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Potential Dermatological Effects of Climate Change in Africa

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Abstract

Climate change represents a major existential threat facing the global community, and it has already begun to affect human health in a multitude of ways. This article highlights and discusses the implications that climate change has already had and is expected to have for dermatologists.

A number of conditions are affected by climate changes. The distribution and frequencies of infections have changed due to the changes in the causative organisms. Inflammatory conditions like atopic dermatitis have been exacerbated and the raised temperatures will also worsen the effects of ultraviolet radiation Extreme weather events that result from climate change are followed by an array of dermatologic conditions that may be unusual for the given location. Dermatologists should be prepared to manage these potentially unfamiliar dermatologic consequences of climate change.

Key words: climate change; skin; Africa

Introduction

The United Nations Framework Convention on Climate change (UNFCCC) defines climate change to mean a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."[1]. According to the South African Weather Service, "Climate change is the natural cycle through which the earth and its atmosphere are going to accommodate the change in the amount of energy received from the sun. Naturally, the climate goes through warm and cold periods and it takes centuries to complete one of these cycles. Changes in temperature also influence the rainfall, but the biosphere is able to adapt to a changing climate if these changes take place over centuries. Unfortunately, human intervention is currently is causing unnaturally rapid climate change. Climate models predict that the mean air temperature over South Africa will increase by an estimated 2°C over the next century or sooner.[2].

Climate change affects human health adversely and its impact on the skin is no exception. It is one of the greatest threats to our capacity to benefit in the context of ''Skin Care for All.'' The BMJ in November 2010 stated, ''Health professionals everywhere have a responsibility to put health at the heart of climate change.''[3] No healthcare profession is doing more in this respect than those concerned with skin care. The International Society of Dermatology has made ''Climate Change'' one of its lead topics, hoping to educate its members to be proactive in support of interventions to slow down the change, protect populations and teach them to reduce the effects of climate change on their skin.[4] .

It is well-established that many skin diseases are sensitive to climate conditions. Only a few of the many publications describing health impacts of climate change have focused on skin disease. On the other hand, extensive research has been done on increased ultraviolet radiation and the development of skin cancer**.**

Cutaneous infections and infestations

There is emerging evidence that climate change is impacting on cutaneous infections and infestations. The enhanced survival and expanded geographic range of climate-sensitive vectors and animal reservoirs means that climate-sensitive vector-borne diseases are following suit. This includes arthropod borne viruses like dengue fever, Chikungunya, and Zika, the major arboviral diseases transmitted by *Aedes spp.* mosquitos; Lyme disease, caused by the spirochaete *Borrelia burgdorferi* and transmitted by *Ixodes scapularis* tick has increasingly been diagnosed further away from the traditional boundaries in North America over the last few decades; cutaneous larva migrans in non-tropical areas that correlates with sharp temperature increases; changing

Phlebotomus spp. sandflies distribution patterns not only dependent on climate change, also loss of tree cover resulting in increasing distribution of leishmaniasis.[5-8]The altering of bird migratory patterns and snail overgrowth is increasing the incidence of cercarial dermatitis (swimmer's itch) which is caused by avian schistosomes with snails being the schistosome's intermediate host.[9]

Rising temperature and humidity increase skin bacteria growth overall geographical distribution of other organisms that infect humans. The different organisms that form the skin microflora have variable optimal temperature for survival and growth. *Staphylococcus aureus and* Corynebacterium *sp.* amongst others are more tolerant to rising temperatures and higher salt conditions compared to other, non-commensal bacteria. This overgrowth, apart disturbing the microbial equilibrium of the skin, leads to increased infection rates by the dominant species.[9,10] The rise in temperature also results faster rate of bacterial growth of organisms like *S. aureus*, increasing the risk transmission and mutations. The increased risk of mutations, potentially conferring enhanced survival to the bacteria, is concerning considering the current threat of antibiotic resistant strains like methicillin resistant *S. aureus* (MRSA). It is estimated that a 10 minimum temperature increase across North America could result in a 2.2% increase in antibiotic resistant *S. aureus* strains.[11] A 1% temperature increase results in an additional 10% increase in sebum production which favours the growth of lipophilic organisms such as *Cutibacterium* (formerly known as *Propionibacterium)* and *Malassezia* species and their associated disorders.[10].

