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Review

The effects of the El Niño Southern Oscillation on skin and skin-related diseases: a message from the International Society of Dermatology Climate Change Task Force

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Abstract

The El Niño Southern Oscillation (ENSO) is a complex climate phenomenon occurring in the Pacific Ocean at intervals of 2–7 years. The term refers to fluctuations in ocean temperatures in the tropical eastern Pacific Ocean (El Niño [the warm phase of ENSO] and La Niña [the cool phase of ENSO]) and in atmospheric pressure across the Pacific basin (Southern Oscillation). This weather pattern is attributed with causing climate change in certain parts of the world and is associated with disease outbreaks. The question of how ENSO affects skin and skin-related disease is relatively unanswered. We aimed to review the literature describing the effects of this complex weather pattern on skin. El Niño has been associated with increases in the occurrence of actinic keratosis, tinea, pityriasis versicolor, miliaria, folliculitis, rosacea, dermatitis by *Paederus irritans* and *Paederus sabaeus*, and certain vector-borne and waterborne diseases, such as dengue fever, leishmaniasis, Chagas' disease, Barmah Forest virus, and leptospirosis, and with decreases in the occurrence of dermatitis, scabies, psoriasis, and papular urticaria. La Niña has been associated with increases in the occurrence of varicella, hand, foot, and mouth disease, and Ross River virus (in certain areas), and decreases in viral warts and leishmaniasis. Reports on the effects of ENSO on skin and skin-related disease are limited, and more studies could be helpful in the future.

Introduction

The term El Niño Southern Oscillation (ENSO) refers to fluctuations in ocean temperatures in the tropical eastern Pacific Ocean (El Niño and La Niña) and in atmospheric pressure across the Pacific basin (Southern Oscillation). This complex climate phenomenon is attributed with causing changes in weather patterns around the world and associated changes in patterns of disease, including skin and skin-related disease.

El Niño is the warm phase of ENSO and is characterized by unusually high sea surface temperatures (SSTs) in the Pacific Ocean; by comparison, La Niña is the cold phase, characterized by low SSTs. The strength of the Southern Oscillation is measured as the Southern Oscillation index (SOI), or the atmospheric pressure difference between Tahiti and Darwin, Australia. El Niño is associated with negative SOI values, whereas La Niña is associated with positive SOI values.[1,2]

El Niño causes extreme weather. It occurs when SSTs across the central and eastern Pacific Ocean become much warmer than normal. When SST increases, rain-producing cloud mechanisms shift eastward and away from cooler SSTs occurring over the western Pacific Ocean and around Southeast Asia. This results in unusually wet conditions and flooding along the western coast of South America, in the southern tier of the USA, and in eastern Africa. Simultaneously, El Niño causes long dry periods and droughts in southeastern Asia, Australia, southern Africa, and northeastern Brazil. La Niña, however, is linked with effects opposite to those associated with El Niño[1–3] (Figs. 1 and 2).

El Niño typically occurs at intervals of 2–7 years and lasts 12–18 months. However, in recent decades, the frequency and intensity of El Niño have increased, whereas the frequency of La Niña has decreased. These shifts have been associated with global climate change.[4,5]

Over the past 20 years, additional studies have shown that climate variability linked with this extreme weather phenomenon influences the incidences of diseases, such as diarrhea, cholera, Rift Valley fever, and hantavirus pulmonary syndrome.[2,6] The extent to which ENSO affects skin and skin-related diseases is still relatively unknown. We present a summary of the literature describing how

