El Niño related health hazards in India

Rais Akhtar

The term El Niño (means Christ child in Spanish) was originally used by fishermen along the coasts of Ecuador and Peru to refer to a warm ocean current that typically appears around Christmas time and lasts for several months. Fish are less abundant during these warm intervals, so fishermen often take a break to repair their equipment and spend time with their families. Over the years, the term 'El Niño' is referred to these exceptionally strong warm intervals that not only disrupt the normal lives of the fishermen, but also bring heavy rains.

El Niño phenomenon (current) was first observed by the German explorer/geographer and naturalist Alexander von Humboldt (1769–1859). The Humboldt Current was named after him.

In a letter dated 18 September 1839, Humboldt wrote to Charles Darwin as follows: '. . .I wished to tell you still more about this running cold water which runs alongside the Peru of which I am very concerned, believing that it will much modify the climate of the littoral. . .'[1].

The cool Humboldt Current flows north along the west coast of South America. It is part of the anti-clockwise flow of the South Pacific gyre, a circular current on the ocean's surface. As the wind and current push seawater away from the coast, upwelling occurs, which allows cool, deep, nutrient-rich waters to rise to the sunlit zones. This, in turn, creates a food-rich marine environment that includes penguins and sea lions, and productive fishing grounds.

The cool upwelling also produces fog, but little rainfall in the desert coasts of Peru and northern Chile. Occasionally, the pattern is broken, the upwelling stops and is overridden by warm tropical waters from the central Pacific. This reversal of marine temperature conditions is known as El Niño. This causes great loss of marine life and changes conditions from dry and desert-like to stormy and humid. On rare occasions, such as in 1982 and 1983, a prolonged El Niño may extend beyond the Humboldt Current region to as far north as California and as far south as the Antarctic.

Table 1 shows the El Niño events which were noted during the 20th century[2].

When El Niño event occurs, there is a decline in the production of plankton which has repercussions on fish and sea bird populations.

The 1998 El Niño

A severe El Niño in 1998 killed more than 2000 people and caused billions of dollars damage to crops and infrastructure in Australia and India. It came in the middle of the Asian crisis that severely affected the financial markets.

The 1998 El Niño severely affected the climatic conditions in India; causing heat waves which resulted in great loss of life[3] (Figure 1; Table 2).

Major parts of the country extending from north India, parts of north-east India to the northern parts of peninsular India experienced severe heat wave during May 1998. The heat wave was the severest in 50 years and resulted in more than 2600 deaths. In Orissa, one of the poorest states, the temperature rose to a scorching 49.5°C and killed nearly 1300 people. Bihar, West Bengal, Andhra Pradesh, UP, Maharashtra and Punjab also experienced temperatures as high as 45–49°C (ref. 4). Even south interior Karnataka and parts of Tamil Nadu were under the grip of severe heat wave conditions during this period. Chennai recorded the second highest maximum temperature (44°C) of the present century on 24 May, which was 8°C above normal; the highest ever recorded maximum temperature in Chennai being 45°C (21 May 1910).

Table 1. El Niño event in 20th century

Year	Strength of El Niño
1899–1900	Very strong
1902–1903	Strong
1913–1915	Strong
1918–1920	Strong
1940–1941	Very strong
1972–1973	Strong
1982–1983	Very strong
1987–1988	Strong
1991–1994	Three separate events
1997–1998	Very strong

It is a fact that the people residing at a place for a sufficiently long time get more or less acclimatized to the normal weather conditions of that place. Thus, though, the maximum temperature of north-west India especially Rajasthan was nearing 50°C, the death toll in Rajasthan and north-west parts of the country was less, compared to that of Orissa. The large number of deaths in Orissa was perhaps due to lack of adaptability by the people to such extreme conditions. A comparative scenario of heat wave mortality between European and Indian heat waves in 2003 reveals that in India, the 2003 mortality figure was second highest in the country after 1998. It is also interesting to note that both the heat wave as well as cold wave mortalities were highest in India (Figure 2).

Table 2. Heat waves in India

Year	Number of deaths
1979	361
1980	156
1981	72
1982	16
1983	185
1984	58
1985	142
1986	156
1987	91
1988	637
1989	44
1990	2
1991	252
1992	114
1993	42
1994	434
1995	412
1996	20
1997	20
1998	1662
1999	126
2000	57
2001	70
2002	806
2003	1539
2004	117
2005	587
2006	135
2007	476
2008	294

Source: IMD[6] Annual Reports on 'Disastrous Events', Pune.

