El Niño and human health

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The El Niño–Southern Oscillation (ENSO) is the best known example of quasi-periodic natural climate variability on the interannual time scale. It comprises changes in sea temperature in the Pacific Ocean (El Niño) and changes in atmospheric pressure across the Pacific Basin (the Southern Oscillation), together with resultant effects on world weather. El Niño events occur at intervals of 2–7 years. In certain countries around the Pacific and beyond, El Niño is associated with extreme weather conditions that can cause floods and drought. Globally it is linked to an increased impact of natural disasters. There is evidence that ENSO is associated with a heightened risk of certain vector-borne diseases in specific geographical areas where weather patterns are linked with the ENSO cycle and disease control is limited. This is particularly true for malaria, but associations are also suggested in respect of epidemics of other mosquito-borne and rodent-borne diseases that can be triggered by extreme weather conditions. Seasonal climate forecasts, predicting the likelihood of weather patterns several months in advance, can be used to provide early indicators of epidemic risk, particularly for malaria. Interdisciplinary research and cooperation are required in order to reduce vulnerability to climate variability and weather extremes.

Keywords: atmospheric pressure; meteorological factors; climate; disease transmission; disease vectors; malaria, transmission; arboviruses; diarrhea, etiology.

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Introduction

El Niño is a complex climatic phenomenon that is, perhaps unfairly, associated with death and destruction. It increases the risk of extreme weather but also has more subtle effects on human health. This article reviews those studies that have examined the relationship between the quasi-periodic climate pattern and disease risk. The attribution of any single epidemic to El Niño is difficult since the climate phenomenon is not the same as extreme weather. The relationships between extreme weather and deaths, injuries and subsequent outbreaks of disease have been well described. Particularly during disasters, initial outbreaks may be compounded by the displacement of populations and failures in health infrastructures. Many recent events have shown how easily health services are overwhelmed by atypical weather conditions. Between October 1999 and March 2000 there were major disasters associated with La Niña conditions in India, Mozambique, and Venezuela. Given the context of global climate change, which poses an increasingly certain threat (*1*), a better understanding of the relationships between weather, climate and human health is necessary.

Climate variability and ENSO

El Niño refers to the exceptionally marked and prolonged warm periods that occur in the Pacific Ocean around the equator (*2*, *3*). They are linked to weather changes all over the world. The cycle of warming and cooling of the East Pacific is closely mirrored by air pressure deviations over the East and West Pacific, called the Southern Oscillation. When pressure rises in the East Pacific it usually falls in the West. Walker pioneered the use of statistical methods to link weather anomalies with the Southern Oscillation, including the Asian monsoon, and was one of the first to explore the possibility of seasonal forecasting (*4*). In the 1960s the link was made between the atmospheric Southern Oscillation and the oceanic El Niño, now referred to as the El Niño – Southern Oscillation (ENSO) (see Box 1). The broader definition of El Niño has sometimes been used interchangeably with ENSO because the latter term is less well known. The two extremes of ENSO are El Niño (a warm event) and La Niña (a cold event). Global weather patterns associated with La Niña are generally less pronounced and, in some areas, tend to be the opposite of those associated with El Niño.

El Niño begins when the prevailing easterly winds weaken over the Pacific. The major rain zone is shifted eastwards towards the central Pacific, causing a prolonged dry period in northern Australia, Indonesia, and the Philippines. The Pacific Ocean is warmer along the western coast of South America and during El Niño the upwelling along this coast is reduced, i.e. the nutrient-rich cold waters from the deep ocean no longer appear at the surface. Because of this there is a decline in the production of plankton, which has repercussions for populations of fish and sea birds. Sea levels on either side of the Pacific are also affected. The behaviour of the ocean and that of the atmosphere reinforce each other until El Niño is fully established.

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Box 1. **The discovery and investigation of El Niño**

1860s	First recorded use of the term "El Niño" in Peru to describe periodic warming of coastal waters
1910–1930s	Gilbert Walker documents the Southern Oscillation and its linkages with the Asian monsoon
1960s	Jacob Bjerknes links El Niño in the Pacific Ocean with the Southern Oscillation in the atmosphere
1981–1982	First international efforts to reduce the impact of El Niño and improve forecasting
1985–1987	First global climate models to simulate ENSO
1997	United Nations Interagency Task Force on El Niño established
1997	Many models successfully forecast the onset of El Niño but fail to forecast its magnitude

ENSO events are a strong determinant of interannual climate variability in many countries of Africa, the Americas, and Asia, influencing whether conditions are atypically hot or wet. With the exceptions of North America and Australia, the greatest climatic affects of El Niño are experienced in developing countries. Weather patterns associated with ENSO beyond the Pacific region include regional land and sea surface warming, changes in storm tracks, and changes in rainfall patterns, particularly in respect of heavy rain or prolonged drought. For example, Indonesia and countries of southern Africa often experience drought during the El Niño phenomenon. The effect of El Niño along the western coast of South America is very significant, particularly in Ecuador and Peru. Nearly every El Niño event, whether weak or strong, is associated with heavy rainfall in this region. ENSO also has an important effect on the character of the annual monsoon in Asia.

