Executive Summary

At present, there is no concrete data which demonstrates that an increase or decrease in infectious diseases is directly related to El Niño events. However, indirect evidence 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, however, has to be considered within the context of disease ecology (epidemiological endemic levels, existing vector reservoirs, host/parasite interactions, etc.), degree of the El Niño event anomalies, and social change.

In particular, waterborne diseases like leptospirosis and diarrhea infections increase during heavy rains. Also, in 1997, the malaria incidence in Iquitos, Peru and Boa Vista, Rorima, Brazil decreased during an El Niño related drought. Yet, extreme weather events can also occur in non-El Niño years and cause outbreaks of infectious diseases, such as the outbreak of leptosporosis in Nicaragua in 1995.

El Niño is a natural phenomena which causes anomalies (extremes) in rainfall and temperature. The major difference between climate change caused by El Niño and other extremes in climate is that in El Niño years the extremes in rainfall and temperature are of longer duration.

The fact that El Niño events are extended climate events makes them extremely important to the public health sector. Moreover, the ability to project in advance when El Niño events will occur gives the public health sector the opportunity to prepare for and to better control disease transmission.

There is a need to develop a scientific agenda that will examine the impact of extreme events such as El Niño/Southern Oscillation on human and animal health. Attention should be paid to the vulnerability of ecosystems to ENSO, how diseases will respond to extreme events, and how health programs will adjust to climate-induced changes.

An eco-epidemiological approach to disease prevention and control will be crucial as we continue to learn more about ENSO and anthropogenic induced climate change, and the health impact.

The Pan American Health Organization, as part of its role in providing expertise in disease management, recommends an immediate review of sound empirical data to document linkage between ENSO events and infectious diseases, and an initiative to implement an eco-epidemiological approach to health management programs in the Americas.

In conclusion, the impact of El Niño/ Southern Oscillation on human and animal health is not something that can be given a simple definition or elucidated in a few sentences. One must look at the health impacts of ENSO from the historical contexts of disease transmission and understand that there is continuous change.

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Introduction

On September 26th 1997, the Directing Council of the Pan American Health Organization passed 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 adequate response to the health problems arising from this phenomenon.
2. To request 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) continue 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 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 risk. The long-term impacts on health could be drastic and irreversible.

Examples of observed climate changes are an increase in global temperatures from $0.3^0C - 0.6^0C$, diurnal temperature range decrease, major glaciers in retreat globally, and an increase or decrease in precipitation in certain regions of the world (Jackson 1995).

The impacts of human-induced climate change are presently being studied and debated by professionals in many fields of science and health. There are also naturally induced changes in atmospheric and oceanic circulation patterns caused by El Niño and the Southern Oscillation. These shifts have shown a bias toward warmer climatic events since 1976. It is projected that there will be an increase in severity of El Niño events in the future.

Public interest and concern over El Niño is escalating. 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 and disquieting effects of the phenomenon. As El Niño continues to receive greater attention, public demand for understanding grows. Table 1 reflects popular concern following the ENSO event of 1982-1983.

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 U.S.	Storms	66 dead	N/A
Cuba	Flooding	15 dead	$170 million
Mexico & Central America	Drought	N/A	$600 million
Ecuador & Northern Peru	Flooding	600 dead	$650 million
Southern Peru & Western Bolivia	Drought	N/A	$240 million
Southern Brazil, Northern Argentina & 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	N/A	$450 million
Southern China	Wet weather	600 dead	$600 million
Southern India, Sri Lanka	Drought	N/A	$150 million
Middle East, chiefly Lebanon	Cold, snow	65 dead	$50 million
Southern Africa	Drought	Disease, Starvation	$1 billion
Iberian Peninsula, N. Africa	Drought	N/A	$200 million
Western Europe	Flooding	25 dead	$200 million

Table 1. Effects of the 1982-1983 ENSO. New York Times, August 2, 1983.

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

Oscillations, and then discusses the steps PAHO can take to assist member nations as they confront the problems of changing climate.

EL Niño and the Southern Oscillation (ENSO)

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 strength. 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, Canada, the United States, Latin America, and Africa.

Unlike annual weather patterns which are predictable, El Niño events recur at irregular intervals every 2-7 years and are never the same (Annex 1). They typically set in around Christmas and last 12-18 months. During an El Niño event, rains fall in the eastern Pacific and the western Pacific is dry. Normally monsoons occur in the western Pacific and the eastern Pacific is dry. The most severe ENSO event recorded was in 1982-83. Since then another occurred in 1986-87 and there was an extended ENSO event from 1990-95. We are presently undergoing an ENSO event now which 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.

