Journal Pre-proofs

Review

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PII: S2352-6475(20)30129-5
DOI: https://doi.org/10.1016/j.ijwd.2020.08.002
Reference: IJWD 401

To appear in: *International Journal of Women's Dermatology*

Received Date: 19 April 2020
Revised Date: 2 August 2020
Accepted Date: 6 August 2020

Please cite this article as: G.S. Silva, M. Rosenbach, Climate change & dermatology: An introduction to a special topic, for this special issue, *International Journal of Women's Dermatology* (2020), doi: https://doi.org/10.1016/j.ijwd.2020.08.002

Climate Change & Dermatology: An introduction to a special topic, for this special issue

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Words: 2,226 (3,000 max)

References: 58

Conflict of Interest disclosure:

Misha Rosenbach is the Co-chair of the AAD's Climate Change & Environmental Affairs Expert Resource Group. He has received research funding from Processa Pharmaceuticals, and honoraria from Processa, Merck, aTyr, and Janssen. He received salary support from JAMA during his tenure as Deputy Editor of JAMA Dermatology.

Funding: N/A

Climate Change & Medicine

Anthropogenic global climate change spurred by fossil fuel consumption is a well-documented phenomenon that has led to average global temperatures climbing to approximately 1° C above pre-industrial (1850-1900) levels, with even higher regional deviations in some areas and significantly increased average warming in densely populated urban centers and in the Arctic.[17; 30] Although the scientific community has held the consensus for decades that climate change is human-caused, this was last year elevated to '5-sigma' certainty – the gold standard for level of scientific evidence.[46] In 2018, the United Nations' Intergovernmental Panel on Climate Change set a threshold of 1.5° C of average warming (above pre-industrial baseline levels), beyond which our planet will become significantly less hospitable to human life.[28; 30] Some impacts include extremes of temperature, powerfully destructive natural disasters, sea level rise rendering coastal areas uninhabitable, increased spread and emergence of disease, and severe food shortages as agricultural regions are changed. Experts have attempted to project our trajectory toward these outcomes using models such as representative concentration pathways (RCPs) and shared socioeconomic pathways (SSPs) that predict average warming and outcomes by 2100 based upon current and future emissions activity.[18] A 2020 *Nature* commentary by climate scientists posits that global policies are currently on track to lead to 3° C of warming by 2100 – well above the best-case scenarios and "still catastrophic" – and reiterates our need to take more stringent action to avoid surpassing 1.5° C.[18] The current Covid-19 pandemic has illustrated the fallacies of insufficient or laggardly responses to projected risks and scientific warnings and has revealed how such decision-making can lead to avoidable loss of lives and resources.[10]

It is critical to take rapid action at this juncture to avoid surpassing 1.5° of warming – the more we mitigate, the less extreme the consequences will be. However, adverse human health impacts are already occurring due to current levels of global climate change, as summarized by publications such as the *The Lancet*'s annual "Countdown on Health and Climate Change," initiated in 2016.[7; 56; 57] The human health impacts of climate change are truly cross-disciplinary, with nearly every medical specialty either facing or set to face effects. The medical profession in the US has recently begun to respond to climate change as a human health crisis: the American Medical Association signed the 2018 US Call to Action on Climate and Health Equity, and multiple specialty-specific national organizations have released position statements outlining health risks due to climate change.[3; 13; 52] The field of dermatology is not immune to these impacts, as was recently acknowledged by the American Academy of Dermatology (AAD).[2]

This special issue of the *International Journal of Women's Dermatology* is dedicated to the cross section of dermatology and climate change. This initial article will serve as an overview to introduce readers to the topic and lay the groundwork for the rest of the issue. We are delighted to work with the Women's Dermatological Society and welcome their support for this dedicated edition. The articles in this issue will provide in-depth information on key topics relevant to the climate change-dermatology interface: infectious disease, the effect of air pollution on the skin, the impact of climate change on pediatric dermatology, heat-related illness and sweating, implications for skin cancer, sunscreens & the environment, skin issues related to flooding and extreme weather events, refugee health, and environmentally-friendly office practices and changes that dermatologists can incorporate into their professional lives.

Overview of the Dermatologic Impacts of Climate Change

The ways in which our planet's climate is changing will influence the distribution and frequency of dermatologic conditions, particularly those associated with infectious etiologies, sun exposure, environmental irritants, and aquatic transmission.