Malaria outbreak in western Rajasthan during the 1994 El Niño

The outbreak of malaria epidemic in four districts of desert region of western Rajasthan state – Bikaner, Jodhpur, Barmer and Jaisalmer, in 1994 has broken the myth that desert zone is less prone to malaria epidemic. This wrong notion over the years led to laxity on the part of state government and the National Malaria Eradication Programme (now National Vector Borne Disease Control Programme), in adopting suitable preventive measures.

A couple of studies pertaining to this outbreak appeared in 1995 (ref. 5). Two different hypotheses[3] regarding the meteorological correlation and the canal irrigation system were put forth. Significantly, almost all studies lack empirical bases on malaria incidence as well as the meteorological data.

Changing pattern of rainfall in the Thar desert – historical context

It is worthwhile at this stage to study the changing rainfall pattern in the desert region. Goudie, who studied the changing rainfall pattern in arid areas, including the Thar noted a noticeable change in rainfall from 1890 to 1895 (ref. 6). Conditions had been relatively wet in 1880 and 1890 (June–September summer monsoon rainfall; 1818–90 (2422 mm) and 1891–1900 (2472 mm)), but then there followed a period of low precipitation, with precipitation in the driest decadal period being generally only between 52% and 69% of that for the wettest decade of this century. A decrease in the summer rainfall was also noted during 1957–70 (Table 3). Analysis of data for Bikaner and Jodhpur of Thar desert showed that summer monsoon rainfall decreased steadily by more than 45% since 1957.

Table 3. Five-year running mean percentage of normal summer monsoon seasonal rainfall centred on 1957 and 1970

	1957	1970
Bikaner	114	71
Jodhpur	115	68

Source: Goudie, A., *Environmental Change*, Clarendon Press, Oxford, 1983, p. 156.

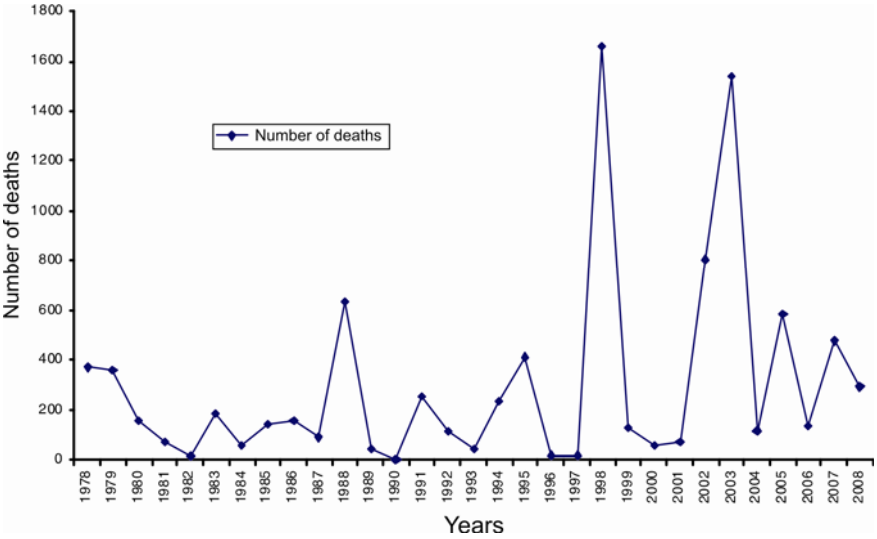

Figure 1. Heat wave deaths in India (1979–2008). Source: IMD Annual Reports on 'Disastrous Weather Events', Pune.

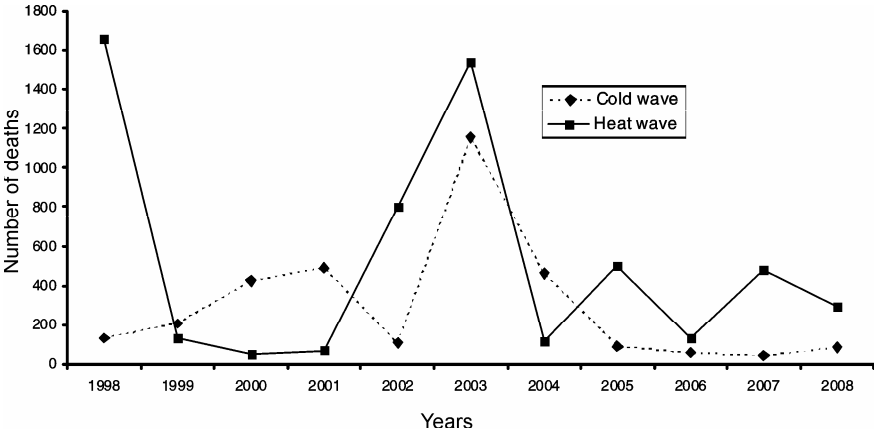

Figure 2. Heat wave and cold wave mortality in India: comparative pattern (1998–2008). Source: India Meteorological Department, Pune.

