International Journal of Current Research and Review
DOI: https://doi.org/10.31782/IJCRR.2024.161501

Review Article

IJCRR
Section: Life Sciences

Copyright@IJCRR

Climate Change and Ocular Surface Disease Epidemic

Manish Kumar Sah[1*], Melina Madai[2], Bikash Jaiswal[3], Sumi Rajak[4], Ruchika Sah[5]

[1,*]Assistant Professor, Optometry, SSAHS, Sharda University, Greater Noida, U.P., India; [2]B.Optom Student, Optometry, SSAHS, Sharda University, Greater Noida, U.P., India; [3]B.Optom Student, Optometry, SSAHS, Sharda University, Greater Noida, U.P., India; [4]B.Optom Student, Optometry, SSAHS, Sharda University, Greater Noida, U.P., India; [5]Optometrist, Department of optometry, Ramlal Golchha Eye Hospital Foundation, Biratnagar, Nepal.

ABSTRACT

Climate change offers several difficulties to global health, including a considerable influence on ophthalmology. Ocular surface disorders (OSDs) refer to a group of ailments that affect the cornea, conjunctiva, and tear film, with dry eye syndrome (DES) being the most common. Various environmental variables, such as increasing temperatures, changed humidity levels, and increased airborne contaminants, are thought to exacerbate OSDs in response to changing climate conditions. These environmental stresses have a direct impact on ocular physiology, resulting in tear film instability, epithelium damage, and inflammation. Climate change's rising temperatures, changing precipitation patterns, and increased frequency of extreme weather events all have serious consequences for ocular surface disorders. The intricate relationship between climate change and the epidemiology of OSDs, with a focus on how environmental factors such as heatwaves, air pollution, and allergen distribution influence the prevalence and severity of diseases such as dry eye syndrome, allergic conjunctivitis, and other ocular surface diseases.

Key Words: Climate Change, Dry eye, Ocular allergy, Ultraviolet radiation, Pterygium, Photokeratitis

INTRODUCTION

Climate change, defined as long-term fluctuations in temperature, precipitation patterns, and extreme weather occurrences, has emerged as one of the most important global concerns of the twenty-first century.[1] Human activities, particularly the release of greenhouse gases like carbon dioxide, methane, and nitrous oxide, are principally responsible for these changes. Global warming has resulted in a number of environmental changes, including rising sea levels, more frequent and severe weather events, and alterations in ecosystems and biodiversity. These environmental changes have far-reaching consequences for numerous aspects of human health, with ocular health being an important but largely disregarded area of concern. While the impacts of climate change on respiratory and cardiovascular systems are well-documented, its impact on ocular health is a new area of research that requires major attention.[2] The Intergovernmental Panel on Climate Change (IPCC) has confirmed that global temperatures are rising, with 2010-2019 being the hottest decade on record.[3] This warming trend is accompanied by more frequent and intense heat waves, changing precipitation patterns, and higher levels of air pollution. These environmental changes might have both direct and indirect effects on ocular health. For example, increased temperatures and extended exposure to ultraviolet (UV) radiation can cause oxidative stress on the ocular surface, while changed humidity levels can affect the tear film's equilibrium. Increased air pollution, such as particle matter (PM), ozone, and nitrogen dioxide, might worsen inflammatory reactions in the eye tissues.[4]

The ocular surface is a complex and dynamic structure that connects the eye to the surrounding world. It is critical for preserving visual acuity and safeguarding the eye against infections and environmental damages. The tear film, a thin coating of fluid that covers the ocular surface, is necessary for lubrication, nutrition delivery, and debris removal. It is made up of three layers: the lipid layer, which is created by the Meibomian glands; the aqueous layer, which is released by the lacrimal glands; and the mucin layer, which is produced by the conjunctival goblet cells.[5] Any disturbance to this delicate equilibrium might result in ocular surface disorders. Ocular surface disorders are a collection of ailments that affect the cornea, conjunctiva, and tear film. Dry eye