Natural disasters

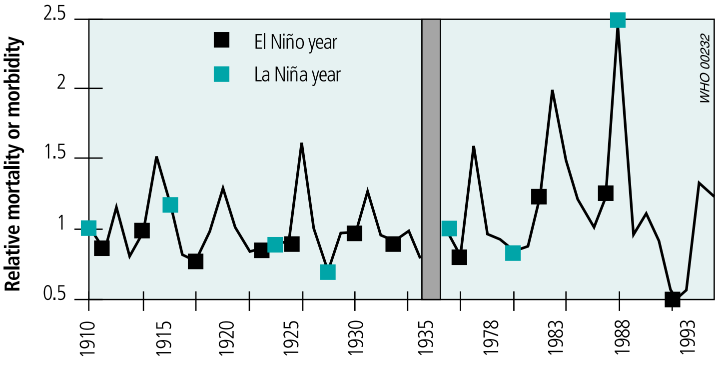
El Niño brings changes in risk of droughts, floods and tropical cyclones. During 1997–98, for example, Kenya was affected by excessive rainfall and flooding, and severe floods and mudslides occurred in the coastal regions of Ecuador and northern Peru, severely damaging the local infrastructure (*3*). In Peru, 9.5% of health facilities were damaged, including 2% of hospitals and 10% of other health centres (*5*). At the other extreme, Guyana, Indonesia and Papua New Guinea were severely affected by drought. Global estimates of deaths attributable to El Niño in 1997–98 vary from 21 000 (*6*) to 24 000 (*7*). Time series studies have shown that El Niño has an effect on the total number of persons affected by natural disasters (*8*, *9*).

The climatological affects of El Niño are strongest in many developing countries that are poorly equipped to deal with weather extremes. The number of people killed, injured or made homeless by natural disasters is increasing alarmingly, partly because of population growth and the concentration of populations in high-risk areas, e.g. coastal zones and cities (*6*). Many large shanty towns with flimsy dwellings are located on land subject to frequent flooding. In many areas the only places available to poor communities are on land with few natural defences against extreme weather conditions.

Hurricanes in the Caribbean, the Gulf of Mexico, and Queensland, Australia are less common during El Niño months than during La Niña months (*10*). This reduced storm activity seems to be the main positive benefit of El Niño. It should be remembered, however, that the most expensive natural disaster ever in terms of insured losses, caused by Hurricane Andrew, occurred in 1992, an El Niño year. The disaster-related cost of El Niño in 1997–98 was estimated to be US$ 34.36 billion (*7*, *11*).

El Niño events have been occurring for millennia and individual events were first described in about 1500 AD. Those that occurred in the 20th century are listed in Table 1. No two are alike but most seem to follow a general pattern, usually lasting for 12–18 months and occurring at intervals of 2–7 years, but varying in frequency, time of onset, duration and intensity. Those of 1982–83 and 1997–98 were the largest of the 20th century, with the catastrophic impacts of the former event, especially in South America, impelling governments and scientists to improve their understanding of the nature and predictability of ENSO. The forecast of a major event in 1997 led to significantly increased international action, including the creation of the United Nations Interagency El Niño Task Force, aimed at reducing the impact of weather disasters (*12*).

Fig. 1. **Malaria mortality and morbidity in Venezuela.** Malaria increases by 36.5% on average in years following recognized El Niño events. Relative change in mortality (deaths, 1910–1935) and morbidity (cases, 1975–1995), calculated as (No. of cases in year n) / (No. of cases in year n-1).



Source: ref. *26*.

Drought, food shortages and famine

Food production is most susceptible to drought in arid regions where the precipitation pattern is markedly seasonal or is otherwise highly variable. El Niño is important because it is associated with drought in many vulnerable regions at the same time. This aggregate effect has led to several world food crises (*13*). In 1972, for example, drought affected several of the major grain-producing regions, including northern and western parts of southern Asia and north-eastern China. Clearly, food shortage and famine have complex social and environmental causes. However, climate is still a significant factor in many modern famines. Vulnerability to climate variation can be reduced by appropriate action, for instance through early warning systems that include climate forecasts. Famine was averted in this way following the severe drought in southern Africa during 1992, despite 80% crop failure rates in some of the most severely affected regions (*14*).

