Central and South America



Source: NOAA 1997

In Central America and the Caribbean, precipitation is lower than normal and the dry season will occur from July to October during an El Niño event. It is suggested that a region of ENSO-related precipitation extends from southern Mexico and Guatemala southward into Panama and eastward into the Caribbean. South America generally experiences extremes of dryness or wetness (Figure 1), depending on the region.

In the northeast region of South America (north equatorial Brazil, French Guiana, Guyana, Suriname, and Venezuela) there is less precipitation from July to March. In southeastern South America (southern Brazil, Uruguay, and parts of northeastern Argentina), there is greater than normal precipitation from November to February (Figure 1).

The Pacific coast of South America in Ecuador and Peru also has greater than normal precipitation during El Niño years.

In the Amazon region low rainfall does not coincide with ENSO events but lags one year behind (*4*). However, because there is a lack of long-term precipitation data from this region and the region has complex rainfall regimes, it is hard to construct a regional index for the entire basin (*4*). In other words, less than normal precipitation would more than likely occur, but precipitation extremes are not as highly correlated with ENSO as are other parts of South America.

The Andean region is also affected by ENSO. There is, however, insufficient information available to make generalizations. It is assumed that the impact of El Niño on precipitation extremes is less in the Andean region than in other regions.

In all regions, the specific timing and duration of the climatic effects associated with an El Niño event may vary, depending on such factors as the season of onset (e.g., the 1997 El Niño began in May-June, which is much earlier than usual). Within this overall picture El Niño exhibits different strengths and patterns in specific localities. Thus, disease patterns may vary within an El Niño-affected area.

1.4 *Infectious Disease Impacts*

ENSO events cause extremes in precipitation, temperature, and humidity and it is known that these climatic factors can be detrimental (or beneficial) to health. In Table 3, WHO has reviewed the potential impact of climate change (both anthropogenic and natural) on health (*18*). Vectorborne diseases are a major concern in the Americas and the possible impact of climate change and El Niño events has also been reviewed in 1996 by WHO (Table 4). These scenarios are based on historical events, generalized climatic models, and information on disease transmission.

Following an El Niño event, the potential risk of communicable disease is influenced not only by changes in the environment, but also by changes in population density, disruption of public utilities, and interruption of public health services. It should also be noted that the risk of communicable disease following an El Niño event is related to the endemic level of the disease in the community; therefore, little risk exists of a given disease if the causative organism is not present beforehand (*14*). This underscores the need for an effective disease surveillance program prior to an El Niño event.

The challenge for health professionals is to incorporate climate forecasting into disease surveillance, emergency preparedness, and prevention programs. El Niño events and other climate changes are seldom used in the planning or management of health programs. Furthermore, existing meteorological data is infrequently used to analyze seasonal differences in disease incidences.

Table 3. Likely Relative Impact on Health Outcomes of the Components of Climate Change

	Aspects of Climate Change			
Health outcome	Change in Mean Temperature, etc.	Extreme Events	Rate of Change of Climate Variable	Day-Night Difference
Heat-related deaths and illness		+++		+
Physical and psychological trauma due to disasters		++++		
Vectorborne diseases	+++	++	+	++
Non-vectorborne infectious diseases	+	+		
Food availability and hunger	++	+	++	
Consequences of sea level rise	++	++	+	
Respiratory effects:				
– air pollutants	+	++		+
– pollens, humidity	++			
Population displacement	++	+	+	

++++ = greatest effect; += smallest effect; blank cells indicate no known effect.
Source: WHO, 1996

