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EL NIÑO AND ITS IMPACT ON HEALTH

El Niño events are notable for their wide geographic influence and the long duration of their extremes. The fact that they 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 the transmission of disease.

Both the health services infrastructure and basic sanitation services were damaged by El Niño in 1997-1998. At present, no concrete data are available that demonstrate that the incidence of infectious diseases is consistently and reliably related to El Niño events. The countries developed disaster mitigation programs prior to the appearance of El Niño.

There is a need to develop a scientific agenda that will examine the impact of extreme events such as El Niño/Southern Oscillation (ENSO) on human and animal health, as well as on health infrastructure and services. 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 changes in morbidity and mortality caused by climate change.

This document summarizes existing knowledge of the effect of El Niño on health. Much is known, but there is much more to be learned. The document is presented to the 122nd Session of the Executive Committee of PAHO to inform it of the latest data on the impact of El Niño and to seek input from the Committee on the role that PAHO should play in addressing the health effects that could occur due to this environmental phenomenon.

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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 these 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 better control the transmission of disease.

The physical infrastructure of the health services has been seriously affected by El Niño which has produced flood damage; damage to equipment and furniture, as well as to roofs, walls, windows, materials, and supplies; and problems with drainage and sewerage systems, water supply, and electricity, gas, and fuel services.

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 has had an impact on the incidence of certain infectious diseases. El Niño's impact on disease transmission should be considered within the context of disease ecology (epidemiological endemic levels, existing vector reservoirs, host/parasite interactions), the severity of the El Niño event, other climatic influences, and social change. The relationship between El Niño and health is complex.

There is a need to develop a scientific agenda that will examine the impact of extreme events such as El Niño/Southern 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 the changes in morbidity and mortality caused by El Niño.

This document is presented to the 122nd Executive Committee to inform it of the latest data and conclusions about the direct and indirect impact of El Niño on human health and to request input about the role that PAHO should play in responding to this environmental phenomenon.

1. Introduction

Public interest and concern over El Niño is increasing. Traditionally, meteorological changes and environmental impacts of the phenomenon have been the focus of the press related to El Niño/Southern Oscillation (ENSO). After the severe ENSO event of 1982-1983, major social, economic, and other consequences were reported.

Only rarely are predictions on El Niño and other climate changes utilized in the planning and administration of health programs. In fact, the existing meteorological data are seldom used to analyze seasonal differences in the incidence of diseases.

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 ENSO, and then discusses the steps PAHO can take to assist Member States that are experiencing the effects of El Niño.

The 40th Directing Council of the Pan American Health Organization (1997) approved Resolution CD40.R13, which refers to preparedness for health emergencies produced by El Niño events.

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 Ecuador and Peru 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 climate changes across much of the globe, including the equatorial Pacific, the United States, Canada, Latin America, and Africa.

During an El Niño event, the eastern Pacific and monsoon areas experience heavy rains, while the climate in the western Pacific is dry. Unlike annual weather patterns, which are predictable, El Niño occurs at irregular intervals every two to seven years and is never the same. It typically begins around Christmas and lasts from 12 to18 months. The most severe ENSO event ever recorded took place in 1982-1983. Another occurred in 1986-1987, and there was an extended ENSO event from 1990-1995. We are presently experiencing an ENSO event that is expected to last until mid-1998.

La Niña is the cold phase of ENSO and is a situation in which the surface temperatures in the eastern and central equatorial Pacific are cold. In the western Pacific, a La Niña event increases precipitation, a phenomenon that is not analyzed in this document.

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 or drought) of El Niño events.