The incidence of infectious skin disease—viral, fungal, and vector-borne—is already shifting due to climatic conditions that favor microbe propagation, with a trend towards broadening geographic distributions of cases.[9; 20] For example, studies have found demonstrable weather-related relationships for both incidence and severity of hand, foot, and mouth disease, an enteroviral-associated skin disease.[8; 26; 50] Warmer average temperatures and shifting windstorm patterns are largely responsible for the expanding geographic distribution and incidence of fungal skin disease, such as coccidioidomycosis.[20; 21; 29; 38] Changing environmental conditions also influence the behavior and habitat of disease vectors, which has resulted in newly-broadened regions of endemicity in the US for both tick-borne Lyme disease[20; 36; 49] and parasitic Leishmaniasis, carried by the sand fly.[6; 12; 20; 31; 40] Although the relationship between global climate change and mosquito-borne disease is non-linear, Dengue, Zika, and Chikungunya are all associated with dermatologic manifestations and have experienced atypically-expanded case distributions over the past 1-2 decades.[16; 33; 37; 44] In the current *IJWD* issue, Coates and Norton explore in greater depth the theme of climate change and infectious diseases with cutaneous manifestations (Ed: add ref to article in this issue). The important connections between climate change and infectious disease will likely experience greater focus as healthcare systems look to planning for the post-COVID-19 future.

Global populations are at a universally increased risk of skin cancer due to the earth's diminished atmospheric ozone layer, a results of the anthropogenic activities leading to climate change.[54] We are doubly-exposed to elevated ultraviolet (UV) radiation, both from the depleted

protective ozone layer and from higher temperatures, which lead to increased UV damage at the same dose.[14] Warming climates in temperate zones also encourage more outdoor activity in the general population, compounding the extra UV exposure. Not only does this contribute to melanoma and nonmelanoma skin cancer incidence, which will be covered by Parker in this issue (Ed: add ref to article in this issue), but UV radiation, temperature, and air pollution are also associated with exacerbation of other skin diseases.[43]

Inflammatory dermatoses are sensitive to changing environmental conditions; air pollutants, such as small particulate matter, may exacerbate chronic conditions like pemphigus and atopic dermatitis (discussed in this issue's section on pediatric dermatology as the focus of Schachtel, Dyer, and Boos (Ed: add ref to article in this issue).).[22; 23; 25; 34; 35; 43; 45] In turn, these air particles are tied to climate change both causally (released via fossil fuel burning) and as a result of expanded pollen seasons,[58] wildfire activity,[48] and urban air stagnation events that trap pollutants in the lower atmosphere.[53] Returning to skin cancer, air pollutants have also been shown to potentiate oxidative damage to the skin.[23] The review by Roberts (Ed: add ref to article in this issue) included in this issue addresses the adverse consequences of fossil fuel emissions on skin and its normal function and disorders.

Warming bodies of water and precipitation shifts due to climate change also pose an exposure risk for aquatically transmitted dermatologic conditions. More hospitable water temperatures can foster early blooming seasons and growth of jellyfish larvae and aquatic snails, leading to risk of seabather eruption and cercarial dermatitis (swimmer's itch), respectively.[20; 24; 39; 42; 51] Additionally, aquatic *Vibrio* species of bacteria may lead to infection, cellulitis, and sepsis;[55] increasing case reports have been associated with the warming of coastal waters and

flooding events.[4; 15] Such flooding-associated dermatologic infections are covered in Bandino's Image Quiz in this issue (Ed: add ref to article in this issue).

Response of the American Academy of Dermatology

In 2018, the AAD responded to climate change as a dermatologic risk factor by forming an Expert Resource Group (ERG) for Climate Change and Environmental Affairs. Since its inception, this group has worked with the AAD and helped guide the Academy to join the Medical Society Consortium for Climate and Health; assisted in helping the AAD partner with mygreendoctor.org to offer guidance to dermatologic practices in reducing their carbon footprints; led educational sessions around the dermatologic impacts of climate change at the AAD 2019 Annual Meeting; and begun development of task forces targeting multiple domains in which climate change poses a threat to dermatologic health. Interested physicians may join the ERG by emailing Allen McMillen, Misha Rosenbach, or Mary Williams. Importantly, this group's endeavors resulted in the creation of the AAD's Position Statement on Climate and Health, approved by the Board of Directors in July 2018.[2]

AAD Position Statement & Vulnerable Populations

The AAD position statement confirms the scientific consensus that there exists a strong link between human health and climate change, with risks projected to worsen. It states the intention of the AAD to: (1) raise awareness about the effects of climate change on skin health and skin disorders; (2) work with other medical societies in ongoing and future efforts to educate the public and to mitigate the effects of climate change on global health; (3) educate patients about the effects of climate change on the health of their skin; and (4) support and facilitate

efforts of its members to decrease the carbon footprint of their dermatology practices and medical organizations in a cost-effective (or cost-saving) manner.[2] In this special issue of *IJWD*, Fathy, Nelson, and Barbieri expand upon low-emission office practices and lecture options – particularly relevant in the pandemic era (Ed: add ref to article in this issue), while Fivenson, Buckland et al. (Ed: add ref to article in this issue) delve into 'greening' the office in a cost-effective fashion with insight from MyGreenDoctor (now also a partner of the AAD). Being an environmentally responsible dermatologist also includes being cognizant of the downstream impacts of the products recommended to patients; Fivenson, Sabsevari et al. describe in this issue what practitioners should know about sunscreens and the environment (Ed: add ref to article in this issue).