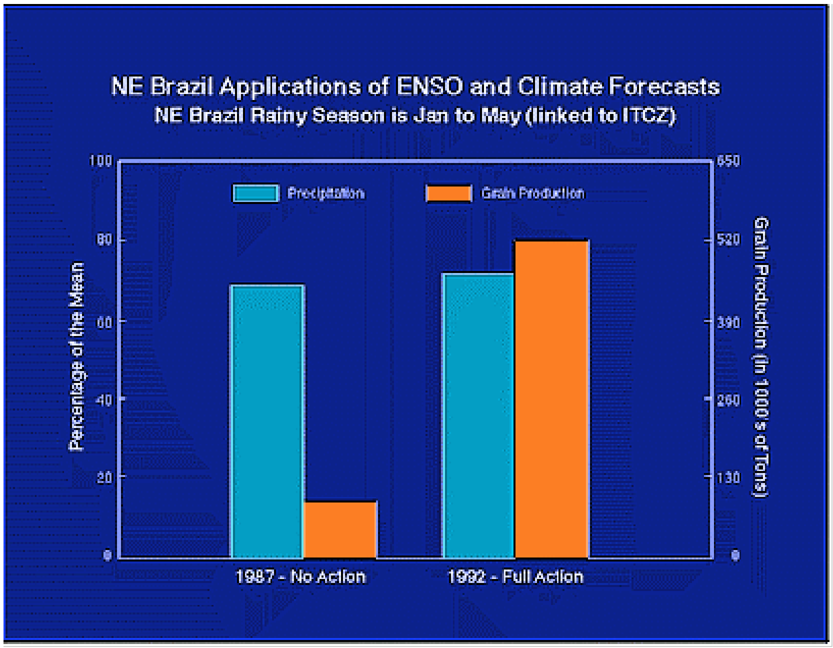
Table 4. Major Tropical Vector-Borne Diseases and the Likelihood of Change in Their Distribution as a Result of Climate Change

Disease	Vector	No. at Risk (millions)[a]	Number Infected or New Cases per Year	Present Distribution	Likelihood of Altered Distri-bution with Climate Change
Malaria	Mosquito	2400	300-500 million	Tropicssubtropics	+++
Schistosomiasis	Water snail	600	200 million	Tropicssubtropics	++
Lymphatic filariasis	Mosquito	1094	117 million	Tropicssubtropics	+
African trypanosomiasis	Tsetse fly	55	250,000-300,000 casesyear	Tropical Africa	+
Dracunculiasis	Crustacean (copepod)	100	100,000year	South AsiaMiddle East Central-West Africa	?
Leishmaniasis	Phlebotomine sandfly	350	12 million infected, 500,000 new [b]	AsiaSouth Europe Africa Americas	+
Onchocerciasis	Blackfly	123	17.5 million	AfricaLatin America	++
American trypanosomiasis	Triatomine bug	100	18-20 million	CentralSouth America	+
Dengue	Mosquito	2500	50 millionyear	Tropicsubtropics	++
Yellow fever	Mosquito	450	<5000 casesyear	Tropical South America and Africa	++

+= likely; ++= very likely; +++= highly likely; ?=unknown
[a] Top 3 entries are population-pro-rated projections, based on 1989 estimates.
[b] Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases per year.
Source: WHO, 1996

El Niño forecasting can be successfully applied to agriculture. Climate predictions are used routinely in agriculture to determine which crops to grow during an El Niño year. Figure 2 shows the value of predicting El Niño events on crop production in Brazil. In 1987, when El Niño prediction was not incorporated in crop selection in northeastern Brazil, the yield was less than 20% of normal. In 1992, when El Niño was predicted, drought-resistant crops were planted, and 80% of the normal yield was obtained.

Figure 2. Impact of El Niño Prediction on Brazil Crop Yields



Source: NOAA 1997

At present we have a general idea of where and when weather extremes caused by El Niño events will occur. Therefore, we can determine the regions of highest vulnerability and of greatest epidemic risk, and begin to incorporate climate change into existing health programs. As better predictive models become available they can be updated and should be used.

It has been argued that El Niño and climate change will influence the distribution and intensity of infectious diseases in the Americas (*2*). To date there is little definitive data, which directly links El Niño to infectious disease transmission. The consequence of El Niño's impact on disease transmission, however, has to be considered within the context of disease ecology, the degree of the El Niño event anomalies, and social change.

There is a need to develop methods of determining environmental risk indicators, which can be used in El Niño situations. The biggest drawback in projecting the impact of ENSO or other long-term climate changes on health is the lack of empirical data. Various climate scenarios are being developed using modeling and historical databases. These data are, however, insufficient. There still exists a vast amount of uncertainty concerning the true impacts of El Niño events. In order to provide the correct empirical information for modeling, multidisciplinary teams of researchers and health specialists must work together to address the complex problems associated with projecting the impact of climate change on health.

2. Disease Transmission in the Americas

To underscore the dilemma in linking El Niño events to health, data on several of the most important communicable infectious diseases in the Americas are presented below.