Changing environmental conditions directly impacts geographical distribution of a variety of microbes. The incidence of enterovirus-associated infections like hand-foot-and-mouth disease is increasing and due to climate change, they are expected to have longer and more intense infectious seasons.[12] The geographical distribution of fungal infections like coccidioidomycosis is expanding across North America and becoming endemic in new areas.[13] Reproduction and proliferation of *Vibrio spp*, bacteria species that causes wound infections, cellulitis, and sepsis is accelerated in warm water. The change in climate has prolonged infectivity seasons as well as the geographical distribution. [9,14]

A study in The Gambia showed that scabies occurred with equal frequency in the wet and dry seasons, but that secondary infection was more common during the wet season.[15] A small study in Ethiopia showed an association between flooding and an increase in scabies, possibly due to overcrowding.[16]

Population displacement due to climate change forces results in migrants carrying diseases from their place of origin to their destinations and once there may be susceptible to diseases in which they had not been previously exposed to and vice-versa. However, the focus tends to be unfairly biased against migration from developing to developed countries. Climate-related migration is often clumped with other causes of migration blurring the true impact of climate change on migrant transmission of communicable diseases.

Waterborne and Foodborne diseases

Outbreaks of waterborne diseases due to climate change includes a variety of bacterial, fungal, parasitic and helminthic infestations.[17] Humans are infected by *Toxoplasma gondii*, the causative agent of toxoplasmosis through consumption of undercooked and infected meat or by water contaminated with oocysts. Toxoplasmosis is the most prevalent zoonotic parasitic infection globally. An increase in rainfall, median temperature and more frequent climate extremes are predicted to result in the disease encroaching into previously non-endemic areas like North America and North West Europe.[18,19] Schistosomiasis is a tropical and subtropical disease caused by parasitic blood flukes. Freshwater snails are a necessary intermediate host. It is thought that cold Northern hemisphere winters prevented spread from warmer climate and increasing precipitation and temperatures favour survival of disease-carrying snails and their geographical range.[20]

Tungiasis peaks during flooding when the *Tunga penetrans* sandflea burrows into the skin especially on the feet. Similarly, the incidence of Buruli ulcers, an infection with *Mycobacterium ulcerans,* which presents with large, non-healing with joint contractures and often with permanent joint disability peaks during the rainy season, as is eumycetoma, a deep fungal infection. Actinomycetoma, a deep bacterial infection of the skin caused by anaerobic bacteria is more prevalent during hot, dry seasons.[4] Heavy rainfalls or flooding is associated with an increase in the incidence of Leptospirosis. Flooding in Anuradhapura, Sri-Lanka saw a sevenfold increase in Leptospirosis in 2011.[21,22]

Podoconiosis

Podoconiosis is an endemic non-filarial elephantiasis, acquired through barefoot contact with volcanic soil. Although mainly reported in central highlands of Ethiopia it has been reported in 32 countries in Africa, Latin America and Asia.[12, 23,24] The prevalence of the disease increased with altitude, precipitation and silt fraction of soil and decreased with population density and clay content, some of which are impacted by climate change.[23]

Malnutrition related skin conditions

The prevailing human impact is accelerating dry conditions in the Horn of Africa-which includes Ethiopia, Somalia and parts of Kenya faster than at any time in the last two millennia. Food and water insecurity has spurred mass internal displacement and migration. This has led to higher food prices for important staple grains - wheat, rice and maize which has put an already vulnerable population at an even greater risk for malnutrition. This manifests as numerous trace element deficiencies including pellagra (niacin), acrodermatitis enteropathica (zinc), scurvy (vitamin C), phrynoderma (vitamin A), angular cheilitis (vitamin B), alopecia (biotin and others), xerosis and dermatitis (vitamin B), poor wound healing (vitamin C) and increased vulnerability to skin infections.[12,17]

Arthropod bites

Overall, a global decline in arthropod populations has been observed.[17] This may be due to intolerance to rising temperatures, as arthropods are highly sensitive to changes in ambient temperature. However, the decline may not be due entirely to climate change, as other factors, such as habitat destruction, pollution and the use of pesticides may be having major impacts. In addition, extreme weather events, such as flooding and fires, may cause further decline in some areas. Studies from Europe suggest that certain arthropods may move from tropical areas to temperate areas, (towards the poles or to higher altitudes) and this could influence the pattern of human diseases.[25,26] The expanded reach to previously unexposed populations to the insect species poses a challenge for dermatologists and allergologists.[27] In Africa, and throughout the world, arthropods tend to have most impact on poorer communities, where overcrowding may be a factor and where washing facilities may be inadequate. Most arthropod-related skin disease presents with itching. Secondary infection is common and may be complicated by glomerulonephritis. A further problem is hypersensitivity to insect bites (papular urticaria), the most severe form of which is called papular pruritic eruption and most commonly seen HIV infection. However, the true impact of climate change on arthropod bites is not always clear as shown by Kuria, in a systematic review of the prevalence of myiasis in Africa. The authors found inadequate data to reach any conclusions.[28] There is a lack of clear data to provide guidelines for future healthcare strategies.[28,29]