Forecasting El Niño

There has been considerable progress in forecasting ENSO events. Coupled atmosphere-ocean forecast models have been developed which can make predictions from 4 months to a year before El Niño appears. The warming of sea surface temperatures in the tropical Pacific was predicted one year before the ENSO phenomenon of 1986-87. The use of sea surface temperature data will continue to be used to predict El Niño events.

At present climate forecasts related to upcoming rainy seasons 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, and (4) cooler than normal waters offshore, with higher than normal chance of drought (NOAA 1994).

El Niño in the Americas

In the Americas there are several general changes in precipitation patterns associated with ENSO events (Ropelewski & Halpert, 1987). 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.

In Central America and the Caribbean, precipitation will be 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.

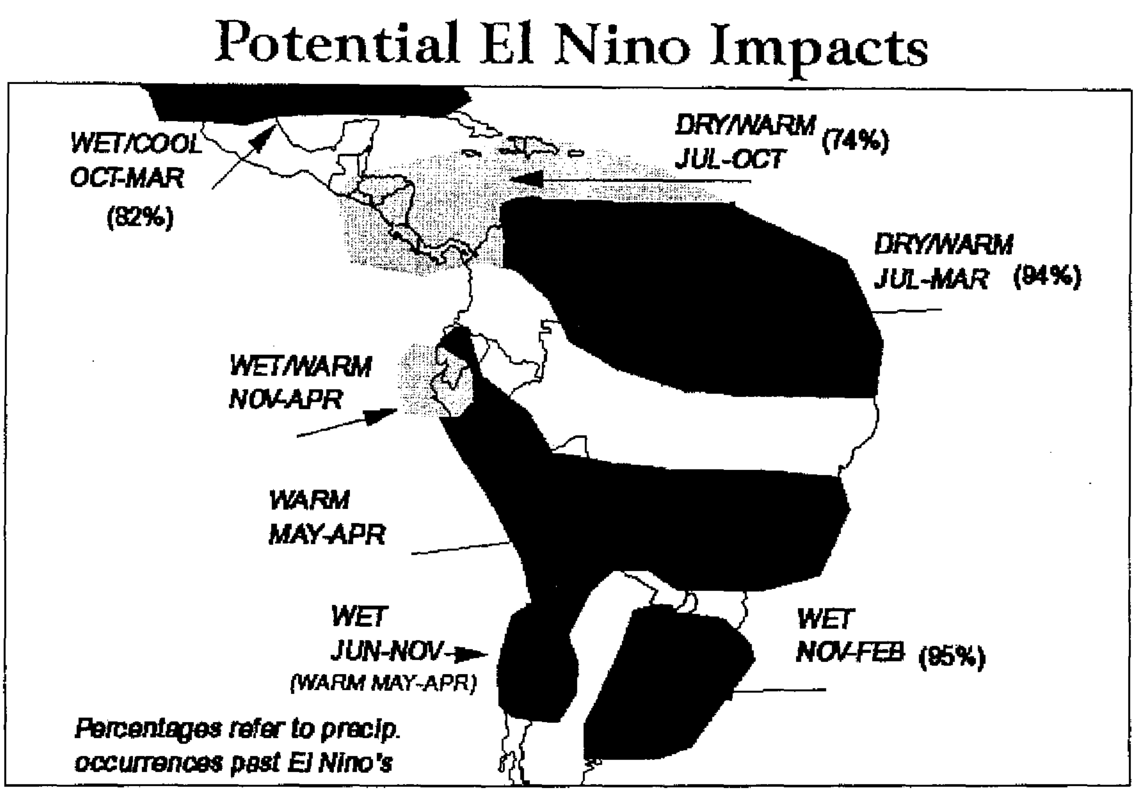

Figure 1. Potential impacts of El Niño on Mexico, Central, and South America (Source, NOAA 1997).

South America generally experiences extremes of dryness or wetness depending on the region (Figure 1). In the northeast region of South America (north equatorial Brazil, French Guiana, Surinam, Guyana 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 (Chu, 1991). 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 (Chu,1991). In other words, less than normal precipitation would most likely occur, but precipitation extremes are not as highly correlated with ENSO as 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 than in other regions.

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 2, the World Health Organization has reviewed the "potential" impact of climate change (both anthropogenic and natural) on health (WHO, 1996). Vector-borne diseases are a major concern in the Americas and the "possible" impact of climate change and El Niño events have also been reviewed by WHO (1996) (Table 3). These scenarios are based on historical events, generalized climatic models (GCM), 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 remembered that the risk of communicable disease in a community following an El Niño event is proportional to the endemic level; there is generally little risk of a given disease when the causative organism is not present beforehand (PAHO 1982). This underscores the need for effective disease surveillance programs prior to an El Niño event.

