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 disease transmission.

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, has to be considered within the context of disease ecology (epidemiological endemic levels, existing vector reservoirs, host/parasite 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 leptosporosis in Nicaragua in 1995. Alternately, some effects of El Niño may be beneficial. In 1997, the malaria incidence in Iquitos, Peru and Boa Vista, Rorima, 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 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 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 and anthropogenic induced climate change, and their health impacts. PAHO will continue to monitor climate changes and infectious diseases occurrence in order to identify potential risks and propose control actions activities.

This document summarizes existing knowledge of the effect of El Niño on health. There is much to be learned.

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 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 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.

As El Niño continues to receive greater attention, public demand for its understanding 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 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

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 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 extend from southern Mexico and Guatemala southward into Panama and eastward into the Caribbean. South America generally experiences extremes of dryness or wetness depending on the region (Figure 1).

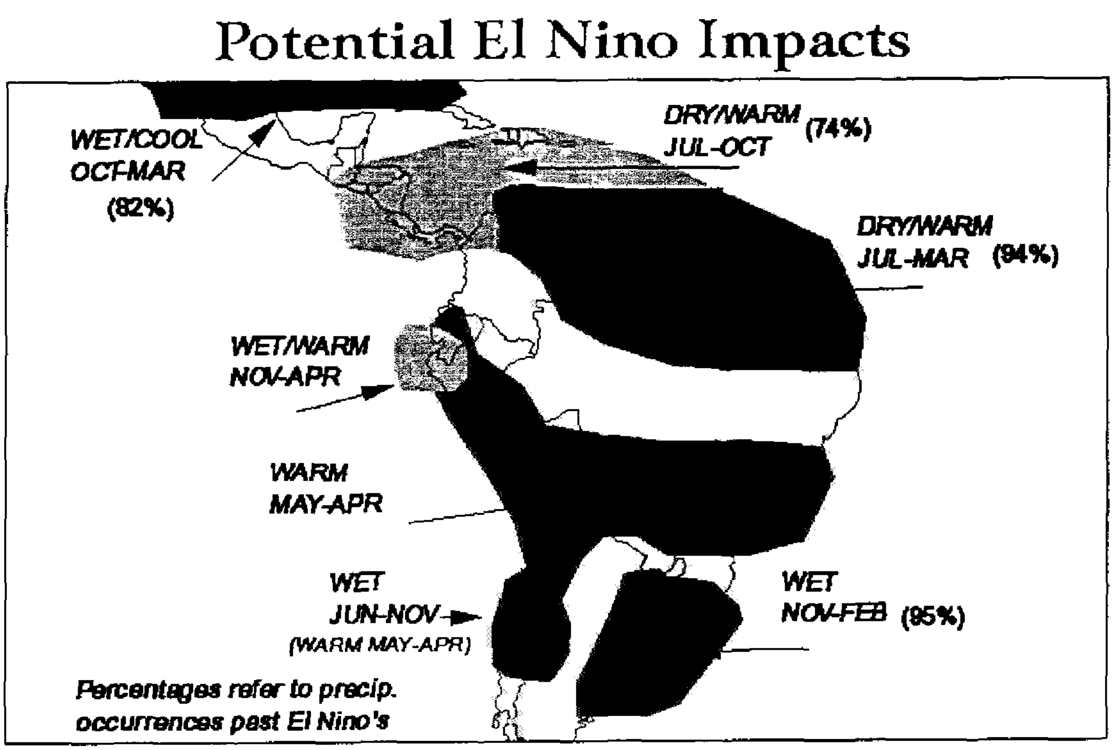

Figure 1. Potential impacts of El Niño on Mexico, Central, and South America (Source, NOAA 1997).

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

	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).

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.

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 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. 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.

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.