Countries in north-eastern South America typically experience conditions that are drier than normal during El Niño events. The periodic occurrence of severe drought associated with El Niño in the agriculturally rich region in north-eastern Brazil has resulted in occasional famines. In 1998, such conditions extended from north-east Brazil to Panama (*3*); water supplies were contaminated when rivers and streams stopped flowing.

Southern Africa is subject to recurrent droughts that cause severe food shortages. There is an increased risk of drought during El Niño in a region encompassing parts of Mozambique, South Africa, and Zimbabwe. The 1991–92 El Niño was accompanied by the worst drought in southern Africa of the 20th century, affecting nearly 100 million people (*13*). Fortunately, there was not a serious drought in this region during the 1997–98 El Niño, some areas even receiving more than the average rainfall (*3*). This illustrates the large variability between El Niño events.

Forest and bush fires

Drought increases the susceptibility of some forests and rangelands to fires. Widespread bush fires in Australia during 1983 were partly attributable to the preceding drought associated with the 1982–83 ENSO, which had depleted moisture in vegetation and soil (*2*). Indonesia suffers recurrent drought associated with El Niño (*15*). Such drought in association with slash-and-burn methods of land clearance can trigger uncontrolled forest fires. Every El Niño since at least 1982 has been associated with fires in Kalimantan, and there have been consequent public health implications. Smoke from the 1997 forest fires in Kalimantan and Sumatra affected surrounding countries (*16*). Starting in late July 1997 there were elevated levels of particulates in the air for approximately two months. The public health implications of haze-type air pollution are considerable because of the large number of people who may be exposed.

Disease, weather and climate

In all epidemiological studies there are difficulties in estimating the role of climate per se as a cause of change in health status. Field-based epidemiological research into climatic influences on disease causation requires sufficient information enabling differentiation between the effects of coexistent climatic and non-climatic factors (*17*). For example, the periodic nature of some epidemics may be attributable to the waxing and waning of herd immunity. Table 2 indicates the factors that need to be addressed when evaluating a relationship between climate and health.

Many regions in the tropics have no effective public health infrastructure, and the transmission of vector-borne diseases often has a natural boundary where ecological or climatological conditions limit the distribution or activity of the pathogen or vector. Weather events can have a significant effect on insect or rodent reproduction and mortality rates and can influence the overall abundance of these disease vectors. There is a well-studied relationship between rainfall and diseases spread by insect vectors, e.g. mosquitoes, that breed in water and are therefore dependent on the availability of surface water. The ecology of local vector species needs to be understood in order to describe the epidemiology of diseases and the role of climate variability. There is rarely a simple relationship between climate, vector abundance and disease transmission.

Table 1. **El Niño events during the 20th century**

Years	Magnitude	Year(s)	Magnitude
1899–1900	Very strong	1951	
1902–1903	Strong	1953	
1905–1906		1957–1958	
1913–1915	Strong	1963	Immature event
1918–1920	Strong	1965	
1923–1924		1969[a]	Immature event
1925–1926		1972–1973	Strong
1930–1931		1976–1977	
1932–1933		1979	Immature event
1939–1940		1982–1983	Very strong
1940–1941	Very strong	1987–1988	Strong
1941–1942		1991–1994	Three separate events?
1946–1947		1997–1998	Very strong

[a] There has been some disagreement about this event.

Malaria

In areas of unstable malaria, populations lack protective immunity and are at risk of epidemics when atypical weather conditions facilitate transmission. At the fringes of malaria transmission there are areas where rainfall and/or temperature are the main limiting factors for disease transmission. In highland areas the transmission of malaria may be increased by higher temperatures associated with El Niño, particularly during the autumn and winter. This happened in northern Pakistan during the period 1981–91 (*18*). Higher temperatures in conjunction with heavy rainfall have been associated with increases in highland malaria in Rwanda (*19*) and Uganda (*20*).