	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		++++		
Vector-borne diseases	+++	++	+	++
Non-vector borne infectious diseases	+	+		
Food availability and hunger	++	+	++	
Consequences of sea level rise	++	++	+	
Respiratory effects: – air pollutants – pollens, humidity	 + ++	 ++		 +
Population displacement	++	+	+	

++++ = great effect; += small effect; empty cells indicate no known relationship.

Table 2. Likely relative impact on health outcomes of the components of climate change (WHO, 1996).

Disease	Vector	No. at risk (millions)[a]	Number infected or new cases per year	Present distribution	Likelihood of altered distribution with climate change
Malaria	Mosquito	2400	300-500 million	Tropics/subtropics	+++
Schistosomiasis	Water snail	600	200 million	Tropics/subtropics	++
Lymphatic filariasis	Mosquito	1094	117 million	Tropics/subtropics	+
African trypanosomiasis	Tsetse fly	55	250.000-300.000 cases/year	Tropical Africa	+
Dracunculiasis	Crustacean (copepod)	100	100.000/year	South Asia/Middle East/ Central-West Africa	?
Leishmaniasis	Phlebotomine sandfly	350	12 millions infected, 500.000 new cases/year[b]	Asia/South Europe/Africa/ Americas	+
Onchocerciasis	Blackfly	123	17.5 million	Africa/Latin America	++
American trypanosomiasis	Triatomine bug	100	18-20 million	Central/South America	+
Dengue	Mosquito	2500	50 million/year	Tropic/subtropics	++
Yellow fever	Mosquito	450	<5000 cases/year	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.

Table 3 Major tropical vector-borne diseases and the likelihood of change in their distribution as a result of climate change (WHO, 1996).

It has been argued, right or wrong, that El Niño and climate change will influence the distribution and intensity of infectious diseases in the Americas. The consequence of El Niño's impact on disease transmission, however, has to be considered within the context of disease ecology, degree of the El Niño event anomalies, and social change. As will be shown in this paper, there is no concrete data which directly links El Niño to infectious disease transmission.

The challenge for health personnel 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 incidence.

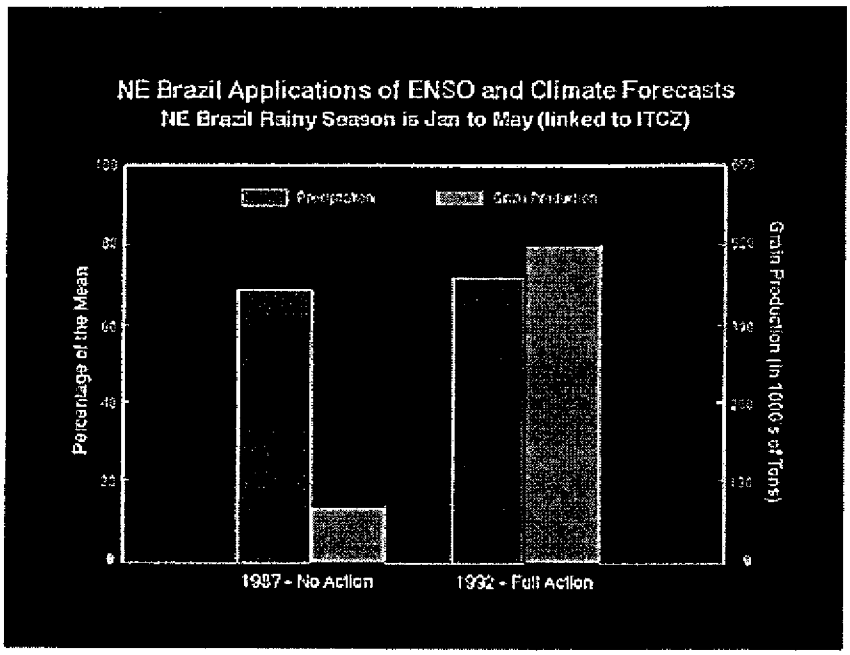

Figure 2. Impact of El Niño prediction on Brazil crop yields (Source, NOAA 1997).

As an example of how El Niño forecasting can be successfully applied, consider its uses in 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.

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.

El Niño events occur over relatively short time scales and there is a need to develop methods of determining environmental risk indicators which can be used in these situations. The necessary information will come from the modeling of future impacts of climate change. In order to provide the correct empirical information for modeling there needs to be created multidisciplinary teams of researchers and health specialists who can work together to answer the complex problems associated with projecting the impact of climate change on health.

The biggest drawback in projecting the impact of ENSO or other long-term climate changes on health is the lack of empirical data. Various scenarios are being developed using modeling and historical data bases. These data are, however, not sufficient. There still exists a vast amount of uncertainty concerning the true impacts of El Niño events.