Analysis of flood years[7] in the desert region for a period of 123 years after 1871 showed that only five years (flood years) recorded summer monsoon rainfall above 500 mm. These years were 1908 (573 mm), 1917 (564 mm), 1944 (542 mm), 1990 (777 mm) and 1994 (544 mm); 1994 being the year of the most recent malaria outbreak in the region. Similarly, malaria was also reported in epidemic form during the 1990 flood year. This argument can be supported with empirical evidences as shown in Figure 3 and Table 4. Thus, it is evident that rainfall pattern in the desert region has been changing. However, the summer monsoonal rainfall of 500 mm and above may be taken as an indicator in forecasting malaria outbreak in the Thar desert[8,9].

Role of irrigation canals

The construction of canals in the desert region commenced in 1962, and the first phase was completed in 1990. But the canals have created waterlogging problems. The soil structure has changed with increased moisture retaining capacity. And a new vector, *Anopheles culicifacies* is increasing in this area, which was earlier dominated by *A. stephensi*. *A. culicifacies* remains active throughout the year. Such an environment must have contributed to the increased incidence of

Table 4. Rainfall, rainy days and incidence of malaria in Jodhpur

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Average November temperature	24.0	21.0	23.0	24.5	24.0	24.6	23.2	24.2	23.0	23.0	22.4	24.1	22.7
Total annual rainfall (in mm)	417	513	231	214	249	111	270	230	844	204	526	326	595
Number of rainy days	36	41	21	20	17	16	38	28	44	25	27	29	51
Total malaria cases	1509	5934	4803	2918	1034	399	2877	6011	10,462	6374	9685	3096	14,919
Percentage of *P. falciparum* cases to total cases	15	25	9	10	11	7	9.5	23	28.7	16.3	48.3	26.0	64.2

Source: India Meteorological Department, New Delhi.

malaria in the Thar desert. However, the outbreak of malaria in the region, particularly in 1994, cannot be associated with the changed environment due to canal irrigation network. Sudden rainfall due to El Niño Southern Oscillation created flooding conditions, and because of poor drainage in the Thar desert, resulted in the creation of breeding places. This caused both high morbidity and mortality. In 1993, 354 deaths in India were attributed to malaria. However, in 1994, some 372 deaths were officially reported in the four districts of Thar deserts, which accounts for about 0.6% of India's population.

It should also be noted that Punjab which has about 2.4% of India's total population with 98% irrigated cultivated area reports only 185 cases of *Plasmodium falciparum* with no deaths, compared to 88,310 *P. falciparum* cases with 452 deaths in Rajasthan. Thus the hypothesis that canal irrigation and waterlogging are the main reasons for malarial outbreak cannot be proved empirically[8].

Rainfall distribution in Thar desert (1982–94)

Based on 13 years data, an attempt has been made to study the association between rainfall conditions and the incidence of malaria. Figure 1 and Table 4 show that both the total annual rainfall and the number of rainy days are positively correlated with the total positive cases of malaria in the epidemic years of 1983, 1990 and 1994. Thus the hypothesis of meteorological correlation is proved positively (Figure 3; Table 4).

Attempt has also been made to correlate the average November temperature (average of mean minimum and maximum) with the incidence of *P. falciparum* cases during 1982–94. The correlation has been negative, as there is hardly any positive correlation in any year except during 1988 and 1989. It should be noted that 1994 was one of the four years which experienced the highest monsoon rains since 1871 (other years being 1917, 1944 and 1990). Besides, Table 4 reveals that since 1982, the highest number of rainy days occurred (i.e. 51) only in 1994. Therefore the contention of Tyagi *et al.* that the epidemic occurred in the desert region irrespective of high rainfall does not hold good[10]. Patrick Hehir in his book *Malaria in India*, published in 1927, classified the desert region as a moderate epidemic zone. He further said that malaria is markedly seasonal in character (usually autumnal) and moderately prevalent[11]. It may be mentioned that no study was conducted in the desert area in the past except the one by Green who studied the distribution of malaria parasites in Nasirabad (near Ajmer), a border zone of the desert. Green stated that in 1909, 90% of malaria occurred due to *P. vivax*, with the remaining 10% due to *P. falciparum*[11].