Corresponding Author:
Manish Kumar Sah, Department of Optometry, Sharda School of Allied Health Sciences, Sharda University, Greater Noida, U.P. 201306 India; Phone: +91 7015273496; E-mail: sahmanish52@gmail.com

ISSN: 2231-2196 (Print) **ISSN:** 0975-5241 (Online)

Received: 17.06.2024 **Revised:** 20.07.2024 **Accepted:** 29.07.2024 **Published:** 05.08.2024

disease (DED), allergic conjunctivitis, and infectious keratitis are three of the most prevalent ocular surface disorders (OSD). These disorders can cause substantial pain, vision impairment, and a decrease in overall quality of life. Infectious keratitis, a severe and possibly blinding illness, can be aggravated by environmental factors such as water pollution and inadequate sanitation.[6] Age, gender, genetics, and environmental exposures all have a role in OSDs. The tear film, which maintains ocular surface homeostasis, is especially susceptible to environmental factors including temperature, humidity, and air quality.

Linking Climate Change to Ocular Surface Diseases

Temperature and humidity variations can influence the stability and content of the tear film. Higher temperatures can cause increased evaporation rates, which can contribute to tear film instability and the development of dry eye disease.[7] Furthermore, low humidity conditions might aggravate tear evaporation and ocular surface dryness.[8] Climate change has been linked to higher levels of air pollutants such as particulate matter, ozone, and nitrogen dioxide. These pollutants can produce oxidative stress and inflammation on the ocular surface, resulting in allergies and dry eye syndrome. Air pollution levels have been linked to an increased risk of OSDs, according to studies.[9, 10] The ozone layer's depletion causes an increase in ultraviolet (UV) radiation reaching the Earth's surface. Prolonged UV exposure can harm the ocular surface, contributing to disorders including Pterygium and pinguecula. UV exposure can also cause oxidative stress and inflammation, which aggravates OSDs. Climate change has an impact on how allergies and infections are distributed and concentrated. Longer pollen seasons and greater pollen output may raise the risk of allergic conjunctivitis.[11] Climate changes can also alter pathogen dispersal, thereby raising the incidence of infectious keratitis.

Ocular Surface Diseases

Ocular surface disorders are growing more common over the world, which has serious consequences for public health and quality of life. For example, millions of individuals worldwide suffer from dry eye disease, which causes pain, visual impairment, and an increased risk of ocular infections. Another common illness is allergic conjunctivitis, which is frequently provoked by environmental allergens and is projected to grow more widespread as climate conditions change. Infectious keratitis, a dangerous and possibly sight-threatening illness, can be impacted by environmental variables such as water pollution and poor sanitation, which may be aggravated by climatic catastrophes.

Dry Eye

Dry eye syndrome (DES) has arisen as a major public health problem across the world, impacting millions of people, especially in areas undergoing fast climate change. Dry eye syndrome is a multifactorial ocular condition characterized by inadequate tear production, poor tear quality, or excessive tear evaporation, resulting in pain, visual abnormalities, and probable ocular surface injury.[12] The disorder is impacted by a variety of environmental, behavioral, and systemic variables, with climate having an important role in its occurrence and presentation. Temperature and humidity fluctuations affect tear film dynamics, aggravating symptoms and increasing the likelihood of developing dry eye.[4] Weather patterns shifted by climate change have a substantial influence on tear film stability and ocular surface health. Rising temperatures and lower humidity levels contribute to increased tear evaporation, jeopardizing tears' protective role and worsening dry eye symptoms.[13] Arid or desert areas are especially vulnerable, with people at increased risk of dry eye due to extended contact to dry and dusty conditions.