Disease Transmission in the Americas

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

***Malaria*:** Recent studies have implied that increases in temperatures, humidity and precipitation have contributed to the increase in malaria transmission (Attenborough et al. 1997, Papua New Guinea; Lindsay and Marten, unpublished, Zimbabwe; Bouma et al. 1996, Pakistan). In addition, global climate models have been used to analyze scenarios of climate change and malaria transmission (Marten 1997). The results of these scenarios project a global increase in malaria.

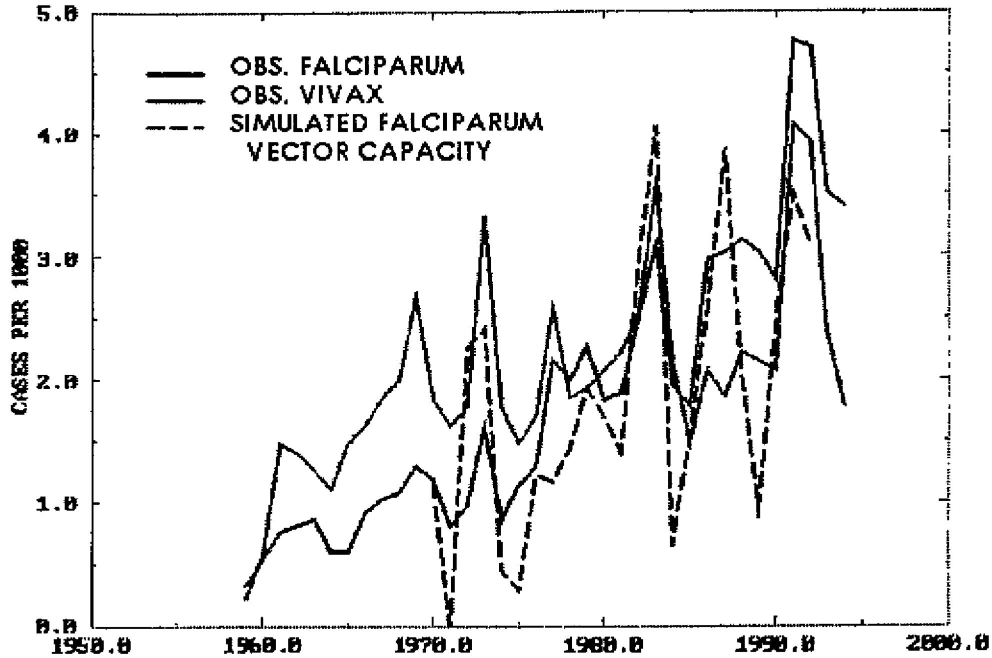

Figure 3. Malaria in Colombia (Source, International Reseach Institute for Climate Change, 1997)

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 increase in temperature and precipitation during El Niño have been suggested as the potential causes of malaria epidemics. In Colombia, it has been proposed that increases in malaria cases over the last three decades correlated with El Niño events of 1972-73, 1982-83, 1986-87, 1992-93) (Figure 3).

However, other malaria prevalence data from Colombia indicate that one can not so easily generalize. 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 (IPA) actually decrease from 1991 to 1996 during an apparently continuous ENSO event from 1990-95 (Figure 4). The contradiction in results may be due to differences in vector species and/or 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 and vary from one locality to another.