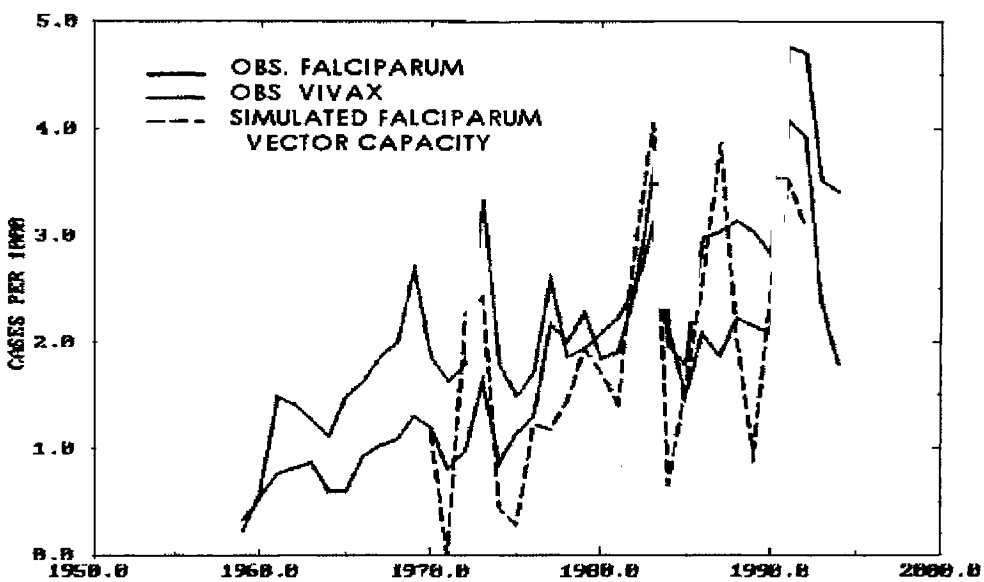

Figure 3. Malaria in Colombia (Source, International Research Institute for Climate Change, 1997).

increase in malaria cases over the same time period in Colombia (Figure 3) and throughout South America (PAHO, malaria reports), puts into 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. Conversely, 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. 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 as important factors in prolonging the periods of intensive dengue transmission (Fock, unpubl. data). 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 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 2^0C 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 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 (Reiter, pers. com.). In fact, peaks in Dengue did not occur in El Niño years.

There have been tremendous increases in movement of people 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 *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, the quality of the water/sanitation system as a 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 feces should also be considered.

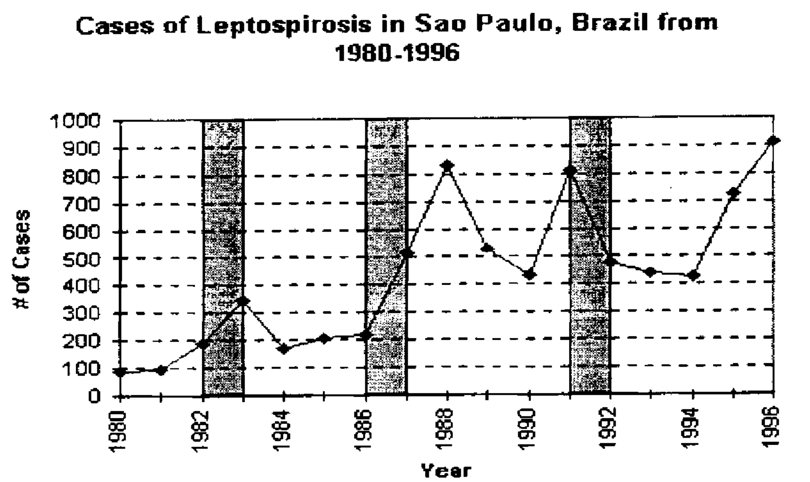

Figure 5. Cases of Leptospirosis in São Paulo over a 16 year period.
Data courtesy of Instituto Adolfo Lutz. Shaded areas denote El Niño years.

Hantavirus pulmonary syndrome and other rodent-associated diseases

The emergence 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 known. It has been suggested that prolonged drought conditions destabilize the predator-prey cycle which controls rodents.(Epstein 1995, Stone 1995). 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 (Epstein, 1995). 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.

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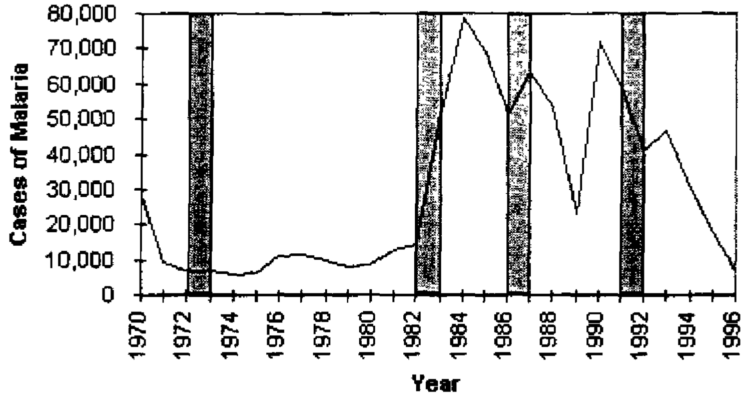
ANNEX 1

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?	