Table 2. **Factors to be considered when assessing the scientific plausibility of a statistical relationship between ENSO and health outcomes**

Type of evidence	Description	Example
Climatological	Evidence of regional or local climate effects related to ENSO	Below average rainfall during typical El Niño event
Biological plausibility	Evidence that health outcome is causally affected by climate variables (rainfall, land surface temperature, sea surface temperature)	Field studies on the abundance of vectors in relation to temperature and rainfall changes
Epidemiological	Statistical evidence of an association between health impacts and climate variables (rainfall, land surface temperature, sea surface temperature) or ENSO parameter (Southern Oscillation index), with due consideration of confounders	Southern Oscillation index (a parameter of ESNO) associated with changes in annual risk of malaria

Conditions in desert fringe areas are normally too dry for malaria transmission. The semi-arid region of north-west India experiences malaria epidemics after excessive monsoon rainfall. The risk of a malaria epidemic in Punjab increased fivefold during each year following an El Niño event over the period 1868 and 1943 (*21*). Historically, monsoon forecasting ability was based on the strong relationship between rainfall and the Southern Oscillation in this region. The sequence of a dry year followed by a wet year appears to be significant for the genesis of epidemics. The mechanisms involved have not been determined, although famine may have increased susceptibility to infection. Because of economic and ecological changes, Punjab no longer experiences malaria epidemics. However, epidemic malaria is still a serious problem in the more arid areas of Gujarat. There is a significant relationship between annual rainfall and malaria incidence in most districts of Rajasthan and some districts in Gujarat (*22*). A high risk of malaria and excessive monsoon rainfall can be expected in years following the onset of El Niño and during La Niña.

In areas with very humid climates, droughts may turn rivers into strings of pools suitable for vector breeding. When this happens, opportunistic breeding by vectors can provide epidemic conditions. South-west Sri Lanka, which experiences two annual monsoons, is one such area; a fourfold increase in the epidemic risk occurred during El Niño events between 1870 and 1940 (*21*). This risk was associated with the failure of the south-west monsoon, often combined with failure of the north-east monsoon in the preceding year.

Many parts of South America are affected by El Niño. In 1983, epidemics of malaria in Bolivia, Ecuador, and Peru were associated with heavy rainfall linked to a strong El Niño event (*23–25*). The malaria epidemic in Ecuador was exacerbated by population displacement caused by flooding. The relationship between ENSO and malaria has been investigated in Venezuela (*26*) and Colombia (*27–29*) (Table 3). These countries usually have below-average rainfall during El Niño events. In Venezuela the number of cases of malaria increased by 37% on average in the year after El Niño events (Fig. 1). In Colombia, there was an increase of 17.3% in malaria cases during El Niño events and of 35.1% in the following year (*27*). El Niño is associated with a reduction in rainfall in much of Colombia, where, normally, the rainfall is relatively high. Reduced run-off and stream flow may increase mosquito abundance by increasing the number of breeding sites (*28*). Higher temperatures during El Niño episodes may also favour malaria transmission. It is not fully understood, however, why the incidence of malaria increases after a dry period, as happens in Venezuela.

Africa has desert fringe malaria around the Sahara and the Kalahari. Southern Africa and a region east of the Sahara show ENSO-related rainfall anomalies. Associations between malaria risk and ENSO have been found in the highlands of East Africa and the dry lands of southern Africa (*7*, *30*). The 1997–98 El Niño was associated with heavy rainfall and flooding in north-east Kenya, a region normally too dry for malaria transmission (*31*); from January to May 1998 a major epidemic of falciparum malaria occurred in a population that had no immunity. This was the first such outbreak since 1952. The epidemic was compounded by widespread food shortages, the late recognition of the outbreak, a concurrent outbreak of Rift Valley fever, and a nurses' strike.

Dengue fever

Dengue fever is an important viral disease transmitted by mosquitoes. It occurs seasonally and is usually associated with relatively warm and humid weather. Although the vectors breed in artificial containers, increased rainfall can affect vector density in some locations (*32*). Many countries in Asia experienced an unusually high level of dengue and dengue haemorrhagic fever in 1998, some of which may have been attributable to weather conditions related to El Niño (*33*). Epidemics of dengue fever in some South Pacific islands have been linked to La

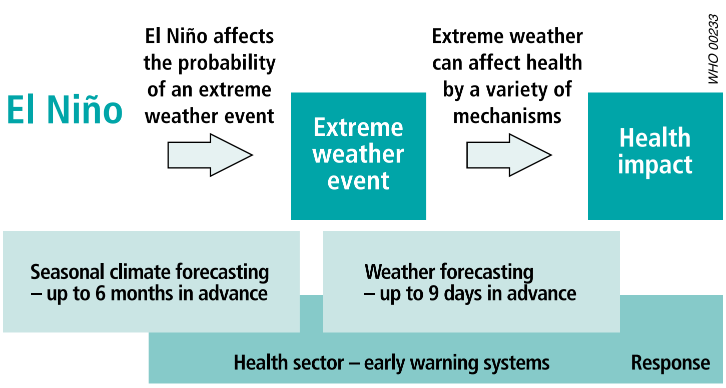
Niña conditions involving weather that is wetter and warmer than normal (*34*, *35*). Unpublished studies have found no relationship between epidemic dengue activity in Puerto Rico and Thailand; good dengue surveillance data exist for the populations in question, which are not significantly affected by El Niño. In Indonesia, which has a strong El Niño signal, i.e. drought, dengue fever epidemics have often occurred in the year after the onset of El Niño. The environmental or meteorological risk factors for increases in dengue fever cases have not been unequivocally identified. Higher temperatures are associated with increased transmission of arboviral diseases. Rainfall may affect vector abundance but this may be less significant in urban areas, where dengue fever primarily occurs, than in rural areas.