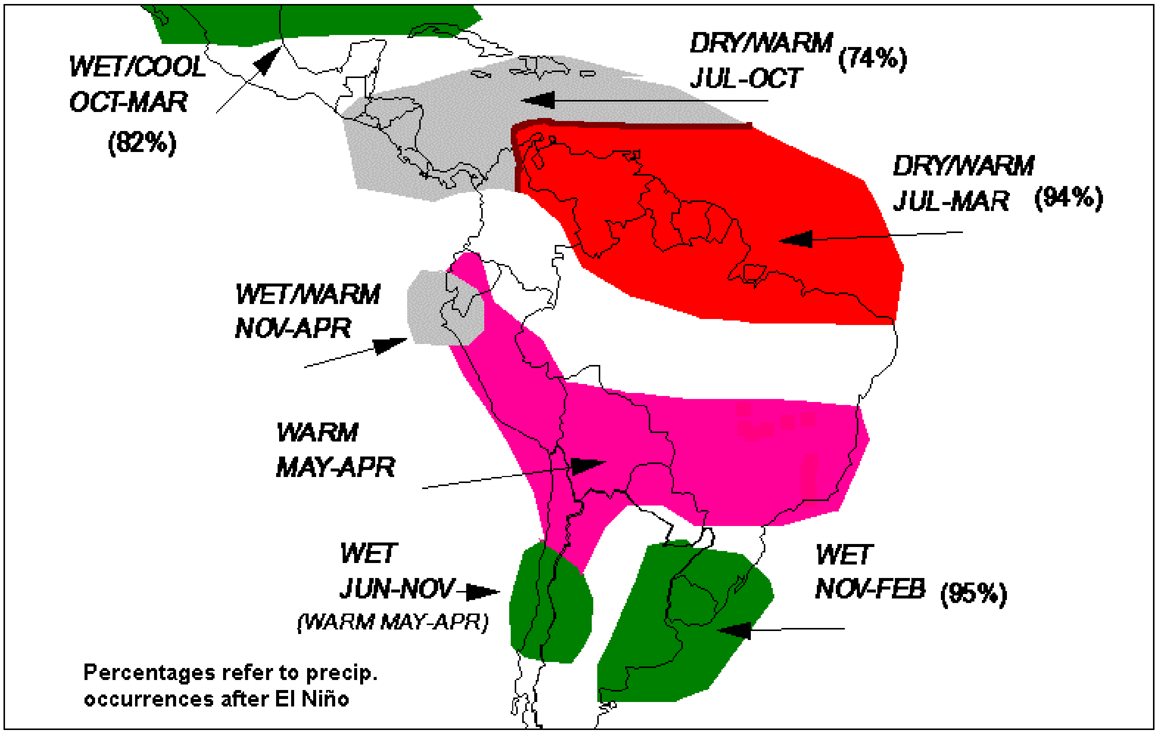
At present, climate forecasts related to upcoming rainy seasons (on the pacific coast of South America) are based on the wind and water temperatures in the tropical Pacific region and the output of numerical prediction models. Four forecast possibilities exist: (1) near normal conditions; (2) a weak 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*).

We now have a general idea of where and when extreme meteorological conditions will occur as a result of El Niño. We can therefore determine which regions are more vulnerable and at higher risk of epidemics and begin to take climate changes into account in the planning of health programs. As better forecasting models become available, it will be possible to update and utilize them.

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 Impact of El Niño on Mexico and on Central and South America



Source: U.S. National Oceanic and Atmospheric Administration (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 experiences more rainfall than normal during El Niño years.

In the Amazon region low rainfall does not coincide with ENSO events but lags one year behind (*4*). However, due to the lack of long-term precipitation data from this region and the region's complex rainfall patterns, it is hard to construct a regional index for the entire basin (*4*). In other words, less than normal rainfall would more than likely occur, but precipitation extremes are not as highly correlated with ENSO as they are in other parts of South America. The Andean region is also affected by ENSO. There is, however, insufficient information available to make generalizations.

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 *Health Impact*

Rarely has such complete information been available on a meteorological phenomenon as in the case of El Niño 1997-1998. Every country in the world received information on the possible impact of this phenomenon, and since March or April 1997 prevention and mitigation programs have been in place in several countries.

For example, Table 1 lists the El Niño events and the preliminary figures on deaths, injuries, and disappearances directly attributed to this phenomenon in 1997-1998 and 1982-1983 for several countries of the Region.

2. Physical Infrastructure of the Health Services

The physical infrastructure of the health services was seriously affected by El Niño which produced flood damage; damage to equipment and furniture, as well as to roofs, walls, windows, materials, and supplies; and problems with drainage and sewerage systems, water supply, and electricity, gas, and fuel services.