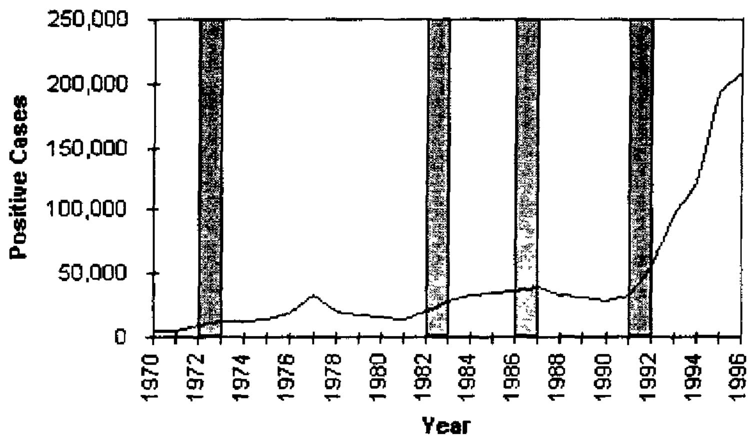
ANNEX 2

■ Denotes El Niño years

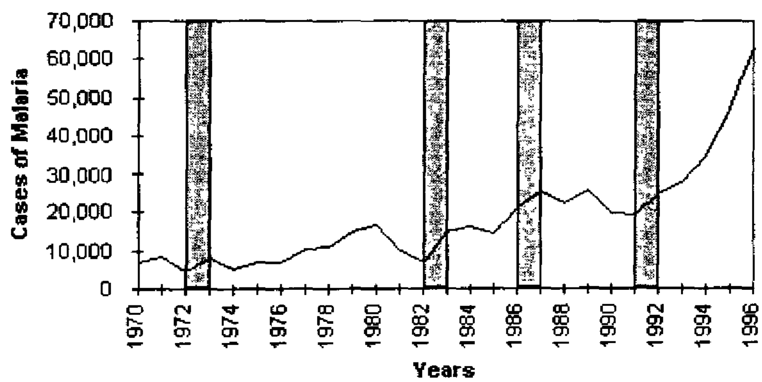
Cases of Malaria in Ecuador from 1970 to 1996



Cases of Malaria in Peru from 1970 to 1996

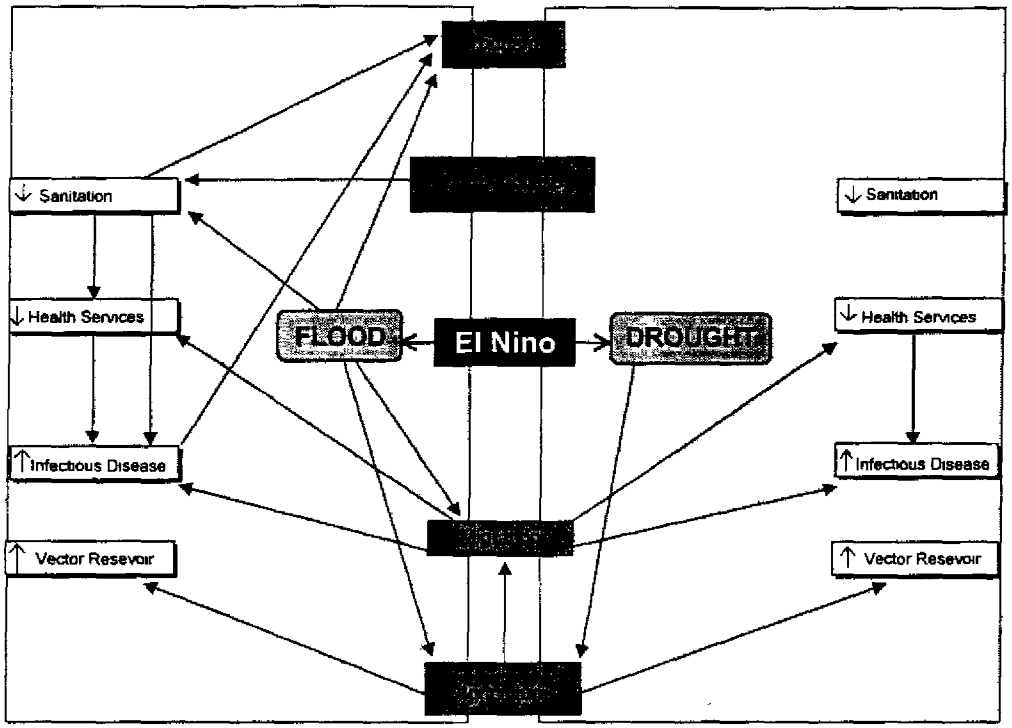


Cases of Malaria in Bolivia from 1970 to 1996



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