Effects in Oceania

ENSO usually has a strong effect on the weather in parts of Australia. Murray Valley encephalitis, also known as Australian encephalitis, is an arboviral disease that has so far been reported only in Australia. Interannual rainfall variability in eastern and northern Australia are closely related to the Southern Oscillation. Frequent small epidemics of Murray Valley encephalitis occur in tropical parts of the country. However, there have been infrequent but severe epidemics in temperate south-east Australia after rainfall well above the average and flooding associated with La Niña episodes (*36*).

Ross River virus, which causes epidemic polyarthritis, is transmitted by a wide range of mosquito species in complex transmission cycles involving several intermediate hosts. The disease is distributed throughout Australia and elsewhere in the South Pacific. Although the relationship with ENSO is less certain than for Murray Valley encephalitis, the public health impact of Ross River virus infection is greater because of the numbers of people affected. In arid areas the virus is thought to persist in mosquito eggs for a considerable time. When environmental conditions become favourable, as happens when there is heavy rain or flooding, the eggs hatch and develop into infected mosquitoes, possibly giving rise to localized outbreaks of the disease. Epidemics of Ross River virus disease in southern Australia between 1928 and 1998 were associated with the Southern Oscillation index (*37*). Some outbreaks may be linked to weather patterns associated with ENSO but a strong relationship has not been proved (*38*, *39*).

Fig. 2. **Time-scale for El Niño early warning systems**



Rift Valley fever

Rift Valley fever is an arboviral disease that primarily affects cattle. In Kenya, outbreaks in the usually dry grasslands are always associated with periods of heavy rain. Analyses of outbreaks between 1950 and 1998 found a strong relationship with persistent rainfall (*40*) and a weaker association with the monthly Southern Oscillation index and other ENSO parameters (*41*). It is thought that infected eggs of the mosquito vector are present in large numbers in grassland depressions, where flooding enables the mosquitoes to develop and appear in high enough densities to cause epidemics. A major outbreak of Rift Valley fever, affecting both humans and cattle, was triggered by extremely heavy rainfall in north-eastern Kenya and southern Somalia between October 1997 and January 1998.

Rodent-borne diseases

Rodents, whether as intermediate infected hosts or as hosts for arthropod vectors such as fleas and ticks,

Table 3. **High-risk years for malaria in relation to the ENSO cycle**

Country/district	Period	Relative risk		Reference
Sri Lanka (south-west)	1870–1945	3.6	El Niño year	*21*
India + Pakistan (Punjab)	1867–1943 (pre-DDT)	4.5	Year after El Niño	*21*
Pakistan (North-West Frontier Province)	1970–1993	—[a]		*18*
India (Rajasthan)	1982–1992	—[a]	El Niño year	*22*
Venezuela	1910–1935	5.0	Year after El Niño	Unpublished
Venezuela (Carabobo)	1975–1990	—[a]	Year after El Niño	*26*
Colombia	1960–1992	—[a]	Year after El Niño	*27*
Colombia	1959–1993	—[a]	Year after El Niño	*27*

[a] Relative risk not calculated.

are reservoirs for a number of diseases. In temperate regions, rodent abundance increases following mild wet winters (*42*). Rodent populations are reservoirs for hantaviruses, with which people become infected mainly by inhaling aerosolized rodent excreta. The emergence of the hantavirus pulmonary syndrome during the early 1990s in the southern USA has been linked to changes in local rodent abundance (*43*). Drought conditions had reduced populations of the rodents' natural predators, and subsequent high precipitation increased the availability of food in the form of insects and nuts. A study in the Four Corners Region of the USA concluded that above-average precipitation during the winter and spring of 1992–93 may have led to a rise in rodent populations, thus increasing contact between rodents and humans and transmission of the virus (*44*). During the El Niño episode of 1997–98 there was a ten- to twentyfold increase in numbers of rodents (*Peromyscus* spp.) in this region. A significant increase in the number of cases of hantavirus pulmonary syndrome was also reported (*45*). This suggests a link between El Niño and the syndrome. Predictive models of disease risk are being developed on the basis of long-term studies of reservoir populations, using data on environmental factors and disease surveillance (*46*).