For example, in Peru it was reported that 9.5% (437/4,576) of health facilities had been damaged, with hospitals showing a damage rate of 2% (9/443) and other health centers a rate of 10.3% (428/4,133). Approximately US$ 1,500,000 has been allocated to keep these facilities in operation by waterproofing roofs, installing drains, digging ditches, protecting equipment, installing generators, and building alternative water supply systems.

Table 1. El Niño Events and Deaths, Injuries, and Disappearances during the 1997-1998 Episode, and Deaths Attributed to this Phenomenon in 1982-1983

Country	Impact	Deaths 1982/1983	Deaths 1997/1998*	Injuries 1997/1998**	Disappearances 1997/1998**
Bolivia	Intense rains in the Cordillera, with roads connecting the capital with Cochabamba and Santa Cruz washed out, freezing temperatures, and hail. New outbreak of cholera in La Paz, Cochabamba, and Oruro.	50	43	400	40
Ecuador	Intense rains with flooding along the coast and bridges and roads destroyed. Cases of leptospirosis and cholera detected in the south.	220	183	91	35
Paraguay	Intense rains with flooding of the Paraná and Paraguay Rivers and major flooding in the areas along the rivers. The capital stricken by a tornado accompanied by a storm, flooding homes, schools, and hospitals.	65	49	---	---
Peru	Intense rains in the northern and Amazon regions of the country, with major flooding, mudslides, and damage to the roadways. Significant increase in the number of cholera cases in the northern region of the country. Health conditions are currently poor in these areas.	380	203	107	No data

*Cumulative to March 1998
Source: Web page. Programa desastres OPS/Ecuador. http://www.salud.org.ec/desastre/

In Ecuador 2.3% (7/299) of the hospitals were damaged, mainly by flooding, mud, damage to the already defective sewerage systems, and problems with drinking water supply. At the present time, there is no information on conditions in smaller facilities.

The majority of the damage to the physical infrastructure of health facilities from El Niño is perfectly predictable, except in this case there was a more intense manifestation of problems that occur at this time of year in the countries. The vast majority of these problems is due to shortcomings and errors in the planning, design, and construction of the facilities, and to the lack of disaster mitigation programs. Contributing factors are the characteristics of the sites selected, i.e., the location of the land, its geology and climate, building systems and materials, water supply and electricity services, and geographical accessibility. It should be underscored that whenever a natural disaster occurs, the health services infrastructure will be affected.

2. Impact on the Environment and Infrastructure

El Niño has indirectly affected the health of individuals, due to its impact on the environment and infrastructure, manifested in various ways (flooding, droughts).

Heavy rains have caused rivers and lakes to overflow, leading to flooding and the contamination of drinking water. Sewerage systems have collapsed. Refuse has not been collected or disposed of in a proper or timely manner owing to the destruction or blockage of roadways, equipment, and other installations. For example, in Peru's Piura region the heavy rains have not only raised the water level of the Piura River, but they have also oversaturated the soil, causing area dwellers (complete with their livestock and meager belongings) to move to temporary shelters on the outskirts of Piura. Some 300 families have been displaced to date. However, if the situation persists this number is expected to rise to 1,200.

In extensive areas, El Niño has manifested itself in a lack of rainfall, jeopardizing the production and/or survival of large population groups. In Bolivia, estimates put the number of persons affected by the drought at more than 300,000. The most significant impact of the drought has been a shortage of drinking water, followed by a decrease in the water available for irrigation and livestock.

During periods of drought the risk of forest fires increases, leading to a loss of green areas, property, livestock, and human lives, and to atmospheric pollution increases due to the suspension of particulate matter in the air. In the Roraima region in northern Brazil, there have been more than 200 fires which have destroyed 37,000 km^2 of forest and endangered the lives of over 45,000 area residents. No casualties have been reported to date, but if these fires continue the population will be seriously affected.

3. National Activities for Disaster Prevention, Mitigation, and Preparedness

Practically all the countries have contingency plans in place to deal with the effects of El Niño and have prepared projects aimed at mitigating and responding in the best possible manner to the health impact of disasters attributable to El Niño.

Several proposals to improve health conditions and the management and distribution of water and investment resources have been submitted to international organizations and financial institutions. Examples of these include projects in Bolivia for US$ 4 million; Ecuador, $1 million; and Panama, $600,000. In Peru a budget of $1.5 million for the health sector was approved to deal with the effects of El Niño.