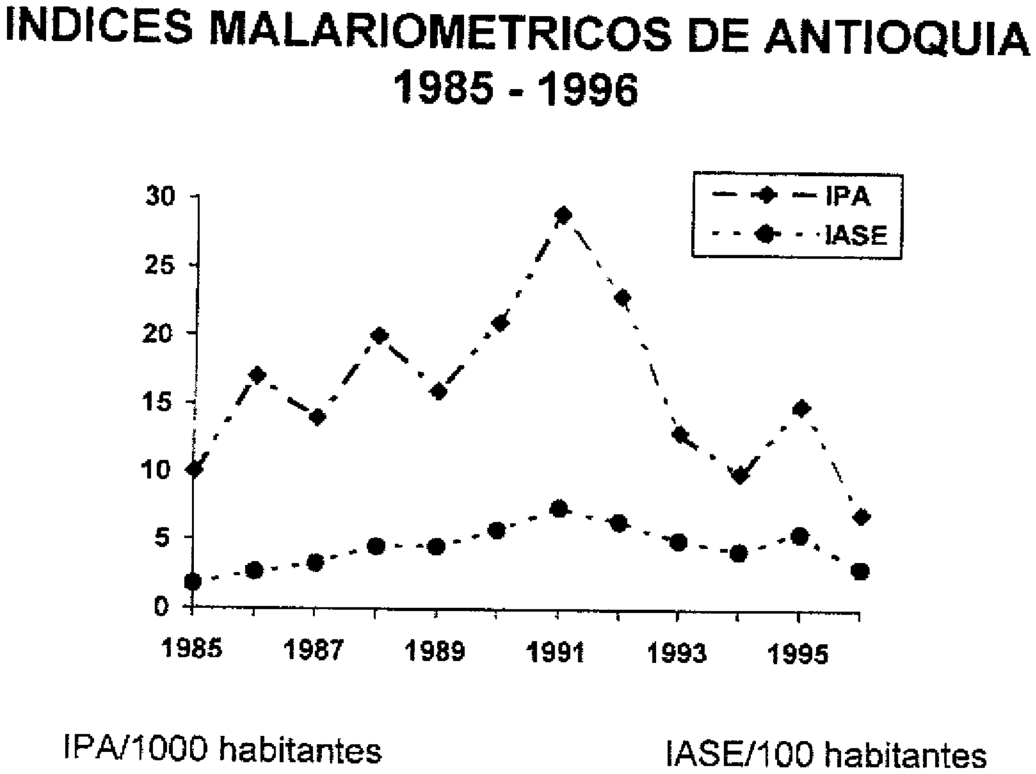

Figure 4. Annual parasitic indices (IPA) for Antioquia province, Colombia (Source, P. Escobar, unpublished data, 1997).

It has been reported that major epidemics of malaria occurred during the El Niño year of 1983 in Peru, Ecuador, and Bolivia (Nicholls, 1994). 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 (Annex 2), but the overall trend from 1970-1996 was an increase in the number of reported malaria cases, and in other El Niño years (71-72, 76-77, 91-92) the malaria seldom increased from previous years. The increase in malaria cases over the same time period in Colombia (Figure 3) and throughout South America (PAHO, malaria reports), makes one question the validity of the author's conclusions. It is known that national malaria control programs in Latin America changed from rigid eradication to flexible control, during the same time period. This alone could have caused an increase in malaria. To the contrary, a good eradication program may have been masking the impact of El Niño in previous El Niño years.

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, the data from Pakistan (Bouma et al. 1996) 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 in the earlier years of malaria increase.

There always seems to be other human or environmental factors that confound any scientific analysis that could directly link El Niño or climate change with malaria incidence. Therefore, if El Niño events do contribute to changes in malaria incidence, it is extremely difficult to separate its effect from other factors that impact malaria transmission.

Dengue and other 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 to be important factors which prolong the periods of intensive dengue transmission (Fock, unpubl. data). Also, it has been insinuated that the presence of dengue and *Aedes aegypti*, (the primary dengue vector) at higher altitudes than previously recorded is the result of an increase in temperatures caused by climate change. Dengue has been recently reported at 1250m in Costa Rica and at 2200m in Colombia (Epstein, unpublished data). Jetten and Focks (1997) used simulation models to study the impact of temperature on dengue transmission and concluded that an increase in temperature of 2°C would increase the latitudinal and altitudinal range of dengue and extend the duration of the transmission season. However, as in malaria, it is difficult to prove with scientific data that the change in distribution of dengue is caused solely by 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 (Reiter, pers. com.). In fact, peaks in Dengue did not occur in El Niño years.

There have been tremendous increases in people migration in recent years, including an increase in international travel. Also, *Ae. aegypti* and *Ae. albipictus* have invaded new geographical regions due to the international trade of used tires, and road penetration into rural areas. The movement of asymtomatic dengue carriers and vectors into non-endemic areas is considerably more important for the spread of Dengue than are El Niño events or climate change.

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 an epidemic of Japanese encephalitis in India (Nicholls, 1994). Riesen (1997, unpublished data) 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 period of year when virus transmission would occur.

However, there is still exist insufficient scientific data on viral encephalitides to implicate extreme events such as El Niño and La Niña as the cause of outbreaks of arboviruses.

Water-borne diseases: It is extremely difficult to quantify the relationship between human health and water-borne disease (WHO, 1996). In Brazil, leptosporosis is more likely to occur during periods of high precipitation (FNS, 1997). However, when cases of leptosporosis are compared with El Niño years there appears to be no correlation (Figure 5). It is well known that El Niño in southern Brazil causes an increase in rainfall (Figure 1). However, sudden intense rainfall appears to be the key factor which triggers an increase in leptosporosis. For example, during the epidemic of leptosporosis in Nicaragua in1995, 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 scale of observation needs to be taken into account when measuring the parameters that cause outbreaks of leptosporosis and other water-borne disease in areas where flooding occurs and sewer water mixes with drinking water, or where people come in contact with contaminated water, rodents, and rodent feces.