Cholera and diarrhoeal diseases

Heavy rainfall is often an important factor in the contamination of surface water with sewage or slurry. Common causes of diarrhoea that are linked to contaminated water supplies and flooding include cholera, typhoid, and shigellosis. The health impacts of flooding occur irrespective of whether it is linked to El Niño. Drought can also lead to increased concentrations of pathogens in surface water and to hygiene-related diseases. Furthermore, elevated temperatures are associated with an increase in gastrointestinal infections. Above-average temperatures in Peru during the El Niño event of 1997–98 were associated with a significant increase in the number of children admitted to hospital with diarrhoea (*47*).

Attention has been focused on cholera and ENSO because several major outbreaks occurred in 1997 following heavy rain and flooding, e.g. in Chad, Guinea-Bissau, Kenya, Somalia, and United Republic of Tanzania (*48*). Cholera has traditionally been viewed as a faecal-oral infection. However, recent research supports the idea of a marine reservoir of the pathogen. This may help to explain the endemic character of the disease in certain regions, such as the estuaries of the Ganges and Brahmaputra in Bangladesh. Studies of *Vibrio cholerae* 01 in Bangladesh have found that the abundance of this organism increases with that of copepods feeding on phytoplankton in coastal waters (*49*). A relationship was found between cholera cases in Bangladesh and sea surface temperature in the Bay of Bengal (*50*). El Niño events raise sea surface temperatures and may therefore be associated with an increased risk of outbreaks in the region.

Climate forecasting driven by El Niño

Seasonal forecasts — also termed medium-range climate forecasts — are used to predict major climate trends for a single season up to 12 months in advance. In many areas, especially within or near the tropics, the reliability of such forecasts is greatest when El Niño or La Niña events are occurring. Because individual weather systems are chaotic, the weather is inherently unpredictable for more than 7–9 days into the future. A seasonal weather forecast is usually limited to the probability of temperature or rainfall being above, near or below normal. Predictions are better for some seasons than others and for some regions than others (*3*). The increasing accuracy of many seasonal weather forecasts derives from two recent developments: the availability of real-time climate data from monitoring stations around the world; and the availability of sufficient computing power to simulate the global climate. Farmers and agricultural agencies have been successfully using such forecasts for several years to mitigate the effects of drought in Australia, Brazil and elsewhere. Seasonal forecasts are now sufficiently reliable to be of use for health purposes (Fig. 2). Seasonal forecasts may assist in achieving preparedness for epidemics and in targeting the use of scarce resources. However, these forecasts should be integrated into comprehensive and well-supported early warning systems. The relationships between seasonal climate anomalies and disease impacts are often not sufficiently predictive for operational use (*21*, *27*, *37*, *41*). Local, near-time information is also required in order to provide early warning indicators of epidemic risk — principally concerning the local environmental factors that are associated with epidemics. Satellite data can provide proxy ecological variables such as rainfall estimates or vegetation indices at more appropriate spatial resolution (*51*). The early detection of an epidemic requires epidemiological surveillance of high quality. Many countries lack good surveillance systems that would help them to detect epidemics sufficiently early to be able to respond adequately (*52*). The potential exists for developing models for medium-term forecasts of disease risk, based on seasonal climate forecasts. Clearly, as seasonal forecasting becomes more reliable it will be more useful. In addition to the need for reliability, much work is required in order to ensure equal, timely and appropriate access to information on forecasts.

El Niño and global climate change

It is important to distinguish between climate change and climate variability. Climate varies on all spatial and temporal scales. The ENSO phenomenon is an example of quasi-periodic climate variability on the interannual time scale. In contrast, climate change is the incremental long-term change in the expected climate for a given location. The large-scale pollution of the lower atmosphere with greenhouse gases is likely to affect the global climate significantly over the next few decades. Climatologists are becoming more confident that climate change resulting from human activities has already begun (*1*). Climate change will be superimposed on a background of natural climatic variability. There is considerable concern about how climate change might affect the frequency or intensity of ENSO events in the future. If the recurring frequency and/or intensity of El Niño and La Niña were to change there would be profound changes to many local and regional climate extremes, with consequent health impacts (*3*).