The response to the emergencies, which consisted largely of floods and mudslides, differed in each country. Activities ranged from immediate care for the injured to the organization and management of temporary camps or settlements for displaced persons. Part of the response included active surveillance for diseases regarded as a risk in these cases, especially water-, food-, and vector-borne diseases (malaria and dengue) and acute respiratory infections.

In several countries, Ecuador and Peru for example, an ongoing response to the needs of the population was necessary, and the national structure acted in a timely manner. In Bolivia departmental offices were organized to respond to the effects of El Niño.

The countries developed Internet search and communication systems. The main achievements in this area, efforts which began before the acute manifestations of the phenomenon, were:

- information searches through networks and regional and worldwide meteorological organizations;

- information exchange among countries, especially the sharing of contingency plans and information on the response of the health sector and on the damages and needs identified;

- Web pages maintained by PAHO (through the Program on Emergency Preparedness and Disaster Relief, the Subregional Office in Quito, and CEPIS) that offer the latest information available on El Niño.

Unfortunately, only a handful of individuals in these countries have access to the Internet, which makes it possible to take part in discussion groups on disasters in Central and South America. Moreover, the number of people skilled in the use of this tool is still small.

2. Infectious Disease Transmission

Following an El Niño event, the potential risk of communicable diseases is influenced not only by changes in the environment, but also by changes in population density, the disruption of public utilities, and the interruption of public health services. It should also be noted that the risk of communicable diseases following an El Niño event is related to the endemic level of the disease in the community; therefore, there is little risk 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.

To date there is little definitive data directly linking El Niño to infectious disease transmission. The consequence of El Niño on disease transmission, however, must be considered within the context of disease ecology, the degree of the El Niño event anomalies, and social change.

To underscore the difficulties involved in linking El Niño with changes in health conditions, data on several of the most important communicable diseases in the Americas are presented below.

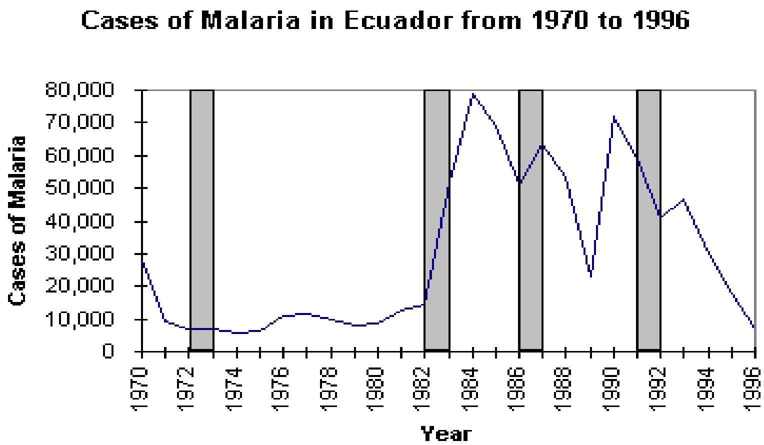
5.1 *Malaria*

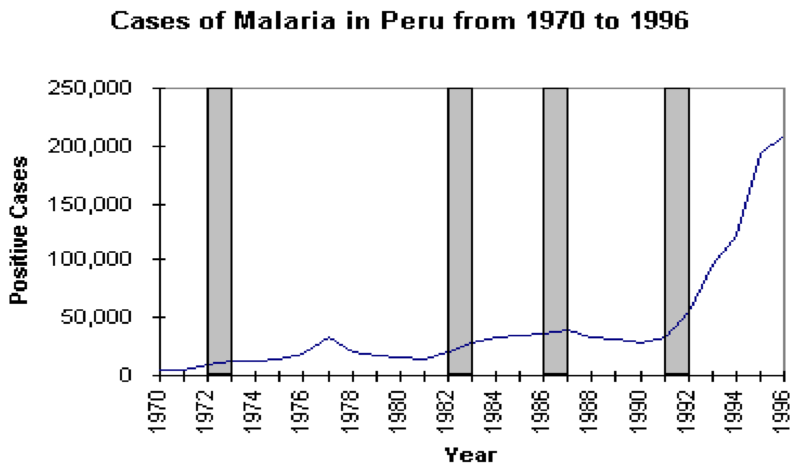
Global climate models used to analyze scenarios of climate change and malaria transmission (*11*) predict a worldwide increase in the disease associated with increases in temperature, humidity, and rainfall (*1, 3*).