2.1 Malaria

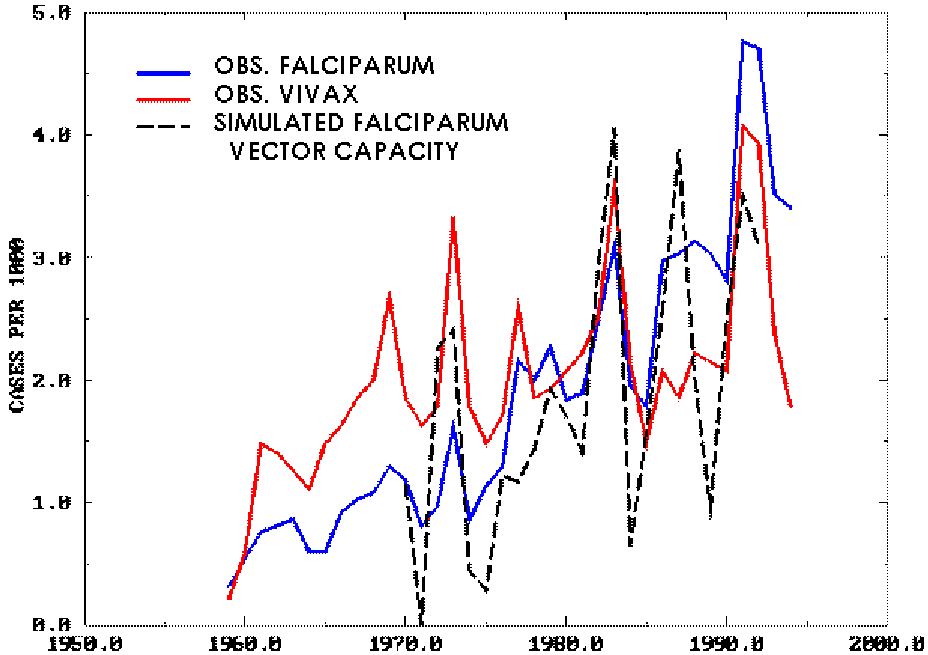
Recent studies have implied that increases in temperature, humidity, and precipitation have contributed to the increase in malaria transmission (*1*, *3*). In addition, global climate models have been used to analyze scenarios of climate change and malaria transmission (*11*). The results of these models predict a global increase in malaria.

El Niño is a component of climate change that contributes to extremes in weather conditions over short periods of time (seasonal and annual cycles). The increases in temperature and precipitation during El Niño have been suggested as the potential causes of malaria epidemics. In Colombia, it has been suggested that increases in malaria cases over the last three decades correlated with the El Niño events of 1972-1973, 1982-1983, 1986-1987, and 1992-1993 (Figure 3).

However, other malaria prevalence data from Colombia indicate that a definitive conclusion is not possible. The impact, if any, of El Niño on malaria in Colombia appears to be localized. For example, in the province of Antioquia, Colombia, the annual parasitic indices actually decreased from 1991 to 1996 during the apparently continuous ENSO 1990-1995 event (Figure 4). The contradiction in results may be due to differences in vector species andor parasites. A vector's response to changes in climate extremes is species-dependent and cannot be generalized for all species. Control measures also impact the number of malaria cases, which vary from one locality to another.

It has been reported that major epidemics of malaria occurred during the El Niño year of 1983 in Peru, Ecuador, and Bolivia (*12*). A review of the malaria data reported by each country (1970-1996 PAHO malaria reports) shows that malaria did increase in each country in 1983 (Figure 5), but the overall trend from 1970 to 1996 was an increase in the number of reported malaria cases, and in other El Niño years (1971-1972, 1976-1977, 1991-1992) malaria cases seldom increased from previous years. The increase in malaria cases in Colombia (Figure 3) occurred over the same time period throughout South America. It is known that national malaria control programs in Latin America changed from rigid eradication to flexible control during this same time period. This alone could have caused an increase in malaria cases. Conversely, a good eradication program may have been masking the impact of El Niño in previous El Niño years.

