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Climatic shifts and vision: understanding the impact of climate change on ocular health

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***Abstract*---**Climate change poses multifaceted challenges to global health. Among its lesser-known repercussions is the significant impact on ocular health. Firstly, climate change exacerbates air pollution, leading to an increase in airborne particulate matter and pollutants. These pollutants, including ozone, nitrogen dioxide, and fine particulate matter, can exacerbate ocular surface diseases such as dry eye syndrome, conjunctivitis, and allergic eye diseases. Moreover, prolonged exposure to air pollution has been linked to the progression of age-related macular degeneration and cataracts. Secondly, alterations in climate patterns contribute to the spread of infectious diseases, including vector-borne illnesses. Mosquito-borne diseases like dengue fever and Zika virus, whose prevalence is escalating due to changing climatic conditions, can cause ocular complications such as uveitis and retinitis. Thirdly, extreme weather events associated with climate change, such as hurricanes, floods, and wildfires, pose direct threats to ocular health. Traumatic injuries to the eyes, corneal abrasions, and chemical burns from debris and contaminated water are common ocular emergencies following such disasters. Furthermore, climate change-induced shifts in environmental allergens and pollen seasons heighten the incidence and severity of allergic conjunctivitis and other allergic eye diseases. Addressing these challenges requires interdisciplinary

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collaboration among public health experts, policymakers, ophthalmologists, and environmental scientists.

***Keywords*---**Ocular, Heat, cold, hurricanes, rainfall, drought.

Introduction

Changes in the climatic environment have shown to have an adverse effect on human health, including the eyes, whether directly or indirectly. There are three potential ways in which climate change will impact human health[1]. Firstly, through direct effects linked to extreme events like heatwaves, droughts, and heavy rainfall. Secondly, through influences on natural control systems, such as alterations in disease vectors, waterborne diseases, and air pollution. Thirdly, climate change may lead to malnutrition and mental stress due to inhospitable conditions. Variations in temperature or rainfall patterns affecting harvests can directly impact nutritional intake, thereby affecting human health.

Regarding direct consequences, Global Warming is an ongoing pattern characterized by varying intensity worldwide. These episodes of elevated temperatures are closely linked to a rise in mortality rates. The frequency and severity of various "extreme" weather events, such as heat waves, hurricanes, tropical storms, and droughts, have risen as a result of climate change [2]. Despite some adaptability to different climatic changes, the population still experiences the impacts of extreme-temperatures[3].

A slight heat shock leads to an elevation in the synthesis of inflammatory cytokines, specifically Interleukin 1β (IL-1β) and Interleukin-6 (IL-6), along with heightened expression of heat shock protein 90 (HSP90). This, in turn, amplifies the phosphorylation of AKT. The activated AKT subsequently enhances the phosphorylation of IκBα, facilitating the nuclear translocation of NF-κB. This cascade ultimately upregulates the expression of IL-1β and IL-6 in Statens Serum institute Rabbit Cornea (SIRC) cells. The HSP90-AKT-NF-κB signalling pathway plays a crucial role in the inflammatory response induced by mild heat shock in corneal cells[4].

The rise in temperature and reduction in humidity due to climate change contribute to the widespread occurrence of dry eyes. Symptoms such as pain, swelling, and redness in the eyes are prevalent, especially among children. This condition arises when the tear film evaporates prematurely, often triggered by elevated temperatures. Consequently, the eyes experience redness, irritation, and a burning sensation.

Moreover, research indicates that these severe heat waves heighten susceptibility to infectious viral conditions like herpes and viral conjunctivitis, as well as bacterial and fungal infections, along with allergies. The elevated risk of recurrent ocular HSV is particularly notable during periods of high UV index.[5] The potential mechanisms explaining the influence of UV exposure on HSV recurrence primarily involve two aspects. First, UV exposure may depress the immune response by inhibiting HSV antigen presentation in epidermal cells[6] leading to decreased secretion of type 1 cytokine[7], which is an important part of immunological control. Additionally, HSV reactivation can occur directly[8].

Elevated levels of ultraviolet radiation have also been linked to a rise in ocular tumors, cataracts[9], and retinal detachment[10]. Higher temperatures also raise the risk of forest fires, resulting in an increase in particulate matter and smoke in the air, leading to irritation, inflammation, and blurred vision.

The disruption of natural regulatory systems results in an uptick in the prevalence of vector-borne illnesses like malaria and Trachoma, as well as the resurgence of other diseases such as dengue, hemorrhagic fever, tick-borne diseases, Chikungunya, and Japanese encephalitis. These diseases also exhibit significant and well-documented effects on ocular structures[11-13].