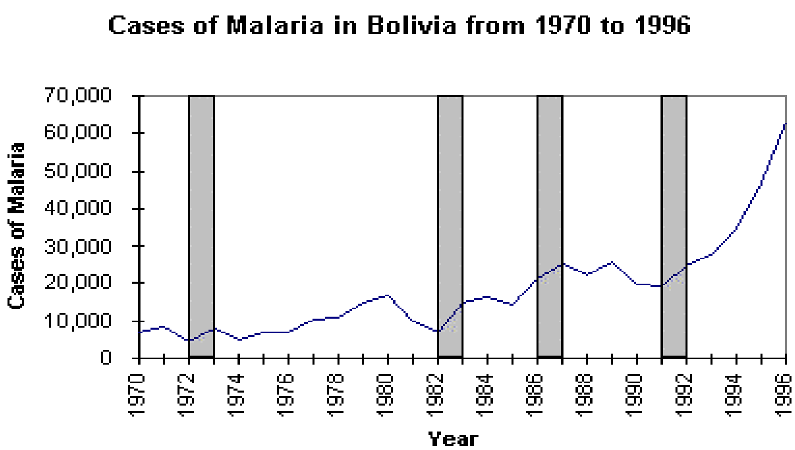
It has been reported that major epidemics of malaria occurred during the El Niño year 1983 in Bolivia, Ecuador, and Peru (*12*). A review of the data reported by each country on malaria (1970-1996 PAHO malaria reports) shows that the incidence of this disease began to rise in all the countries in 1983 (Figure 2). However, the overall trend from 1970 to 1996 was an increase in the number of cases reported, while in other El Niño years (1971-1972, 1976-1977, 1991-1992) the incidence of malaria seldom increased over that of previous years. An increase in number of malaria cases was observed in Colombia during the same period as in the rest of South America. It is known that, during this time, national malaria control programs in Latin America switched from a strategy of rigid eradication to flexible control. That alone could have caused the increase observed. Conversely, a good eradication program may have been masking the impact of El Niño in previous El Niño years.

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 that of other factors that impact malaria transmission.

Figure 2







Denotes El Niño years

5.2 *Dengue and Other Diseases Caused by Arboviruses*

As with malaria, it is difficult to prove scientifically that changes in the distribution of dengue are the result of El Niño events. In a preliminary study to correlate dengue with increased rainfall, no positive correlation between the two factors was found. In fact, peaks in dengue did not occur in El Niño years.

There has been a tremendous increase in the movement of people and goods, with a significant increase in international travel and trade. *Aedes aegypti* and *A. albopictus* have invaded new geographical regions due to the international trade in 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.

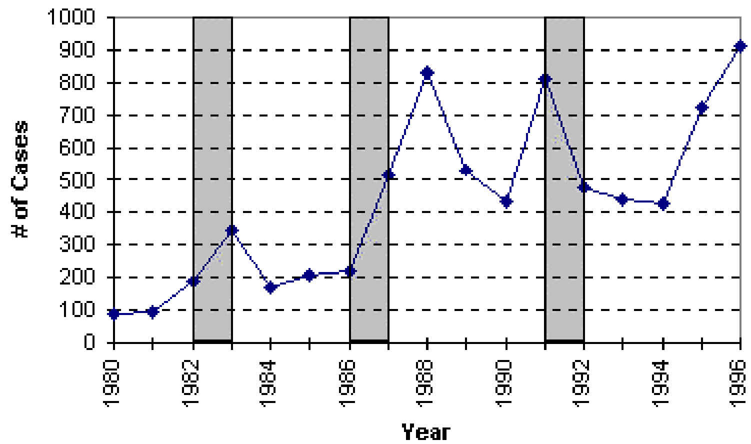
5.3 *Viral Encephalitides*

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 growth rate in extrinsic incubation of the virus and extend the time frame when virus transmission would occur. However, there is still an absence of scientific data on viral encephalitides, and a correlation of El Niño or La Niña with outbreaks of arboviruses cannot be supported by current data.