Figure 3. Malaria in Colombia



Source: International Research Institute for Climate Change, 1997

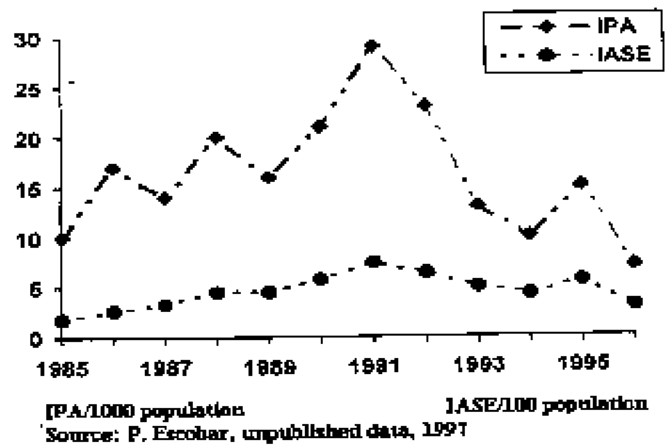
Other factors such as forced migration of non-immune populations (caused by flooding, drought, war, etc.) into areas of endemic malaria may provoke malaria outbreaks. For example, data from Pakistan (*3*) shows a positive correlation between malaria and temperature, but the data is confounded by the fact that mass emigration of refugees from Afghanistan into Pakistan occurred during the earlier years of the malaria increase.

It appears that human or environmental factors confound any scientific analysis that could directly link El Niño or climate changes with malaria incidences. If El Niño events do contribute to changes in malaria incidences, it is extremely difficult to separate their effect from other factors that impact malaria transmission.

2.2 Dengue and Other Diseases Caused by Arboviruses

Dengue in the Americas has increased dramatically over the last 10 years, both in its distribution and intensity. Precipitation and temperature have been suggested as important factors in prolonging the periods of intensive dengue transmission. Also, it has been suggested that the presence of dengue and the primary dengue vector *Aedes aegypti* at higher altitudes than previously recorded is the result of an increase in temperatures caused by climate change. Dengue has been recently reported at 1,250m in Costa Rica and at 2,200m in Colombia. Jetten and Focks (*9*) used simulation models to study the impact of temperature on dengue transmission and concluded that an increase in temperature of 2^0 C would increase the latitudinal and altitudinal range of dengue and extend the duration of the transmission season. However, as with malaria, it is difficult to prove with scientific data that the change in distribution of dengue is the result of climate change or El Niño events. In a preliminary study that intended to correlate dengue with increased rainfall, there was no positive correlation between the two factors. In fact, peaks in dengue did not occur in El Niño years.

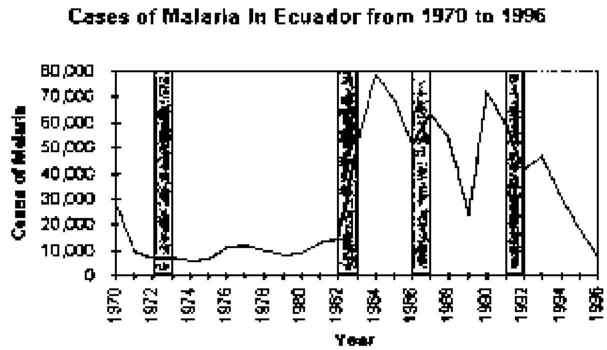
Figure 4. Annual Parasitic Indices (IPA) for Antioquia Province, Colombia

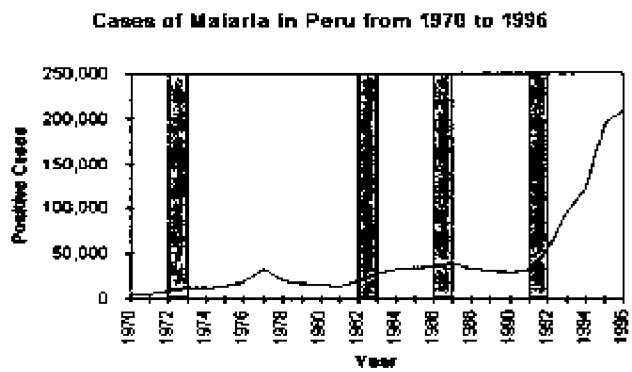


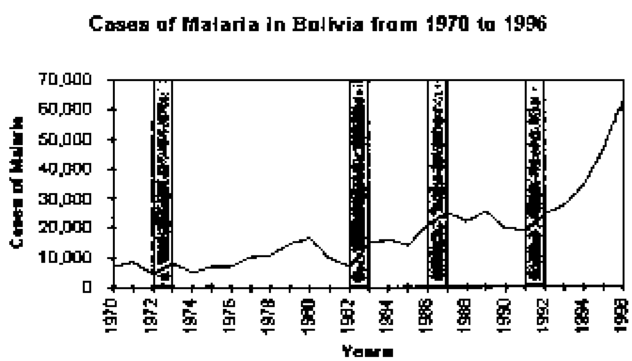
There have been tremendous increases in movement of people and goods, including an increase in international travel and trade. *A. aegypti* and *A. albipictus* have invaded new geographical regions due to the international trade of used tires and to road construction into rural areas. The movement of asymptomatic dengue carriers and vectors into nonendemic areas seems to be considerably more important for the spread of dengue than are El Niño events or climate change.