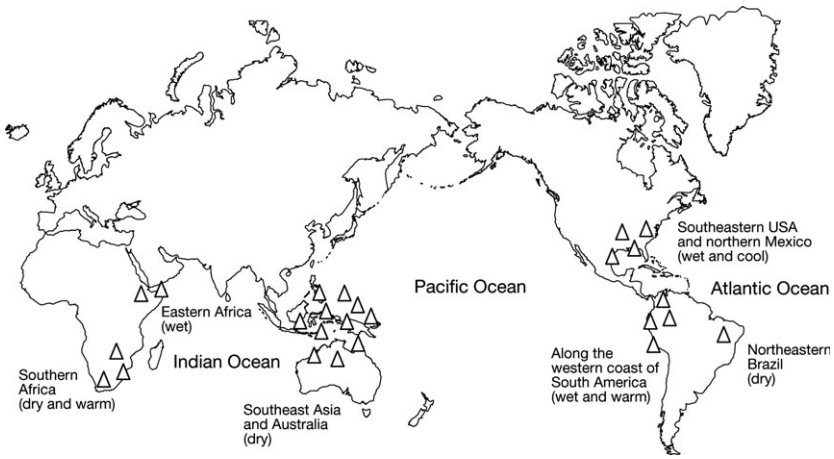

Figure 1 El Niño effects on weather. Triangles indicate affected areas

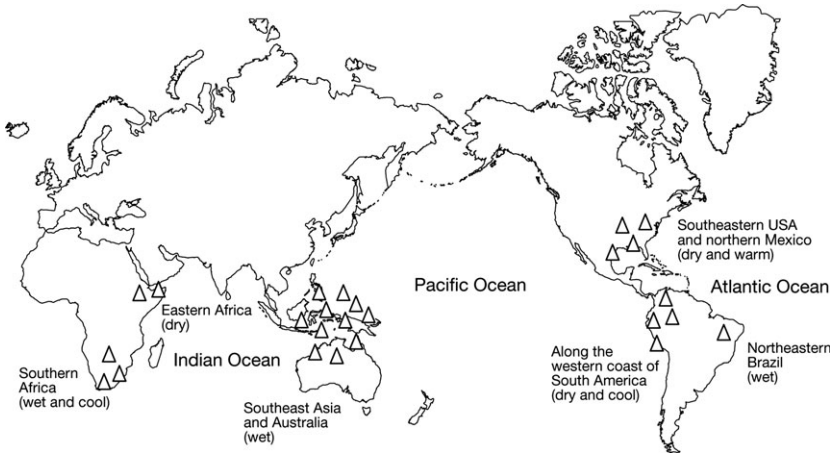

Figure 2 La Niña effects on weather. Triangles indicate affected areas

this complex weather pattern may be responsible for changes in risk for certain skin conditions and skin-related diseases, many of which are vector-borne diseases.

Materials and methods

PubMed and EMBASE were searched for articles using the terms "ENSO", "El Niño", "La Niña", "SOI", "disease", and "skin". Further searches were made in the International Society of Dermatology website library (accessible at http://www.intsocderm.org) and www.google.com. Studies published between 1990 and 2013 in any language were included in this investigation.[7–29] We abstracted information on the study period, region and country, and reported risk for disease associated with El Niño, La Niña, or both.

Results

Changes in climate are associated with ENSO-affected diseases. In relation to skin diseases, El Niño (the warm phase of ENSO) is associated with increases in reported cases of actinic keratosis, tinea, pityriasis versicolor, miliaria, folliculitis, rosacea, and dermatitis by *Paederus irritans* and *Paederus sabaeus*, and with decreases in reported cases of dermatitis, scabies, psoriasis, and papular urticaria. With reference to vector-borne and water-borne diseases, El Niño is associated with increases in reported cases of dengue fever, leishmaniasis, Chagas disease, Barmah Forest virus infection, and leptospirosis. Table 1 provides these data in more detail.[7–23]

In relation to skin diseases, La Niña (the cool phase of ENSO) is associated with increases in reported cases of varicella and hand, foot, and mouth disease, and with a decrease in the occurrence of viral warts. With reference to vector-borne diseases, La Niña is associated with an increase in reported cases of Ross River virus, but only in certain areas, and a decrease in the occurrence of leishmaniasis. Table 2 provides further details.[16,17,24–29]