Here is how climate change is believed to influence the prevalence and severity of dry eye disease. Deteriorating air quality associated with climate change further complicates dry eye management. Airborne pollutants, such as particulate matter, ozone, and allergens, irritate the ocular surface and exacerbate inflammation, contributing to the development and progression of dry eye syndrome.[14] Urban centers and industrialized regions with high levels of air pollution report higher incidences of dry eye, highlighting the detrimental effects of environmental pollutants on ocular health. Rising temperatures can exacerbate evaporative dry eye, one of the most common forms of the disease. Increased temperatures enhance the rate of tear evaporation, especially in individuals with compromised tear film stability. Studies have shown that higher temperatures correlate with increased tear evaporation rates, leading to greater discomfort and ocular surface damage.[4, 15] Changes in humidity levels, often characterized by prolonged periods of low humidity, are detrimental to the tear film. Dry, arid conditions reduce the moisture available to maintain a stable tear film, leading to dryness and irritation.[13] Regions experiencing prolonged droughts or increased temperatures are particularly susceptible to these conditions. Increased UV radiation, a consequence of ozone layer depletion and changes in atmospheric conditions, poses a significant risk to ocular health. UV radiation can damage the ocular surface and tear-producing glands, leading to dry eye symptoms.[16] Protective measures, such as sunglasses with UV protection, become increasingly important in regions with heightened UV exposure due to climate change. At the moment, the majority of dry eye condition treatments are palliative rather than curative. When natural tears are insufficient, artificial tears are frequently employed in their place.[17] These can be divided into groups based on the main components and attributes that are meant to nourish the tear film, stabilize or rectify the imbalance in the tear film, en-

hance the volume of the tears, and/or dilute hypertonic tears. These over-the-counter artificial tears are generally thought to be helpful in lessening the symptoms (such as burning and pain) associated with dry eyes. But several of the artificial tears that are now on the market have shown improvements in symptoms of dry eye, including keratitis, conjunctival staining, and tear film break-up time (TBUT).[18]

It is critical to raise public and healthcare professional knowledge about the effects of climate change on dry eyes. To alleviate the consequences of dry eye, educational efforts can encourage the use of artificial tears, environmental changes, and protective eyewear. Educating the public about the relationship between climate change and DES, as well as taking preventive steps like staying hydrated, using humidifiers, and shielding your eyes from pollution and UV radiation, will help lower the prevalence of DES. Implementing stronger pollution control measures can help to lessen the environmental elements that contribute to DES. Policies addressing industrial emissions, vehicle pollution, and sustainable energy sources are critical. Urban design that integrates green areas and eliminates heat islands can help to alleviate the effects of high temperatures and pollution on eye health. Green areas increase air quality and create a healthier environment for eyes. Promoting early detection and good management of DES through public health initiatives and healthcare practitioner training can improve patient outcomes and lessen the strain on healthcare systems. Policymakers and advocacy organizations should emphasize programs aimed at combating climate change and its health consequences. Policies that limit carbon emissions, encourage sustainable practices, and protect vulnerable people from harsh weather conditions can all assist to minimize the incidence of dry eye disease.

Ocular Allergy

In recent years, the combination of ocular allergy and climate change has become a major worldwide health problem. Millions of people throughout the world suffer from ocular allergies, including allergic conjunctivitis, which can cause minor discomfort to severe inflammation that impairs vision.[19] These problems are aggravated by environmental influences, notably those brought on by climate change. Eye allergies, which include disorders such as allergic conjunctivitis and keratoconjunctivitis, have long been recognized as major causes of eye pain and decreased quality of life. Symptoms might range from minor itching and redness to severe inflammation, affecting eyesight and everyday activities. Traditionally associated with seasonal pollen exposure and indoor allergies, these circumstances are presently undergoing significant modifications as a result of climate change.[20] Allergic reactions in the eyes are immunological responses produced by allergens such pollen, dust mites, pet dander, and mold. When the immune system is exposed to certain allergens, it produces histamines and other inflammatory mediators, causing symptoms such as itching, tears, swelling, and conjunctival redness. Chronic exposure can cause chronic inflammation of the cornea, which can lead to problems such as keratoconus or corneal scarring.