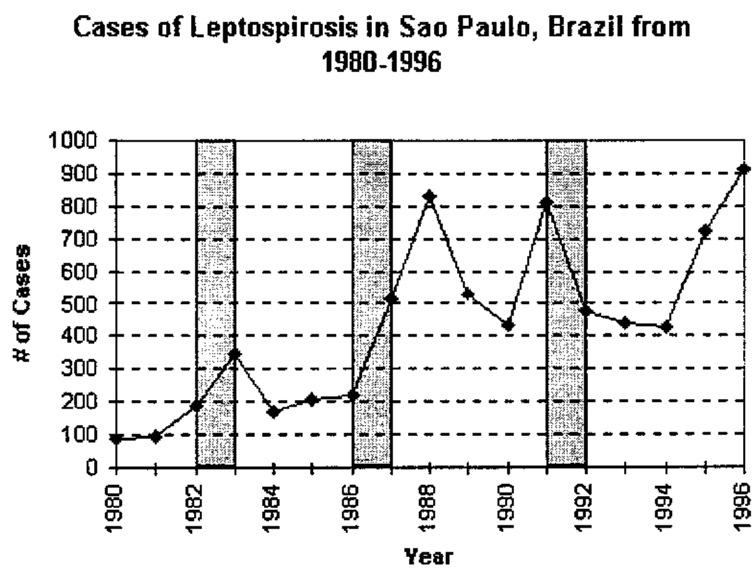

Figure 5. Cases of Leptospirosis in São Paulo over a 16 year period. Data courtesy of Instituto Adolfo Lutz. Shaded areas denote El Niño years.

Recently it has been proposed that higher than normal temperatures in 1997 caused by El Niño increases the number of diarrhoea cases in Lima, Peru (Salazar-Lindo et al., 1997). Unfortunately, no data on diarrhoea during another El Niño was presented for comparison.

Cholera: Cholera outbreaks have been associated with precipitation extremes, both droughts and floods (WHO, 1996). It has been assumed that various components of climate change such as rising temperatures, changing precipitation patterns, uncertainty of storm frequency and floods have caused cholera outbreaks. However, more recently it was discovered that *Vibrio cholerae* is associated with a large range of surface marine life (Epstein et al. 1994). Under adverse conditions *V. cholerae* enters a non-active state on these organisms, and when conditions of nitrogen, phosphorus, and warming are favorable, *V. cholerae* reverts to cultivable and infectious states. 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 (Epstein et al 1994). However, one could equally argue that a breakdown in sanitation was the main cause of the outbreak and its eventual spread.

Hantavirus pulmonary syndrome and other rodent-associated diseases: The emergence of new viruses like 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 known. It has been suggested that prolonged drought conditions destabilize the predator-prey cycle which controls rodents. Predators (raptors) and prey (rodents) populations are both reduced during the drought, but because the reproductive rate of the prey is much higher than the predators, the prey population increases much more rapidly. This increase in rodent populations 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 also can 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. The same scenario applies to the rodent reservoirs of plague.

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

Conclusion

The evidence of a direct association between El Niño and health remains obscured by the lack and quality of existing data. As an extreme event, El Niño is unique in its capacity to manifest itself as both severe flooding and extreme drought. In both cases, health is indirectly influenced by El Niño's impact on migration, agriculture, 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 Annex 3, no one effect of El Niño can be taken in isolation, but rather as a link in a chain of effects.

The projected impacts of El Niño on disease will vary with the expression 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 (Annex 4) 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 only serve to lessen the health impacts of ENSO and other extreme events.

Recommendations

The Pan American Health Organization has always been actively involved in supporting member states in their quest to improve the health of their people. PAHO has provided expertise in disease management, implemented novel control and prevention strategies, and evaluated health programs. Much of this work has been accompanied by capacity building, institutional strengthening, and technical cooperation.

Our present awareness of El Niño events creates another challenge for PAHO. Not because El Niño impacts disease transmission, but because its present day visibility reinforces the need to include weather as a major component in disease prevention and management programs. It has been known for a long time that climate influences our health and environment, but it has seldom been used as a factor to evaluate the risk of disease. We know that the ability to appraise environmental risk factors can contribute to lessening the severity of disease outbreaks.

However, an eco-epidemiological approach to the prevention and control of diseases has only been recently introduced (and promoted) by PAHO to assess the risk of disease. Most health programs rely on clinical reply and vector control as the primary methods for controlling diseases. El Niño events reinforce the need for a major shift in our approach to health problems. It makes us more aware of the importance of weather in disease ecology. Health managers need to incorporate an eco-epidemiological management approach as the foundation of their disease prevention and control programs.