Discussion

We summarized the literature describing changes in the occurrences of specific skin diseases associated with ENSO. In geographic areas where the effects of El Niño

Table 1 Published descriptions of the effects of El Niño on disease

Disease	Disease vector	Skin implications	Reference	Study period	Region/country	Changes associated with El Niño (negative SOI values)
Vector-borne and waterborne diseases						
Dengue fever	Mosquito	Typically, infected persons have a centrifugal maculopapular rash. In other cases, scarlatiniform or petechial rash may develop, starting on the dorsum of the hands and spreading to arms, legs and torso[33]	Cazelles *et al.*[7]	1983–1997	Thailand	Significant increase in incidence
			Gagnon *et al.*[8]	1965–1993	Indonesia	Significant increase in incidence at 95% CI
			Gagnon *et al.*[8]	1965–1993	Colombia	Significant increase in incidence at 90% CI
			Gagnon *et al.*[8]	1965–1993	French Guiana	Significant increase in incidence at 95% CI
			Gagnon *et al.*[8]	1965–1993	Suriname	Significant increase in incidence at 90% CI
			Corwin *et al.*[9]	1998	Sumatra, Indonesia	Dramatic increase in cases
			Colón-González *et al.*[10]	1985–2007	Mexico	Increase in incidence[a]
			Stewart-Ibarra & Lowe[11]	1995–2010	Ecuador	Increase number of cases
			Thai *et al.*[12]	1994–2009	Vietnam	Significant increase in incidence
			Tipayamongkholgul *et al.*[13]	1996–2005	Thailand	Dengue epidemics
Barmah Forest virus	Mosquito	Typically, infected persons have a maculopapular rash mostly affecting the limbs and trunk[36]	Bi *et al.*[14]	1992–1996	Queensland, Australia	Negative SOI values associated with a significant increase in incidence
Leishmaniasis	Sandflies	After incubation, the infection causes a red furuncle or papule at the bite site, which progresses within months to a skin ulcer, typically with indurated borders and a diameter of 2–6 cm[33]	Chaves & Pascual[15]	1991–2001	Costa Rica	Increase in cases
			Cardenas *et al.*[16]	1985–2002	Northeastern Colombia	Increase in cases
			Roger *et al.*[17]	1994–2010	Cayenne, French Guiana	Increase in cases
			Franke *et al.*[18]	1980–1998	Bahia, Brazil	Increase in incidence[b]
Chagas disease[c]	Triatominae bug	Infected persons have cutaneous manifestations; depending on the transmission route and phase of disease, cutaneous manifestation may include indurated erythematous plaques with necrosis, erythematous papules and nodules, panniculitis or skin ulcerations, chagoma Romaña sign, diffuse morbilliform rash[33]	Benchimol-Barbosa[19]	1982–2007	Brazil	A 0.2-cycle-per-year peak incidence

Table 1 Continued

Disease	Disease vector	Skin implications	Reference	Study period	Region/country	Changes associated with El Niño (negative SOI values)
Leptospirosis	Rodents	Occasionally, infected people have petechial rash and later, if severe disease, jaundice[37]	Storck *et al.*[20]	2003–2004	Guadeloupe archipelago, French West Indies	Dramatic increase in incidence, during a period with two El Niños
Skin diseases						
Actinic keratosis			Gutierrez *et al.*[24]	2004–2007	Lima, Peru	Significant increase in prevalence
Dermatitis by *Paederus irritans*			Alva-Davalos *et al.*[21]	1997–1998	Lima, Peru	Increase in cases in 1999
Dermatitis by *Paederus sabaeus*			van Schayk *et al.*[22]	1997–1998	Nairobi, Kenya	A dramatic increase in cases
Tinea			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant increase in incidence
Pityriasis versicolor			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant increase in incidence
Miliaria			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant increase in incidence
Rosacea			Gutierrez *et al.*[24]	2004–2007	Lima, Peru	Significant increase in prevalence
Folliculitis			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant increase in incidence
Dermatitis (not specified)			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant decrease in incidence
Scabies			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant decrease in incidence
Psoriasis			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant decrease in incidence
Papular urticaria			Bravo Sosu & Bravo Puccio[23]	1997–1998	Lima, Peru	Significant decrease in incidence