Importantly, the AAD position statement also calls attention to the fact that certain populations are especially vulnerable to the health impacts of climate change; these include children, the elderly, and individuals in low-income and minority communities. These populations are simultaneously more likely to experience the adverse health impacts of climate change and less likely to be able to adapt to and mitigate those impacts—broadly and in the context of the dermatologic risks of climate change.

Both children and the elderly are at greater risk for many of the dermatologic risks discussed. Pediatric dermatologists recently released a call for action around climate advocacy, outlining youth-specific susceptibilities that will be further discussed in this issue by Schachter, Dyer, and Boos (Ed: add ref to article in this issue).[47] Children's full dependency on adult caregivers compounds the challenges inherent in avoiding deleterious environmental surroundings; this is mirrored in the geriatric population.[1] The elderly are also at elevated risk for

contracting dermatologic disease due to the natural weakening of the immune system with age, which includes reduced resiliency and functionality of the skin's cutaneous barrier.[19; 41]

A variety of circumstances and risk factors combine to make low-resourced communities particularly susceptible to the dermatologic impacts of climate change. The individuals most exposed to air pollution are typically minority communities and/or those living in low-income, densely-populated urban areas adjacent to industrial activities and lacking green spaces; this compounds this compounds health impacts like chronic dermatitis exacerbations and carcinogenic skin damage.[5; 27; 32] For example, a study of pemphigus flares in a representative US sample found an association between ultraviolet index and hospital admissions only in the subset of Hispanic/Latino patients.[43]

Additionally, low-income outdoor laborers must often face prolonged periods in extreme sunlight and heat due to their occupational environment. Indeed, heat is the leading cause of death worldwide from extreme weather events related to climate change. Sweating, the body's natural cooling response, is impaired in certain dermatological conditions and in individuals with preexisting chronic disease like diabetes and renal failure.[9] Williams elaborates upon the themes of hypohidrosis and overheating in this issue (Ed: add ref to article in this issue). Certain at-risk individuals may still accept elevated occupational exposure, despite predisposing conditions, due to economic necessity; this disproportionate risk to outdoor workers will only escalate with increasing climate change.

Climate change is also projected to increase the incidence of extreme weather events and associated displacement of populations. The populations uprooted by weather-related destruction are often low income and/or minority communities in neighborhoods without preexisting disaster-response infrastructure and without the economic resiliency to quickly adapt or rebuild.

Disaster-related migration often leads to overcrowding in temporary shelters and subsequent outbreaks of skin disease, such as scabies and dermatophytosis, or stress-induced flares of conditions like psoriasis, alopecia areata, and vitiligo.[47] For a fuller examination of the complexities of climate-displaced populations and dermatologic health, see Kwak et al. (Ed: add ref to article in this issue).

Environmental injustice remains an issue globally, with populations in the lowest-income and lowest-emitting countries likely to bear the most significant burdens of cutaneous disease associated with escalating climate change. A recent review highlighted climate-compounded dermatologic risks to certain African populations; these are shared by many developing nations.[11] Specific impacts include cutaneous manifestations of severe nutrient deficiency—which will likely be further exacerbated by drought-induced crop shortages due to climate change—and increased rates of skin-manifesting neglected tropical diseases, often due to environment-related shifts in parasitic and vectoral activity.[11]

Conclusion

Moving forward, education around care for high-risk populations and prioritization of environmental justice are essential components in addressing the dermatologic health risks associated with climate change. Many of the subjects discussed by the authors in this special issue, such as eliminating unsustainable medical practices and uncovering the dermatologic consequences of environmental contamination, deserve additional research to elucidate future interventions and best practices. We can also devote further attention to how physicians and medical societies can use their voices to advocate for policy action that protects patient health by promoting safe environments and addressing climate change.

In the wake of the AAD's Position Statement on Climate and Health, and with the growing body of literature elucidating the links between skin disease and climate change, now is the time for the dermatology community to become a leader in advocating for healthy skin in the era of global climate change. Although there is more yet to be done, we hope the articles included in this special issue of the *International Journal of Women's Dermatology* help draw attention to the critical issue of climate change and the impacts that it has on dermatologic disease, our patients, our field, and our future.

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