5.4 *Waterborne Diseases*

It is extremely difficult to quantify the relationship between human health, climate change, and waterborne disease (*18*). In Brazil, *Sp. leptospirosis* 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 seems to be no correlation (Figure 3) 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 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 3
Cases of Leptospirosis in São Paolo, Brazil from 1980 to 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 (*16*). 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*). *V. cholerae* enters a non-active state in these organisms; when nitrogen, phosphorus, and warming conditions 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 Ecuador and Peru, accelerated the outbreak of cholera in this region (*5*). However, the quality of the water/sanitation 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.

3. PAHO Technical Cooperation

The main activities and recommendations of the Pan American Health Organization have been directed toward the following actions:

- Training workshops in the health services network in the areas with the highest risk of disease transmission for the strengthening of entomological surveillance, vector control, and prevention activities. Support for the development of a project to introduce treated mosquito netting. As a complement, in-service training responsible for clinical and environmental management was carried out.

- Active surveillance in the areas at greatest risk.

- Upgrading of health personnel in aspects related to mental health in the most hard-hit subregions (prevention, assistance, and rehabilitation).

- Implementation of the Supply Management Project in the Aftermath of Disasters (SUMA) to strengthen the logistical information process at the national level and in the affected subregions, through workshops and follow-up for the ministries of health, nongovernmental organizations, and United Nations institutions.

- Provision of basic supplies for water storage and treatment.

- Local workshops to find solutions to environmental sanitation problems.

- Training of members of the organized community in the hardest-hit departments (the authorities, leaders, neighborhood representatives, school health monitors, health promoters) in aspects of preparedness for El Niño.

- Identification of shelter sites and requirements for their installation, and food control.

- Characterization of rodents and vectors of public health significance in disaster areas.

- Strengthening of laboratory diagnosis for leptospirosis and hantavirus.

- Vaccination of the affected population against whooping cough, tetanus, and diphtheria to guard against potential outbreaks.

As part of the response, the management of emergency supplies was organized, using SUMA as the methodology. An agreement to use this methodology at the national level was signed between the Government of Ecuador, PAHO, and the Red Cross; in Peru, SUMA was put in place and is currently being used by government agencies and nongovernmental organizations.

2. Conclusion

The impact of El Niño on the facilities where mitigation efforts were carried out was far less serious than in those where no programs existed at all. It is therefore necessary to continue technical cooperation to reduce the vulnerability of health facilities to all types of disasters, improve structural and nonstructural safety, and encourage the health sector to incorporate mitigation measures in health facilities.

When an El Niño event is forecast, the following should be determined about the infrastructure of health facilities: (a) their condition during and after the event to determine whether they can continue to operate and the conditions and needs that must be met to guarantee their operation; (b) the capacity of the affected region or area to receive basic water, electricity, communications, and transportation services; and (c) the operating capacity available to deliver health services to the affected community and the ability of the community to access such services.

The results presented indicate that El Niño events do affect health through the deaths, injuries, and population displacement that they produce or their direct impact on the physical infrastructure of the health services.

In the specific macro analysis it has not been possible to show a direct association between El Niño and infectious diseases. However, with more systematic data collection and better quality data, it would perhaps be possible to revise what has been demonstrated up to now.

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, the health situation is deteriorating, and there is overcrowding and damage to basic services. In preparation, countries should draw up a checklist (Table 2) of regional risk factors, instituting effective disease surveillance that will make it possible to recognize changes in the incidence of endemic diseases associated with the El Niño phenomenon. The incorporation of climate forecasting into existing disease surveillance, emergency preparedness, and disaster prevention and mitigation programs can help to lessen the health impacts of El Niño, the Southern Oscillation, and other extreme events.

El Niño is a singular phenomenon due to its ability to cause major flooding or severe drought. In either case, it has an indirect impact on disease because of its repercussions on agriculture, migration, and sanitation, and its effects are often exacerbated by pre-existing conditions such as poor soil management. The impact of

Table 2. Example of a Disease Checklist

Projected effects of El Niño on Disease

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

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

Note: Each country should prepare its own checklist, taking the endemic levels of disease and regional risk factors into account.

El Niño on health and infrastructure, in turn, has repercussions for trade and tourism. The effects of El Niño cannot be considered in isolation but must be viewed in combination, as a link in a chain reaction.