Figure 5

Denotes El Niño years







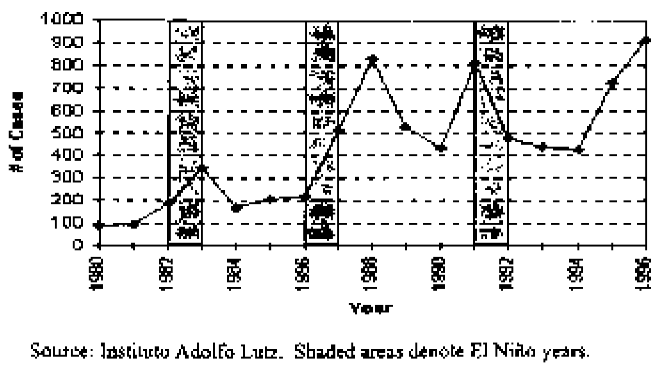
2.3 *Viral Encephalitides*

Arboviruses like Japanese, Eastern, and Murray Valley encephalitis are known to cause severe epidemics after periods of heavy rains. El Niño events have been suggested as the cause of recent outbreaks of Murray Valley encephalitis in Australia, and La Niña events as the cause of an epidemic of Japanese encephalitis in India (12). Riesen showed in a series of studies that an increase in temperature would decrease mosquito survival but increase mosquito growth rate virus-extrinsic incubation, and extend the timeframe when virus transmission would occur. However, an absence of scientific data on viral encephalitides still exists and a correlation of El Niño or La Niña with outbreaks of arboviruses cannot be supported by current data.

2.4 *Waterborne Diseases*

It is extremely difficult to quantify the relationship between human health, climate change, and waterborne disease (*18*). In Brazil, *Sp. leptosporosis* is more likely to occur during periods of high precipitation (*10*). It is well known that El Niño in southern Brazil causes an increase in rainfall (Figure 1). However, when cases of leptospirosis are compared with El Niño years there appears to be no correlation (Figure 6), and it appears that sudden intense rainfall is the key factor, which triggers an increase in leptospirosis. For example, during the epidemic of leptospirosis in Nicaragua in 1995, a non-El Niño year, the rainfall in the municipalities affected by this epidemic was the greatest amount recorded in the last 35 years (>3,500 mm). This suggests that historical rainfall data needs to be taken into account when measuring the parameters that cause outbreaks of leptospirosis and other waterborne diseases. Such measurements should be taken in areas where flooding occurs, where wastewater mixes with drinking water, and where people come into contact with contaminated water or rodents.

Figure 6. Cases of leptsospirosis in Sao Paulo, Brazil from 1980-1996



Source: Instituto Adolfo Lutz. Shaded areas denote El Niño years.

Recently, it has been proposed that higher than normal temperatures in 1997 caused by El Niño increased the number of diarrhea cases in Lima, Peru (*16*). Unfortunately, no data on diarrhea during any other El Niño phenomenon was presented for comparison.

Cholera outbreaks have been associated with precipitation extremes—both droughts and floods (*18*). It has been thought that various components of climate change—such as rising temperatures, changing precipitation patterns, uncertainty of storm frequency, and floods—have caused cholera outbreaks. More recently it was discovered that *Vibrio cholerae* is associated with a large range of marine life located on the surface of the water (*5*). Under adverse conditions, *V. cholerae* enters a non-active state on these organisms; when conditions of nitrogen, phosphorus, and warming are favorable, *V. cholerae* reverts to a cultivable and infectious state. It has been suggested that the 1991 El Niño event, which warmed the ocean along the coast of Peru and Ecuador, accelerated the outbreak of cholera in this region (*5*). However, the quality of the watersanitation system as a possible cause of the outbreak and its eventual spread has not been adequately investigated. The possible interplay between the marine environment and sanitation systems in fostering the spread of cholera should also be considered.