[a]Reported to be significant during the strong 1997–1998 El Niño.
[b]Reported as visceral leishmaniasis.
[c]Describes oral Chagas disease; however, if transmitted by a vector, the vector is the triatominae bug. At the bite site, the infected person can have an inflammatory nodule, a sign of chagoma.
90% CI, 90% confidence interval; 95% CI, 95% confidence interval; SOI, Southern oscillation index.

Table 2 Published descriptions of the effects of La Niña on disease

Disease type	Reference	Study period	Region/country	Changes associated with La Niña (positive SOI values)
Skin disease				
Hand, foot and mouth disease	Lin *et al.*[25]	2008–2010	Shenzhen, China	Extremely high positive SOI values (SOI of 45, with 0 as reference) associated with increase in cases
Varicella	Chan *et al.*[26]	2004–2010	Hong Kong, China	Temperature, atmospheric pressure, and SOI associated with increase in cases
Viral warts	Gutierrez *et al.*[24]	2004–2007	Lima, Peru	Significant decrease in prevalence

Vector-borne disease	Disease vector	Skin implications	Reference	Study period	Region/country	Changes associated with La Niña (positive SOI values)
Ross River disease	Mosquito	Typically, infected persons have a maculopapular rash. Rarely, purpuric lesions and small vesicles occur[38]	Maelzer *et al.*[27]	1928–1998	Australia	High positive SOI values associated with increase in cases
			Kelly-Hope *et al.*[28]	100 years	Australia	Only associated with increase during La Niña in southeastern Australia close to the Murray and Darling rivers, not in other studied zones of Australia
			Harley & Weinstein[29]	1928–1995	Australia	None
Leishmaniasis	Sandflies	After incubation, the infection causes a red furuncle or papule at the bite site, which progresses within months to a skin ulcer, typically with indurated borders and a diameter of 2–6 cm[33]	Cardenas *et al.*[16]	1985–2002	Northeastern Colombia	Decrease in cases
			Roger *et al.*[17]	1994–2010	Cayenne, French Guiana	Decrease in cases

SOI, Southern oscillation index.

and La Niña are strong, risk for many skin and skin-related diseases is likely to increase. However, a single event followed by a disease outbreak can be difficult to interpret because of the risk for confounding factors. Data series for an increased number of disease events in the same geographic area are generally more robust. Both El Niño and La Niña have been found to affect skin and skin-related diseases depending on the geographic area and the pathogenesis of the disease.

The effects of ENSO on skin diseases

In 1997 and 1998, changes in ecological conditions during the strong El Niño resulted in an escalation in the population of *Paederus sabaeus* rove beetles in Nairobi, Kenya. A resulting increase in vesicular dermatitis occurred.[22] Changes in vegetation in Piura, Peru, after the same El Niño season were seen as a factor in the growth of the *Paederus irritans* population, which caused outbreaks of irritant contact dermatitis in 1999.[21] A temperature increase of 1.6 °C as a consequence of the 1997–1998 El Niño was credited with significant increases in incidences of tinea, pityriasis versicolor, miliaria, and folliculitis in an outpatient clinic of the dermatology service at Hospital Nacional Cayetano Heredia in Lima, Peru.[23] The same El Niño event contributed to significant decreases in incidences of dermatitis, scabies, psoriasis, and papular urticaria in the same clinical setting.[23]