The arthropods most commonly responsible for human skin disorders in Africa are shown in Table 1

Organism		**Clinical features**
Insects	**Common name**	
Cimex spp	Bed bug	Itchy papules
Cordylobia anthropophaga, Dermatobia hominis and others	Fly	Myiasis (skin sores)
Pediculus humanus, Pthirus spp	Human louse	Itch, secondary infection

Pulex spp, e.g. *irritans*	Flea	Itchy papules, allergic reactions
Tunga penetrans	Sand flea	Sores, deformity
Mites		
Sarcoptes scabiei	Scabies mite	Itchy lesions, burrows

Table 1Arthropods responsible for human skin disorders in Africa

Thermal injury

Frequent fires are occurring with increasing frequency throughout the world and further increases can be expected. This trend is likely to lead to increasing human injury, including burns.[30]

The effects of ultraviolet radiation (UVR) on the skin

Depletion and erosion of the stratospheric ozone layer, together with climate change, has affected the solar ultraviolet radiation (UVR) on the planet.[30,31] The skin, as the most exposed part of the body, bears the brunt of the harmful effects of global warming, especially exposure to UVR and to a lesser extent, visible light (VL).[17] Global warming and ozone layer depletion work together to exacerbate the deleterious effects of UVR on the skin.[32-35]

Skin cancer

The global incidence of skin cancer has increased over the years. The types of skin cancers that are commonly a consequence of sun-exposure are basal cell carcinoma (BCC), cutaneous squamous cell carcinoma (cSCC) and cutaneous malignant melanoma (CMM).[36-38] Globally, CMM, accounts for 4% of all skin cancers, but is responsible for 80% of skin cancer-associated deaths.[39,40]

The National Registry of Cancer in South Africa releases yearly statistics on the incidence of cancer in the country. Table

Race	BCC		cSCC		CMM	
	2018	2019	2018	2019	2018	2019
Asian descent Male	3.54	3.61	2.62	3.35	1.05	1.03
Asian descent Female	4.08	3.43	2.45	2.34	0.54	1.04
African descent Female	1.28	1.37	1.55	1.74	0.33	0.70
African descent Male	1.30	1.38	1.92	1.81	0.84	0.45
Mixed descent Female	24.41	26.14	10.55	12.45	3.16	4.40
Mixed descent Male	33.59	34.87	15.95	17.89	4.70	4.09
European descent Female	215.55	232	83.50	91.78	32.50	30.35
European descent Male	309.41	322.62	134.39	151.05	38.75	40.42

Table 2. Race crude incidence per 100, 000 of BCC, cSCC and melanoma (CMM) during the years 2018 and 2019.[41]

shows that there was a general increase in incidence of all three types of skin cancer, especially in people of mixed and European descent. From 2018 to 2019, the incidence of cSCC increased by 12.43% and 9.92% amongst the latter males and females respectively, and CMM by 4.31% in males. CMM increased by 92% in females of Asian descent. The increases are noteworthy; however, a 1-year period may not be sufficient to draw solid conclusions.[41],[42]

Air pollution

Climate change and air pollution are closely connected. Climate change disrupts ventilation, dilution and elimination of atmospheric components, consequently the air chemistry. On the other hand, changes in the profile of atmospheric particulate matter influences cloud interaction and rainfall patterns as well as local temperatures by absorbing and retaining heat and increase local temperatures. Heatwaves that result from climate change increase the frequency of wildfires, which in turn lead to air pollution. [43,44] The skin interphases with the environment and endures the most of air pollutants. Multiple studies have suggested that air pollution exacerbates or causes acne, atopic dermatitis, psoriasis, skin ageing and hyperpigmentation. [45-48]

Inflammatory skin conditions exacerbated by climate change

Atopic Dermatitis (AD)

Climate change has been reported to influence environmental factors contributing to the symptoms of AD. These include shifting patterns of temperature, humidity, precipitation, wind and extreme weather events. [49]

i) Rising temperatures: There is conflicting data regarding the effect of temperature on atopic dermatitis. Studies from cohorts in Brazil and the United States found that higher temperatures are associated with poorly controlled AD.50,51 Heat may play a harmful role in some AD patients by provoking perspiration, which is one of the most commonly reported aggravating factors in children with AD. Perspiration may have an irritant effect on the skin mediated by the acidic pH of sweat, possibly promoting Th-2 inflammation, increased cutaneous blood flow due to vasodilation in hot environments, and possibly a neuroanatomic mechanism mediated by C nerve fibres.49

ii) High pollen levels: Exposure to pollen may trigger AD flares in those who are allergic to pollen. Plants produce more pollen, and the pollen season starts earlier when the temperature is higher. Climate change-related temperature increases may raise pollen levels and worsen the symptoms of AD. Furthermore, climate change alters the allergenicity of pollen and spectrum of pollen exposure, which increases atopic eczema symptoms in some patients during the pollen season.52