2.5 Hantavirus Pulmonary Syndrome and Other Rodent-associated Diseases

The emergences of new viruses including Hantavirus and Sin Nombre virus have caused severe health and economic impacts. The impact of El Niño events on the emergence of these diseases is not well known. It has been suggested that prolonged drought conditions destabilize the predator-prey cycle, which controls rodents (*6*, *17*). This causes an increase in rodent populations, which indirectly leads to an increase in human-rodent contact, thereby potentially increasing the risk of rodent-associated disease transmission.

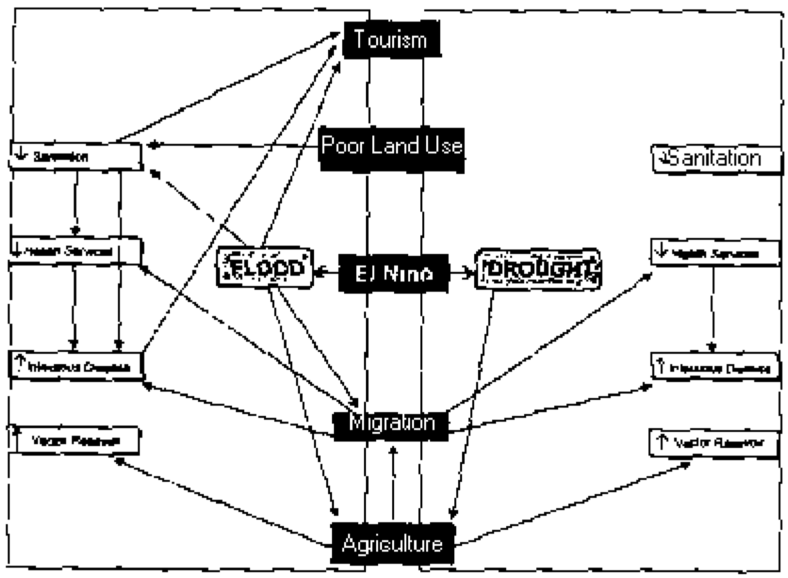
Extreme climate events such as flooding can also increase rodent-human contact. The flooding of rodent burrows forces rodents to seek shelter in human dwellings. This provides the opportunity for increased human-rodent contact (*6*). The same scenario applies to the rodent population that causes plague.

The historic information on rodent-associated diseases and climate suggest that extreme climate events catalyze disease outbreaks. Nevertheless, it has yet to be shown that El Niño increases the risk of rodent-associated diseases.

3. Conclusion

The evidence of a direct association between El Niño and infectious disease remains obscured at most because of the lack and quality of existing data. As an extreme event, El Niño is unique in its capacity to manifest itself as both a severe flood and an extreme drought. In both cases, disease is indirectly influenced by El Niño's impact on agriculture, migration, and sanitation and its effects are often worsened by preexisting conditions such as poor land use. The effects of El Niño on health and infrastructure, in turn, can be seen to negatively impact trade and tourism. As is depicted schematically in Figure 7, no one effect of El Niño can be taken in isolation, but rather in combination as a link in a chain of effects.

Figure 7. Multisectorial Impact of El Niño



The projected impacts of El Niño on disease will vary with the manifestation of the phenomenon (flood, drought, temperature increase). Since El Niño serves to exacerbate conditions already present, the risk of communicable disease will increase in areas where the disease is already endemic. In preparation, countries should prepare a checklist (Table 5) to assess regional risk factors as well as continue effective disease surveillance in order to recognize changes in endemic disease levels related to the El Niño phenomenon. The incorporation of climate forecasting into existing disease surveillance, emergency preparedness, and prevention programs can help lessen the health impacts of El Niño, the Southern Oscillation, and other extreme events.

Table 5. Example of a Disease Checklist

Projected effects of El Nino on Disease

	Flood	Drought	Temperature Increase
Water borne disease			
Cholera	++++	+	
Rotavirus	++++		
Diarrhea non specific	++++		
Viral hepatitis A	++	+	
Dinoflagellates	-	-	+++
Vector borne disease			
Malaria	+	-	+
Dengue	+	?	
Rabies	++	+	
Physical and Chemical factors			
Pesticides	++	-	-
Toxic iron ores	++	-	-
Respiratory disease	-	++	+

++++ = extreme impact, '+++ = large impact, '++ = moderate impact, '+ = small impact

Note: Individual countries should prepare personalized checklists taking into consideration the endemic levels of disease and regional risk factors.

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