Conclusion

There is good epidemiological evidence that El Niño is associated with an increased risk of certain diseases in specific geographical areas where climate anomalies are linked with the ENSO cycle. The associations are particularly strong for malaria but there is also evidence of associations with other mosquito-borne and rodent-borne diseases. However, more research is needed to determine the nature of the ecological mechanisms of these relationships. El Niño provides an opportunity to illustrate the importance of the ecological basis for many diseases. These linkages need to be more fully appreciated by health professionals, policy-makers and the general public. Advances in seasonal forecasting provide the opportunity to develop longer-term predictions of epidemic risk in some vulnerable areas. Current research on the incorporation of climate forecasts into epidemic early warning systems may yield benefits in the near future. It is essential to reduce vulnerability to climate and weather extremes in the interest of achieving sustainable development. ■

Résumé

El Niño et la santé humaine

Le phénomène El Niño/oscillation australe est le meilleur exemple connu de variabilité naturelle et quasi-périodique du climat qui se mesure en années. Il provoque un changement de la température de l'océan Pacifique (El Niño) et de la pression atmosphérique sur l'ensemble du bassin du Pacifique (oscillation australe), ce qui affecte le climat de la planète. L'intervalle entre deux phénomènes El Niño est de deux à sept ans. Cet épisode chaud est parfois suivi d'un épisode froid appelé La Niña. Il se manifeste par des conditions météorologiques extrêmes (sécheresse ou pluies torrentielles) dans certains pays qui bordent le Pacifique ou qui sont plus éloignés. De longues périodes de sécheresse surviennent en Indonésie, dans le nord de l'Australie et aux Philippines, tandis que de fortes précipitations, qui donnent lieu parfois à d'importantes inondations, s'abattent sur l'Equateur et le Pérou. A l'échelle mondiale, les catastrophes naturelles ont des conséquences plus graves pendant les épisodes El Niño. En agissant sur les précipitations, les températures et l'activité cyclonique, El Niño agit sur la santé humaine. Les immenses feux de forêt que provoque ce phénomène et la pollution atmosphérique qui en découle posent un problème de plus en plus important. La plupart des décès et des maladies associés à El Niño sont dus à des catastrophes d'origine climatique.

Le risque de maladies transmises par les moustiques, comme le paludisme, la dengue et autres maladies à arbovirus, évolue avec le cycle d'El Niño. Les variations climatiques ont un effet particulièrement sensible sur le paludisme. Dans les zones où la transmission n'est pas constante, les populations n'ont pas d'immunité protectrice et de graves épidémies peuvent survenir quand la transmission est facilitée par des conditions climatiques inhabituelles. En Colombie et au Venezuela, le nombre de cas de paludisme augmente de plus d'un tiers après les épisodes de sécheresse associés à El Niño ; dans le sud-ouest de Sri Lanka, les épidémies sont quatre fois plus importantes quand se produit ce phénomène. Mais c'est sans doute la variation des précipitations qui a la plus grande incidence sur les maladies à transmission vectorielle. Toutefois, dans les régions montagneuses, l'élévation des températures peut aussi avoir des conséquences importantes sur la transmission du paludisme, comme on l'a constaté dans le nord du Pakistan.

Des études préliminaires ont mis en évidence un lien entre El Niño et l'activité de la dengue dans certains pays insulaires du Pacifique. En Australie, il semble que l'encéphalite de la vallée de la Murray et la maladie due au virus de la rivière Ross (toutes deux causées par des arbovirus) soient influencées par le cycle El Niño/oscillation australe. Les flambées de fièvre de la vallée du Rift surviennent généralement à la suite de fortes pluies, encore qu'El Niño ne se manifeste pas toujours par des précipitations abondantes dans les régions concernées. El Niño influe aussi sur les maladies transmises par les rongeurs. Dans le sud des Etats-Unis, les populations de souris qui servent de réservoirs aux hantavirus augmentent quand se produit El Niño et il semble qu'il y ait une association entre la survenue de ce dernier et une fréquence accrue du syndrome pulmonaire dû aux hantavirus dans ce pays. Des études ont révélé récemment que le plancton pouvait être un réservoir marin de choléra. Une hausse de la température des eaux de surface entraîne une prolifération du plancton et peut donc faciliter la transmission du choléra dans les zones côtières. Certains éléments portent à croire que cela s'est produit dans la baie du Bengale.

Il semblerait que le phénomène El Niño/oscillation australe soit associé à un risque accru pour certaines maladies à transmission vectorielle dans des zones

spécifiques où la situation météorologique est liée à ce cycle et où les mesures de lutte contre la maladie sont limitées. C'est particulièrement vrai pour le paludisme, mais aussi, semble-t-il, pour les épidémies d'autres maladies transmises par les moustiques et les rongeurs que peuvent déclencher des conditions météorologiques extrêmes. Les prévisions météorologiques saisonnières, qui indiquent plusieurs mois à l'avance quelle sera la situation météorologique probable, peuvent permettre d'anticiper le risque d'épidémie à chaque saison, en particulier pour le paludisme.

