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Review

Climate change and dermatology: An introduction to a special topic, for this special issue

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ABSTRACT

Anthropogenic global climate change is a well-documented phenomenon that has led to average global temperatures climbing to approximately 1 °C above preindustrial (1850–1900) levels, with even higher regional deviations in some areas and significantly increased average warming in densely populated urban centers. In 2018, the United Nations Intergovernmental Panel on Climate Change set a threshold of 1.5 °C of average warming (above the preindustrial baseline), beyond which our planet will become significantly less hospitable to human life. However, adverse human health impacts are already occurring due to current levels of global climate change, as summarized by publications such as *The Lancet*'s annual "Countdown on Health and Climate Change," initiated in 2016. The human health impacts of climate change are truly cross-disciplinary, with nearly every medical specialty either already facing or set to face effects. The field of dermatology is not immune to these risks. 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 to 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 issue. Herein, you will read from up-and-coming stars in the field and established experts, including articles on the following key areas: infectious diseases, environmentally friendly office practices, sunscreens and the environment, refugee health, heat-related illness, the effect of air pollution on the skin, the impact of climate change on pediatric dermatology, implications for skin cancer, and skin issues related to flooding and extreme weather events.

Contents

Climate change and 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 preindustrial (1850–1900) levels, with even higher regional deviations in some areas and significantly increased average warming in densely populated urban centers and the Arctic (GISTEMP Team, 2020; Masson-Delmotte et al., 2018). 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 (Santer et al.,

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2019). In 2018, the United Nations' Intergovernmental Panel on Climate Change set a threshold of 1.5 °C of average warming (above preindustrial baseline levels), beyond which our planet will become significantly less hospitable to human life (Maibach et al., 2019; Masson-Delmotte et al., 2018). 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 and shared socioeconomic pathways that predict average warming and outcomes by 2100 based on current and future emissions activity (Hausfather and Peters, 2020). 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 (Hausfather and Peters, 2020). 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 (Coates et al., 2020).

Rapid action is critical at this juncture to avoid surpassing 1.5 °C 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 (Centers for Disease Control and Prevention, 2019; Watts et al., 2019; World Health Organization, 2016). 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 United States 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 (American Medical Association, 2018; Crowley et al., 2016; The Medical Society Consortium on Climate and Health, 2019). The field of dermatology is not immune to these impacts, as was recently acknowledged by the American Academy of Dermatology (AAD; AAD, 2018).

This special issue of the *International Journal of Women's Dermatology* (*IJWD*) 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 and 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 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 toward broadening geographic distributions of cases (Coates et al., 2019b; Kaffenberger et al., 2017). 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 (Coates et al., 2019a; Liu et al., 2015; Stewart et al., 2013). Warmer average temperatures and shifting windstorm patterns are largely responsible for the expanding geographic distribution and incidence of fungal skin disease, such as coccidioidomycosis (Benedict and Park, 2014; Kaffenberger et al., 2017; Marsden-Haug et al., 2013; Park et al., 2005).

Changing environmental conditions also influence the behavior and habitat of disease vectors, which has resulted in newly broadened regions of endemicity in the United States for both tick-borne Lyme disease (Kaffenberger et al., 2017; Ogden et al., 2009; Steere et al., 1983) and parasitic Leishmaniasis, carried by the sand fly (Cardenas et al., 2006; Cross and Hyams, 1996; Kaffenberger et al., 2017; McIlwee et al., 2018; Peterson and Shaw, 2003). Although the relationship between global climate change and mosquito-borne disease is nonlinear, Dengue, Zika, and Chikungunya are all associated with dermatologic manifestations and have experienced atypically expanded case distributions over the past 1 to 2 decades (Farahnik et al., 2016; Morens and Fauci, 2014; Paixão et al., 2016; Rezza, 2014). In the current *IJWD* issue, Coates and Norton explore in greater depth the theme of climate change and infectious diseases with cutaneous manifestations (Coates and Norton, 2021). The important connections between climate change and infectious disease will likely experience greater focus as health care 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, which is a result of the anthropogenic activities leading to climate change (Urbach, 1997). 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 (Diffey, 2004). 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 (2021), but UV radiation, temperature, and air pollution are also associated with exacerbation of other skin diseases (Ren et al., 2019).

Inflammatory dermatoses are sensitive to changing environmental conditions; air pollutants, such as small particulate matter, may exacerbate chronic conditions, such as pemphigus and atopic dermatitis (discussed in this issue's section on pediatric dermatology by Schachtel et al. (2021); Kim et al., 2017; Koohgoli et al., 2017; Li et al., 2016; Nguyen et al., 2019; Noh et al., 2019; Ren et al., 2019; Rosenbach, 2019). 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 (Ziska et al., 2011), wildfire activity (Spracklen et al., 2009), and urban air stagnation events that trap pollutants in the lower atmosphere (Trail et al., 2013). Returning to skin cancer, air pollutants have also been shown to potentiate oxidative damage to the skin (Koohgoli et al., 2017). The review by Roberts (2021) 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 a risk of seabather eruption and cercarial dermatitis (swimmer's itch), respectively (Kaffenberger et al., 2017; Kumar et al., 1997; Patz et al., 2008; Reitzel et al., 2007;

Sullivan et al., 2001). Additionally, aquatic *Vibrio* species of bacteria may lead to infection, cellulitis, and sepsis (Urquhart et al., 2014). Increasing case reports have been associated with the warming of coastal waters and flooding events (Baker-Austin and Oliver, 2018; Esteves et al., 2015). Such flooding-associated dermatologic infections are covered in Bandino's Image Quiz (2021).

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 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 footprint, 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 can join the Expert Research Group 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 (AAD, 2018).

AAD position statement and 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. The statement includes 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 (AAD, 2018). In this special issue of *IJWD*, Fathy, Nelson, and Barbieri expand on low-emission office practices and lecture options—particularly relevant in the pandemic era (Fathy et al., 2021). Fivenson et al. (2021) 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 products recommended to patients. Fivenson et al. (2021) describe in this issue what practitioners should know about sunscreens and the environment.

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 Schachtel et al. (2021). Children's full dependency on adult caregivers compounds the challenges inherent in avoiding deleterious environmental surroundings; this is mirrored in the geriatric population (Ahdoot and Pacheco, 2015). The elderly are also at elevated risk of 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 (Humbert et al., 2016; Quan and Fisher, 2015).

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 health impacts, such as chronic dermatitis exacerbations and carcinogenic skin damage (Bell and Ebisu, 2012; Maantay, 2007; Miranda et al., 2011). For example, a study of pemphigus flares in a representative U.S. sample found an association between UV index and hospital admissions only in the subset of Hispanic/Latino patients (Ren et al., 2019).

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 dermatologic conditions and in individuals with preexisting chronic diseases, such as diabetes and renal failure (Coates et al., 2019b). Williams elaborates on the themes of hypohidrosis and overheating in this issue (Williams, 2021). Certain at-risk individuals may still accept elevated occupational exposure, despite predisposing conditions, out of 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 such as psoriasis, alopecia areata, and vitiligo (Schachtel and Boos, 2019). For a fuller examination of the complexities of climate-displaced populations and dermatologic health, see Kwak et al. (2021).

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 (Coates et al., 2020). 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 (Coates et al., 2020).

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 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 more yet to be done, we hope the articles included in this special issue of *IJWD* help draw attention to the critical issue of climate change and its impacts on dermatologic disease, our patients, our field, and our future.

Declaration of Competing Interest

Misha Rosenbach is the co-chair of the American Academy of Dermatology'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*.

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