Temperature changes can trigger rosacea outbreaks. The higher temperature associated with the 2004–2007 El Niño increased the prevalence of rosacea significantly in Lima, Peru.[24] Wart viruses may be susceptible to changes in temperature, a fact that coincides with a significant increase in the prevalence of viral warts during El Niño in Peru, whereas the following La Niña was associated with a significant reduction in prevalence.[24] In Shenzhen, China, an extremely high positive SOI value (La Niña phase) was linked to an increased occurrence of hand, foot, and mouth disease in children younger than 15 years.[25] In children younger than 18 years in Hong Kong, China, the daily mean temperature, atmospheric pressure, and SOI value were associated with an increase in pediatric varicella.[26]

Changes in climate associated with both El Niño and La Niña are attributed to outbreaks of certain skin dermatoses in affected geographic areas. A higher temperature is reported as being the most important climatic factor for disease outbreak.

The effects of ENSO on vector-borne diseases

The most obvious impact of ENSO is on disease vectors. High temperatures affect disease vectors by influencing their population density, geographic distribution, incubation period (in the case of a virus), and survival. In addition, extreme increases in precipitation and flooding increase vector larval habitats or create new habitats. These changes in ecological conditions can cause outbreaks of vector-borne disease, many of which involve skin manifestations.[30–32]

Dengue fever

Dengue fever is one of the most important mosquito-borne diseases in the world. Its incidence is growing rapidly. Weather patterns associated with El Niño have been associated with increased levels of dengue fever in Southeast Asia[7–9,12,13] and South America,[8,11] including Mexico,[10] in either the El Niño or the post-El Niño years.

Ross River virus and Barmah Forest virus

Ross River virus (RRV) and Barmah Forest virus, also transmitted by mosquito, are occurring throughout Australia. A significant association between the monthly incidence of Barmah Forest virus infection and negative SOI values (from El Niño) was reported for the month studied, as well as for the previous 2, 3, and 4 months, in Queensland, Australia, where the 3-month lagged effect was most significant ($r = 0.42$, $P = 0.001$).[14] In southeastern Australia and close to the Murray and Darling rivers, positive SOI values (La Niña) were associated with outbreaks of RRV; however, this outcome did not apply in four other zones studied in Australia.[28] Maelzer *et al.*[27] reported that outbreaks of RRV infection in the southeastern states of Australia were well predicted by monthly SOI values. By comparison, no association between the yearly average SOI value (mean SOI: >4) and outbreaks of RRV infection throughout Australia was found between 1928 and 1998.[29]

Leishmaniasis

Spread by sandflies, leishmaniasis occurs typically in tropical and temperate zones. In Brazil, El Niño causes increases in the incidence of leishmaniasis in the post-El Niño year.[18] Similar findings were reported in Costa Rica.[15] In two northeastern provinces of Colombia, the number of leishmaniasis cases increased during El Niño; by contrast, during La Niña the number of cases decreased.[16] Similar patterns were reported in French Guiana.[17] Using time series analysis, Chaves and Pascual[15] showed it was possible to predict leishmaniasis incidence (accuracy varied from 72 to 77%) up to 12 months before an El Niño.

Chagas disease

Chagas disease, also called American trypanosomiasis, is typically transmitted by the triatomine bug. Usually, oral transmission may occur after ingestion of contaminated food. Infected people can have cutaneous manifestions.[33] Chagas disease mainly occurs in rural areas of the Americas (Mexico, Central America, and South America). In Brazil, the association between oral Chagas disease and El Niño was studied between 1982 and 2007. A 0.2-cycle-per-year peak in the incidence of Chagas disease was noted during El Niño years.[19]

The effects of ENSO on waterborne diseases

Waterborne diseases are caused by pathogenic microorganisms and are transmitted through contaminated fresh water. Unusually wet conditions and flooding associated with El Niño can effect an increase in risk for waterborne disease in certain geographic areas.