Resumen

El Niño y la salud humana

El fenómeno de El Niño/Oscilación Austral (ENOA) es el ejemplo más conocido de variabilidad natural cuasi periódica del clima a escala interanual. Entraña cambios en la temperatura de las aguas marinas del Océano Pacífico (El Niño) y en la presión atmosférica a lo largo de la cuenca del Pacífico (Oscilación Austral), y como consecuencia se ve afectado el clima mundial. El Niño reaparece a intervalos de entre dos y siete años. A El Niño, un fenómeno cálido, le sigue a veces otro frío, La Niña. El Niño se asocia con una serie de condiciones climáticas extremas (sequía o precipitaciones excepcionalmente intensas) en algunos países situados alrededor del Pacífico y en zonas más alejadas. Puede haber periodos prolongados de sequía en Indonesia, el norte de Australia y Filipinas, mientras que en el Ecuador y el Perú pueden caer fuertes precipitaciones, a veces acompañadas de inundaciones de extensas zonas. A nivel mundial, el impacto de los desastres naturales aumenta durante el fenómeno de El Niño. Los cambios que experimentan la pluviosidad, las temperaturas y la actividad de los huracanes contribuyen a aumentar los efectos de El Niño en la salud humana. Los grandes incendios forestales y la consiguiente contaminación por nubes de humo son un problema cada vez mayor asociado con El Niño. La mayoría de las defunciones y enfermedades asociadas al fenómeno se pueden atribuir a desastres relacionados con el clima.

El ciclo de El Niño se asocia a cambios del riesgo de contraer enfermedades trasmitidas por mosquitos, como el paludismo, la fiebre del dengue y otras enfermedades arbovirales. El paludismo es particularmente sensible a los cambios climáticos. En las zonas donde la transmisión de esa enfermedad es inestable, las poblaciones carecen de inmunidad protectora, de modo que unas condiciones climáticas atípicas pueden facilitar la propagación y causar epidemias graves. En Colombia y Venezuela, los casos de paludismo aumentan más de un tercio después de las sequías provocadas por El Niño. También en el suroeste de Sri Lanka el número de epidemias de paludismo se multiplica por cuatro durante el fenómeno. Los cambios de la pluviosidad son probablemente el principal mecanismo por el que El Niño afecta a la propagación de enfermedades transmitidas por vectores. Sin embargo, las elevadas temperaturas registradas en las zonas montañosas también pueden contribuir a la transmisión del paludismo, como se ha podido constatar en el norte del Pakistán.

Estudios preliminares han demostrado una relación entre el fenómeno de El Niño y los casos de fiebre del dengue en algunos países insulares del Pacífico. En Australia, existen indicios de que el ciclo ENOA influye en los casos de encefalitis del valle de Murray y de la enfermedad causada por el virus del río Ross (ambas de origen arboviral). Es normal que después de episodios de lluvias intensas se den brotes de la fiebre del valle del Rift, pero El Niño no siempre lleva asociadas fuertes precipitaciones en las regiones afectadas. El Niño también puede incidir en las enfermedades transmitidas por roedores. En el sur de los Estados Unidos las poblaciones de ratones, reservorios del hantavirus, han aumentado durante El Niño, y hay indicios de que en ese país los casos de síndrome pulmonar por hantavirus tienden a aumentar coincidiendo con dicho fenómeno. Estudios recientes han demostrado que el plancton puede actuar como reservorio marino del cólera. En consecuencia, el aumento de las temperaturas de la superficie marina puede provocar una mayor abundancia de plancton y facilitar así la transmisión del cólera en las zonas costeras. Se ha sugerido que eso es lo que ha ocurrido en el golfo de Bengala.

Algunos datos llevan a pensar que el ENOA aumenta el riesgo de contraer ciertas enfermedades transmitidas por vectores en determinadas zonas geográficas donde las condiciones meteorológicas están relacionadas con el ciclo del ENOA y donde el control de enfermedades es limitado. Ello se aplica en particular al paludismo, pero también se ha sugerido que existe cierta relación con epidemias de otras enfermedades transmitidas por mosquitos y por roedores y desencadenadas a menudo por condiciones climáticas extremas. Las previsiones meteorológicas estacionales sobre la evolución probable del clima con varios meses de antelación se pueden emplear para obtener indicadores estacionales precoces del riesgo de epidemias, sobre todo en el caso del paludismo.

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