Factors which must be addressed are:

1) *Vulnerability*, the extent to which El Niño will damage the system;

2) *Sensitivity*, how diseases will respond to extreme events; and

3) *Adaptability*, how health programs will adjust to climate change (IPCC, 1995).

PAHO will play a pivotal role in promoting, implementing, and evaluating eco-epidemiological risk assessment as a viable alternative for health management as health programs cope with the added burden of climate-related changes such as El Niño.

The following recommendations are those which PAHO can support to better understand extreme climate events and health.

1) Review known information on infectious diseases, their vectors, and pathogens in the context of their response to climate with emphasis on conditions affecting timing, occurrence, recurrence, and emergence, geographical distribution, transport and spread.
2) Intensify investigations to validate relationships between El Niño, anthropogenic changes, and infectious diseases.
3) Establish and work with multisectorial groups which include climatologists and meteorologists to examine the possibility of incorporating climate and weather data into disease surveillance and prevention programs.
4) Develop a surveillance strategy which incorporates climate change events into the public health surveillance programs and decision-making process.
5) Determine which regions in the Americas are most vulnerable to severe climate and El Niño events.
6) Identify high risk areas and establish monitoring and evaluation stations, particularly in fringe areas of known disease distribution areas.
7) Mobilize and train public health personnel on the potential impact of ENSO and climate change on infectious diseases and health programs.
8) Establish a taskforce within PAHO to carry out the above recommendations. Membership should include representatives from Disease Prevention and Control, Emergency Preparedness and Disaster Relief, and Health and Environment.

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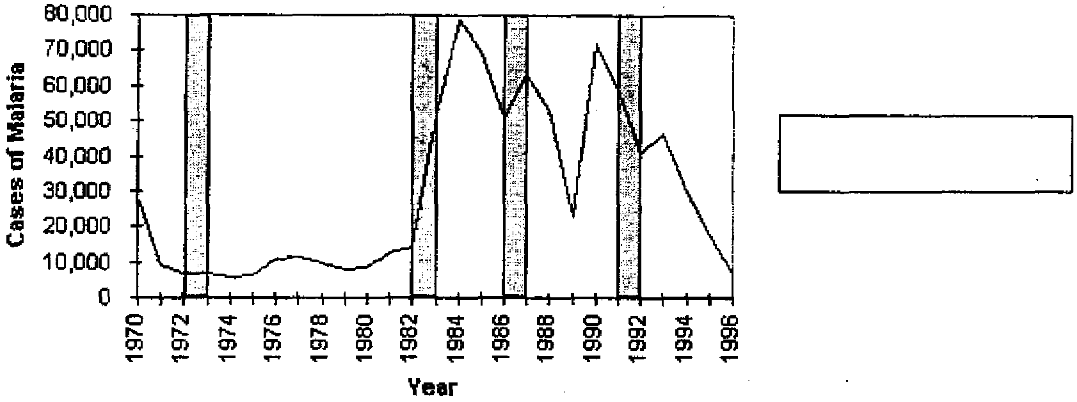
Annex 1

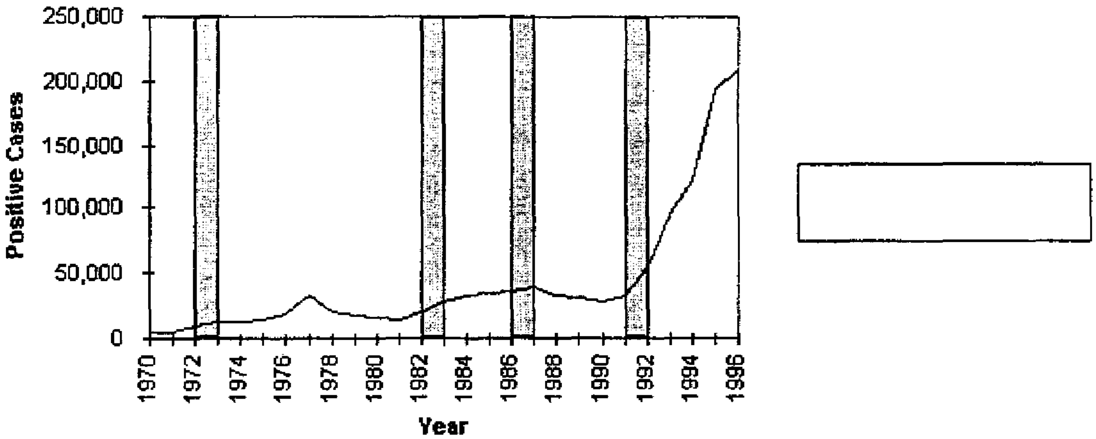
Generally from October to September	
El-Niño Years	La Niña Years
1900-1901	1903-1904
1902-1903	1906-1907
1905-1906	1908-1909
1911-1912	1916-1917
1914-1915	1920-1921
1918-1919	1924-1925
1923-1924	1928-1929
1925-1926	1931-1932
1930-1931	1938-1939
1932-1933	1942-1943
1939-1940	1949-1950
1940-1941	1954-1955
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	
1986-1987	
1991-1992	
1993-1994	
1995?	