Leptospirosis

Transmitted by rodents through their urine, leptospirosis is considered a re-emerging disease in tropical and subtropical areas. Persons become infected through contact with contaminated materials, such as water and wet soil. In the Guadeloupe archipelago, French West Indies, a four-fold increase in the incidence of leptospirosis was reported for 2002–2004, a period with two El Niños.[20]

Interventions in the future

Global climate change is likely to lead to more frequent and intense El Niño events. Changes in weather patterns associated with both El Niño and La Niña can be linked to disease outbreaks. El Niño causes extreme weather, which can also have devastating consequences on buildings, roads, and transport and water supply systems, particularly in developing countries. Many developing countries have a poor public health infrastructure and thus find it difficult to deal with the consequences of El Niño. A better understanding of this complex weather pattern is needed, particularly if, in the future, El Niño becomes more frequent and intense. The ability to forecast El Niño (such as by determining the predictability of El Niño months before its occurrence) may contribute to improved active disease surveillance and to the designing of more specific control measures to mitigate disease transmission. Healthcare initiatives such as that performed by the International Society of Dermatology

Community Dermatology Task Force are needed.[34,35] Strategies to provide clean water and food, and to rebuild houses and roads in affected areas will be necessary. Education of the public about this complex weather pattern through newsletters and campaigns is required. Physicians and other healthcare persons need to be better informed about which diseases may be affected by El Niño or La Niña and how to prevent them through disease control measures.

Conclusions

In summary, there is increasing evidence that changes in climate associated with ENSO affect the occurrence of skin and skin-related diseases in certain geographic areas. A better understanding of the effects of this complex weather pattern may help to reduce damage and outbreaks of skin disease. Improved knowledge of how El Niño and La Niña affect skin and skin-related diseases may also help to reduce the potential health impacts of ongoing global climate change.

Quiz

1 How often does El Niño occur?
a) Every 1–2 years
b) Every 2–7 years
c) Every 7–10 years
d) Every 10–15 years
e) Every 15–20 years

2 El Niño is associated with unusually wet conditions in which region or regions?
a) Southeast Asia
b) Australia
c) Southern Africa
d) The west coast of South America
e) All of the above

3 How long does the El Niño Southern Oscillation (ENSO) typically last?
a) 2–4 months
b) 4–9 months
c) 9–15 months
d) 12–18 months
e) 18–24 months

4 In which country or countries does Barmah Forest virus occur?
a) USA
b) Canada
c) Thailand
d) Australia
e) All of the above

5 Which of the following skin diseases was associated with the 1997–1998 El Niño in Nairobi, Kenya?
a) Tinea
b) Dermatitis caused by *Paederus sabaeus*
c) Lyme disease
d) Actinic keratosis
e) Viral warts

6 Which of the following skin diseases was associated with increased risk after the 1997–1998 El Niño in Lima, Peru?
a) Hand, foot, and mouth disease
b) Rosacea
c) Actinic keratosis
d) Viral warts
e) Pityriasis versicolor

7 Which of the following vector-borne diseases is associated with El Niño in South America?
a) Lyme disease
b) Ross River virus infection
c) Chikungunya virus infection
d) Leishmaniasis
e) West Nile virus infection

8 Which skin disease or diseases were associated with a decrease following the 1997–1998 El Niño in Lima, Peru?
a) Tinea
b) Pityriasis versicolor
c) Miliaria
d) Folliculitis
e) Psoriasis

9 In which country or countries is El Niño associated with increased risk for dengue fever?
a) Mexico
b) Ecuador
c) Thailand
d) Indonesia
e) All of the above

10 In which country or countries is a high Southern Oscillation index (La Niña) associated with increased risk for hand, foot and mouth disease?
a) Peru
b) China
c) Kenya
d) Colombia
e) All of the above

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Answer key

1 (b)
2 (d)
3 (d)
4 (d)
5 (b)
6 (e)
7 (d)
8 (e)
9 (e)
10 (b)