The Internet has facilitated information exchange on solutions that could be implemented to deal with the negative health impact of El Niño events. The ministries of health should move to promote and improve its use, taking advantage of this medium to increase preparedness at little cost and reduce the vulnerability of the health sector. An improvement in radio and cellular phone communication in the Region would give health authorities better access to the information generated at the site of El Niño events.

Many people in the Region are currently trained in the system for managing supplies in the aftermath of disasters; it is suggested that the countries strengthen their knowledge of the SUMA system to improve and facilitate the management of humanitarian assistance.

It is necessary to conduct scientific studies on the impact of extreme meteorological conditions such as ENSO events on human and animal health. Attention should focus on the vulnerability of ecosystems to El Niño events, the manner in which the incidence of disease responds to extreme climate conditions, and the need for the programs to adapt to climate-induced changes in morbidity and mortality.

References

1. Attenborough RD, Burkot TR, and Gardner DS. 1997. Altitude and the Risk of Bites from Mosquitos Infected with Malaria and Filariasis among the Mianmin People of Papua New Guinea. *Trans. Roy. Soc. Trop. Med. Hyg*., 91:8-10.

2. Bouma MJ and Dye C. 1997. Cycles of Malaria Associated with El Niño in Venezuela. *JAMA*, 278:1772-1774.

3. Bouma MJ, Dye C, and Van Der Kaay HJ. 1996. *Falciparum* Malaria and Climate in the Northwest Frontier Province of Pakistan. *Am. J. Trop. Med.* Hyg., 55:131-137.

4. Chu, Pao-Shin. 1991. Brazil's Climate Anomalies and ENSO. In *Teleconnections Linking Worldwide Climate Anomalies*; pp.43-71. Scientific Basis and Societal Impact. Eds. MH Glantz, RW Katz, N Nicholls, Cambridge Univ., NY, 535pp.

5. Epstein PR, Ford TE and Colwell RR. 1994. Marine Ecosystems. Pp.14-17. In Health and Climate Change. Ed D Sharp, *Lancet*.

6. Epstein PR. 1995. Emerging Diseases and Ecosystem Instability: New Threats to Public Health. *Am J. Public Health* 85(2): 168-172.

7. EPA. *Global Warming. Key Findings of the Second Assessment Report of the Intergovernmental Panel on Climate Change*. 2 October 1997.

8. Jackson EK. 1995. Climate Change and Global Infectious Disease Threats. *Med. J. Australia*, 163:570-574.

9. Jetten T and Focks D. 1997. Potential Changes in the Distribution of Dengue Transmission under Climate Warming. *Am. J. Trop. Med. Hyg*., 57:285-97.

10. Fundacão Nacional da Saúde (FNS). 1997. *A Leptospirose humana no Brasil nos anos 1985-1996*. Informe final, 109pp.

11. Marten P. 1997. *Health Impacts of Climate Change and Ozone Depletion: An Eco-epidemiological Modeling Approach*. 158 pp.

12. Nicholls N. 1994. El Niño-Southern Oscillation and Vectorborne Disease. pp.21-22. In Health and Climate Change. Ed. D. Sharp, *Lancet*.

13. NOAA, 1994. *El Niño and Climate Change: Report to the Nation on Our Changing Planet*. University Corporation for Atmospheric Research (UCAR/OIES) and NOAA.

14. PAHO, 1982. *Epidemiologic Disease Surveillance after Disaster*, Scientific Publication 420 pp.3-4; *Emergency Vector Control after Natural Disaster*, Scientific Publication 419.

15. Ropelewski CF and Halpert MS. 1987. Global and Regional Scale Precipitation Patterns associated with El Niño/Southern Oscillation. *Monthly Weather Rev*., 115: 1606-1625.

16. Salazar-Lindo E, Pinell-Salles P, Maruy A, and Chea-Woo E. 1997. El Niño and Diarrhoea and Dehydration in Lima, Peru. *Lancet*, 350 (9091): 1597-1598.

17. Stone R. 1995. Global Warming. If the Mercury Soars, so May Health Hazards. News and Comments. *Science*. 267: 957–958.

18. WHO. *Climate Change and Human Health*. WHO/EHG/96.7.