Annex 2

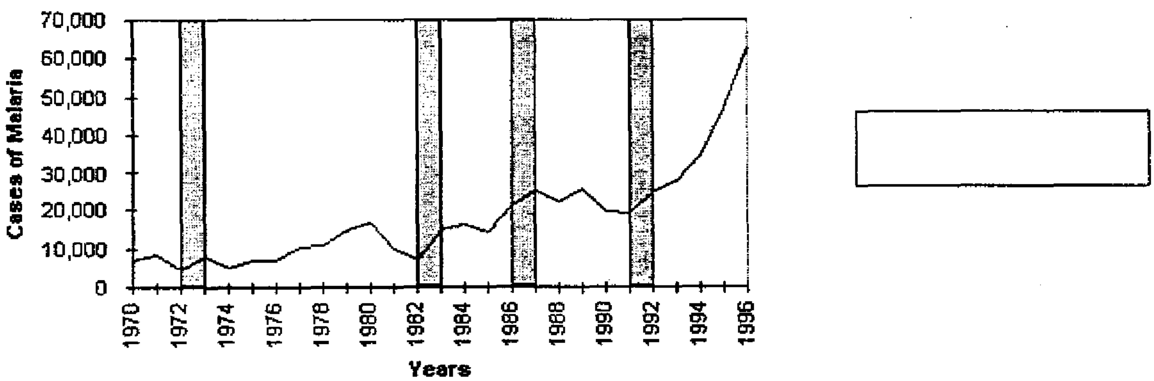
Cases of Malaria in Ecuador from 1970 to 1996



Cases of Malaria in Peru from 1970 to 1996

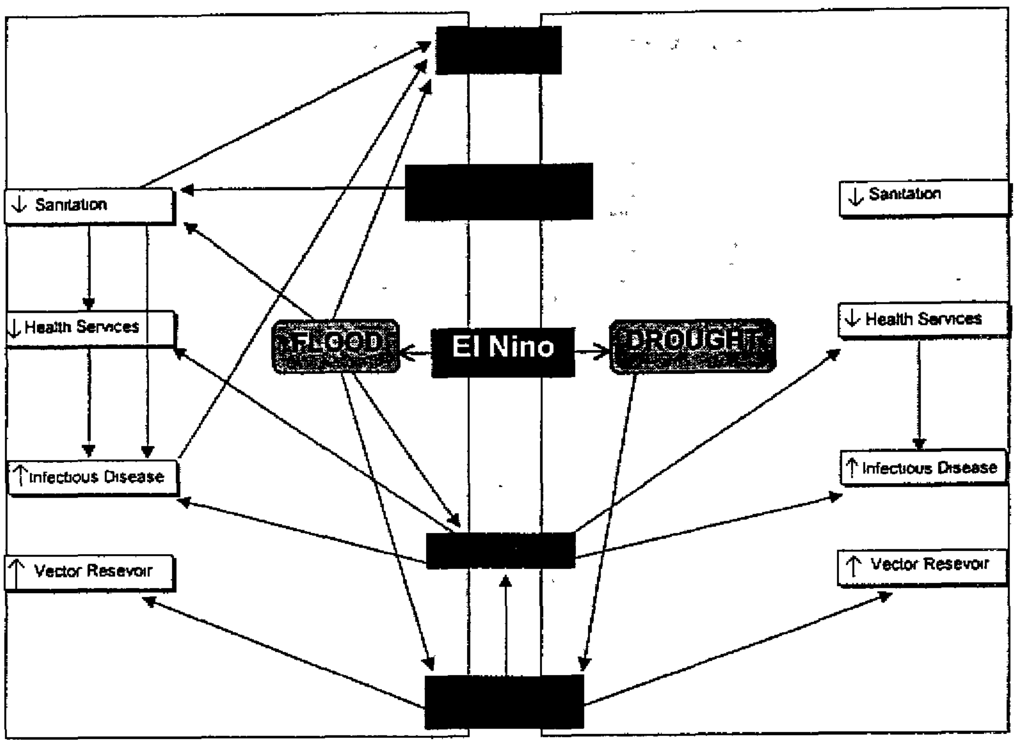


Cases of Malaria in Bolivia from 1970 to 1996



Annex 3

Multisectorial Impact of El Nino



Annex 4

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.