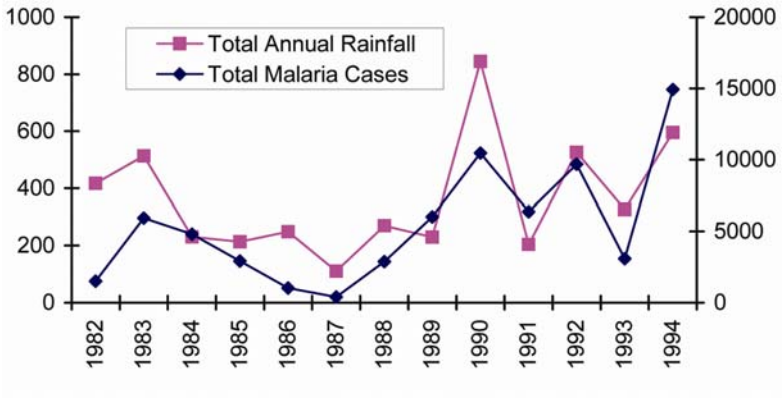

Figure 3. Rainfall and incidence of malaria in Jodhpur.

Conclusion

The heat wave occurrence and malaria outbreak in western Rajasthan do suggest the role of El Niño in health hazards. The current El Niño has also been considered very strong resulting in widespread drought conditions in India. Both kharif and rabi crops were damaged resulting in the import of cereals. Recent report suggests that the country is likely to import rice[12].

The impact of heat waves as well as malaria epidemics could be minimized by prediction and improved prevention through timely heat wave warnings; vector control and provision of sufficient drugs in dispensaries/health centres. Malaria early warning systems are advocated as a means of improving the opportunity for preparedness and timely response. The study also reveals that rainfall is one of the major factors triggering epidemics in desert areas. Explo-

sive epidemics often occur in these regions after excessive rains causing poor health and food insecurity in the region which already suffers from guinea worm disease and deficiency in food supply. Access to frequently updated rainfall information should become one of the essential elements for the development of integrated malaria early warning systems for the desert region.

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Rais Akhtar is in the Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi 110 067, India. e-mail: raisakhtar@hotmail.com

The Biological Diversity Act 2002 – governing conservation and development in India

A. Arunachalam and P. Roy

The Biological Diversity Act 2002 is a landmark in the environment and development field. It is a very comprehensive approach being taken for the first time towards the conservation of earth's biodiversity and sustainable use of its biological resources. The Convention on Biological Diversity was negotiated and signed by the nations at UNCED Earth Summit at Rio de Janerio in Brazil in June 1992. India is one of the 175 countries party to this convention. The main objectives of the convention are conservation of biological diversity, sustainable use of components of biodiversity, fair and equitable sharing of benefits arising out of the utilization of genetic resources. The National Biodiversity Act 2002 has 12 chapters, 65 sections and many subsections pertaining to balancing conservation and development.

Biodiversity means variability among living organisms from all sources including interalia terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are a part; which includes diversity within species, between species and of ecosystems[1]. Indian subcontinent forms part of the 25-mega diversity hotspots of the world, occupying only 2.5% of the land area and accounting for 7.8% of the globally recorded species[2]. India is party to the United Nations Convention on Biological Diversity signed at Rio de Janeiro on 5 June 1992. The convention reaffirms the sovereign rights of the states over their biological resources, and also expects the parties to facilitate access to genetic resources by other parties subject to national legislation. At national level, biodiversity is a multidimensional subject and the stakeholders in biological diversity conservation policy include the Central Government, State Government, Institutions of local Self-Governing organizations, industry, etc.

Recognizing the urgent need for developing human resources, capabilities and public policy, in order to take an active part in the new economy associated with the use of bioresources, 17 biodiversity rich countries have formed a group known as 'Like Minded Megadiverse Countries'.

This value added Act for biodiversity conservation bears policy guidelines that balance biodiversity conservation and sustainable development and warrant self-governance of bioresource utilization. In this article, the advantages and disadvantages of the National Biodiversity Act 2002 (ref. 3) have been elucidated along with the do's and the don'ts as per the Act for public awareness amongst all cross-sections of the society.

The advantages

- The convention reaffirms the sovereign rights of the states over their biological resources.
- It aims at conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of utilization of genetic resources.
- The Act provisions good institutional set-up comprising Chairperson, members, ex-officials, etc.
- Expenses of National Biodiversity Authority (NBA) including salaries, allowances, pension, etc. to be defrayed out of the consolidated fund of India.
- There is an establishment of State Biodiversity Board (SBB) to advise State Governments on issuing guidelines and granting of approvals.
- Under this Act, the State Government in consultation with the local bodies