iii) Air pollution: Recent evidence suggests that a variety of air pollutants, such as environmental tobacco smoke, volatile organic compounds, formaldehyde, toluene, nitrogen dioxide, and particulate matter, act as risk factors for the development or aggravation of AD. These air pollutants probably induce oxidative stress in the skin, leading to skin barrier dysfunction or immune dysregulation. [53]

iv) Wildfires: Air pollution from wildfires may worsen symptoms of AD. A recent study found that short-term exposure to air pollution due to the wildfire was associated with increased health care use for patients with AD and itch. [54]

v) Flooding, typhoons and heavy rains: Recent reports have shown that typhoon and heavy rain increase allergic disease locally by concentration of airborne allergens of pollen, ozone, and fungus, which are causes of allergic disease.[55]

vi) Diminishing biodiversity and exposome: Climate change alters ecosystems, biological invasion patterns and global vegetation phases, with some species likely to outmuscle others in some environments. This reduction in biodiversity is likely to reduce the AD exposome and negatively affect the development of the immune system, resulting in people become more sensitive to allergy triggers. Urbanization leads to an increase in air pollution and a decrease in biodiversity, which negatively affects AD further.52

vii) Psychological stress: Prenatal and environmental stress have been shown to negatively affect AD.56,57 Extreme weather events and forced migration due to climate change can be stressful and impact on AD negatively.[52]

Psoriasis

Bellinato et al reported an association between psoriasis flare and environmental air pollution. In a study involving 957 patients affected by chronic plaque psoriasis with 4398 follow-up visits, the concentrations of air pollutants were significantly higher in the period before psoriasis flare compared with control visits. The air pollutants assessed included carbon monoxide, nitrogen dioxide, other nitrogen oxides, benzene and course particulate matter. Potential mechanisms linking the exposures to flares include the possibility that exhaust particles can activate skin resident T-cells, resulting in abnormal production of pro-inflammatory cytokines including tumour necrosis factor α and interleukins (ILs), including IL-1α, IL-1β, IL-6, and IL-8.8. [58]

Systemic lupus erythematosus (SLE)

A study of 1,600 Americans with SLE found an association relationship between worsening symptoms and changes in the weather or air quality, such as intense heat or cold, high humidity, wind and severe air pollution. Rising temperatures caused joint swelling, inflammation, rashes and decline in erythrocytes, leucocytes and platelets.[59] A recent study in the same cohort also identified clusters of SLE organ-specific flares related to fine particulate matter pollution, environmental temperature, ozone concentration, resultant wind, relative humidity, and barometric pressure.[60]

Acne vulgaris

Changes in climatic variables such as air pollution, humidity, temperature, and UV radiation, affect the skin microbiome. Higher temperatures and increased UV radiation result in overgrowth of *C. acnes* that correlating with acne flares. Specifically, warmer temperatures increase sebum levels, humidity increases pilosebaceous unit swelling, and UV radiation results in hyperplasia of sebaceous glands, consequently promoting growth of *C. acnes*. Although these changes depend on the individual's microbiome, potential result include persistent inflammation and recurrent flares in the absence of other competing microbes.[10]

Conclusion

Climate change has already begun to impact human life through the associated extreme weather events and its detrimental health effects; having a myriad of implications with respect to the skin. Cutaneous infections will appear in areas and at times of the year when they have not been described. A variety of inflammatory and infectious conditions will be exacerbated by the climatic and vegetation changes and the incidence of skin cancers will increase due to more effective UV radiation. There is a clear imperative for dermatologists to work against the processes that promote climate change, namely the protection of their patients. The financial costs cannot be underestimated , according to Wright *et al.*, the cost of the diagnosis and treatment of skin cancer in South Africa was estimated to be ZAR 92.5million (US$15.7million) in 2015.[42] With increasing incidence of non-melanoma skin cancer (NMSC) and CMM, the overall cost of skin cancer management is likely to pose a significant financial burden on the patients and the state.

Throughout much of the African continent, healthcare systems are already strained in their efforts to meet the needs of a growing population using limited resources. Climate change threatens to undermine many of the public health gains that have been made in this region in the last several decades via multiple mechanisms, including malnutrition secondary to drought-induced food insecurity, mass human displacement from newly uninhabitable areas, exacerbation of environmentally sensitive chronic diseases, and enhanced viability of pathogenic microbes and their vectors. Physicians should be aware of the ways in which climate change threatens human health in low- and middle-income countries in general, and particularly in countries throughout Africa. Educating the dermatology community will go a long way to ensuring healthy skin for Africans in the era of climate change.

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