Even lower temperatures can have a profound impact on ocular health. Cold temperatures can induce constriction of blood vessels in and around the eyes, leading to blurriness and double vision. However, this vision impairment is typically temporary, with vision returning to normal once individuals move to a warmer environment away from the cold.

During the colder seasons of autumn and winter, dry eye syndrome tends to affect more individuals due to a combination of cold winds, low moisture in the air, and increased use of central heating. Conversely, excess tearing and watery eyes can be provoked by cold air and icy winds, but wearing sunglasses or goggles outdoors can mitigate this effect and protect the eyes from harsh weather conditions.

Another condition observed in winter months is photokeratitis (snow blindness), resulting from sunburned eyes exposed to UV light reflected off snow and ice. While this condition can cause temporary eye pain and discomfort, symptoms typically subside within a few days.

The decline in air quality stemming from climate change can significantly impact eye health. Persistent exposure to air pollution can lead to blurred vision, watery eyes, and ocular burns. Of particular concern are pollutants other than carbon dioxide, such as tropospheric ozone, a common pollutant associated with heatwaves and linked to various adverse health effects, including reduced lung function, increased respiratory symptoms, and asthma development[14]. Low levels of tropospheric ozone are even correlated with an elevated risk of premature mortality[15].

Climate change's potential ramifications on aeroallergens like pollen and mold spores can lead to conditions such as asthma, allergic rhinitis, dermatitis, and allergic conjunctivitis[16]. Elevated levels of carbon dioxide and temperature may increase pollen production and atmospheric pollen concentrations, with altered turbulent airflow aiding in pollen transport[17]. These aeroallergens, combined with thunderstorms and cyclones, contribute to the prevalence of allergic respiratory and ocular diseases[18].

Furthermore, climate change-induced mismanagement of human systems can result in malnutrition due to changes in harvests influenced by temperature changes and rainfall patterns[19]. This, in turn, contributes to work-related health problems and mental disorders. In the realm of eye health, malnutrition can lead to xerophthalmia due to Vitamin A deficiency, age-related macular degeneration (AMD), cataracts, or glaucoma. Outdoor workers are particularly vulnerable to heatwaves, experiencing psycho-physical damage and secondary ocular diseases such as pterygium, glaucoma, and retino-choroidal injuries[20]. Extremes of changes in normal climatic conditions can affect almost all the ocular structures.

- Elevated ultraviolet radiation and air pollution increases the likelihood of Actinic keratosis, Squamous cell carcinoma of the lids, and blepharitis.
- There is an increased risk of ocular surface inflammation leading to allergic keratoconjunctivitis, chronic episcleritis, corneal metaplasia, and Pterygium.
- Exacerbation of surface infections like herpes simplex, herpes zoster, viral keratoconjunctivitis, bacterial and fungal infections are observed due to increased heat and humidity.
- There are higher chances of epidermoid neoplasia of the ocular surface as well as basal cell carcinoma.
- Elevated temperatures, ultraviolet radiations, and air pollutants act as risk factors for both open-angle glaucoma and closed-angle glaucoma. Ultraviolet radiation induces oxidative stress, which contributes to the risk of glaucoma. Malnutrition and undernourishment further influence the progression of glaucoma.
- Solar radiations, especially, contribute to early cataracts, subcapsular cataracts, and Pseudo-exfoliation syndrome.
- Various environmental factors can lead to uveal melanoma and inflammatory uveitis, which can be infective, noninfective, related to connective tissue diseases, or manifest solely as an ocular disease without systemic involvement.
- Environmental factors, particularly sunlight and ultraviolet radiation, can cause several retinal pathologies such as tractional retinal detachment, posterior vitreous detachment, age-related macular degeneration, and central serous choroidopathy. These issues arise because the less humidified ozone layer provides less filtering of UV radiation from water aerosols.

When the eyes are consistently exposed to harmful environmental factors, damage occurs, eventually leading to vision loss. Short-term damage can result from pollutants emitted by vehicles, factories, cleaning products, and smoke, causing inflammation, irritation, and dry eye. Therefore, to maintain good eye health amid climate change, it is crucial to adopt preventive measures. Increasing education and awareness about climate change and its impact on eye health is essential for promoting preventive measures and early detection of eye conditions.

Conclusion

Understanding that climate change significantly affects human health, particularly in terms of eye health, is crucial. Elevated temperatures, excessive rainfall, droughts, fires, floods, and air pollution all contribute directly or indirectly to the development or worsening of existing ocular conditions. While adaptation does occur over time, the impact of these diseases and the associated treatment costs can profoundly influence a country's social and economic well-being. Without prompt intervention, the economic burden of these eye diseases is likely to escalate. Striking a balance between mitigation and adaptation strategies is essential to decrease the occurrence and severity of these diseases.

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