People with IgE sensitivity might develop allergic conjunctivitis (AC) after being exposed to airborne allergens through their eyes.[21] The most important factors are the type of allergen sensitivity, exposure level, and degree of sensitivity to that allergen; however, other factors can also influence these parameters, making it difficult to conduct an exact scientific study of a highly heterogeneous population in an uncontrolled setting. Four disease subtypes, seasonal allergic conjunctivitis (SAC), perennial allergic conjunctivitis (PAC), vernal keratoconjunctivitis (VKC), and atopic keratoconjunctivitis (AKC), can be used to identify ocular allergies.[22] It is believed that 20% or more of the general population has an eye allergy. Over 90% of them have PAC, SAC, or both. An allergy affects around 15-20% of the world's population, with ocular symptoms prevalent in 40-60% of allergic patients.[23] Allergic conjunctivitis is classified as a condition that affects the conjunctiva, lids, cornea, and tear film, among other areas of the eye. The symptoms include itching, red eyes, burning or stinging, swollen eyelids, runny nose, nasal congestion, watery eye discharge, crying, light sensitivity, and white, ropey discharge. 90% of ocular allergies, which affect more than 20% of the general population, are seasonal or permanent.[24] The other 10% of occurrences are due to drug-induced dermatoconjunctivitis and the more severe but unusual atopic or vernal keratoconjunctivitis (AKC, VKC). Air pollution and pollen dispersion are serious environmental concerns, particularly as they relate to public health policies. According to the study, there are several exogenous and endogenous risk factors associated with ocular allergies. A cross-sectional investigation found that only around 20% of those with ocular allergies blame a specific item for their conjunctivitis.[25]

Rising temperatures have lengthened pollen seasons and boosted allergenic protein synthesis in plants, resulting in more severe allergy responses among vulnerable people. Pollen grains, a common allergy, are becoming more plentiful and powerful as a result of extended periods of warmth and high carbon dioxide levels, which promote plant development. Climate change has an impact on air quality, which is another important element in ocular health, in addition to pollen. Urbanization and industrialization, together with climate-related causes like as wildfires and dust storms, all lead to high levels of particulate matter and air pollution.[26] These pollutants can irritate the eyes, worsening symptoms in those who have ocular allergies. Wildfires and other climate-related phenomena emit smoke and ash particles, which can cause severe allergy responses, complicating management and treatment techniques.[27] Climate change has an impact on

air quality, which is another important factor in the incidence of ocular allergies. Elevated atmospheric temperatures help to create ground-level ozone and particulate matter, both of which are major contributors to pollution. These contaminants carry allergens, allowing them to travel great distances and raising exposure levels. Warmer temperatures encourage the growth of allergen-producing organisms like molds and fungus, increasing airborne allergen levels and worsening ocular allergy symptoms.[28]

Photokeratitis

Climate change, a rapidly worsening worldwide catastrophe marked by rising temperatures, changing weather patterns, and increased ultraviolet (UV) radiation exposure, has far-reaching consequences for human health. Photokeratitis, an acute inflammatory disorder of the cornea induced by high UV radiation, is one of the lesser-known but serious health dangers related with climate change.[29] As climate change continues to modify our environment, knowing its influence on photokeratitis and devising appropriate mitigation techniques is critical for maintaining ocular health. Photokeratitis, sometimes known as "snowblindness," is similar to eye sunburn. It happens when the cornea, the eye's translucent front layer, absorbs too much UVB light, causing cellular damage and inflammation. This overexposure causes epithelial cell death and the production of inflammatory mediators, which results in acute symptoms that often appear several hours later.[30] Photokeratitis symptoms include eye discomfort, redness, tears, swelling, impaired vision, and a gritty feeling. In extreme situations, temporary visual loss may occur. Photokeratitis, which has traditionally been linked with high-altitude habitats and reflecting surfaces such as snow and water, is becoming more significant in light of climate change.[31] UV radiation from natural sunshine reflected UV rays from snow, water, and sand, and artificial sources such as welding torches and tanning beds are all potential causes of photokeratitis.

Any sort of radiant radiation that enters the eye and is absorbed at a level that might cause heat, structural changes, metabolic disturbance, photochemical reactions, or other consequences may be damaging to the eye. The phototoxic effects of the electromagnetic spectrum's optical wavebands can be caused by exposure to excessive amounts of radiation or the presence of a chemical that photosensitizes cells. According to an increasing amount of studies, the effects of ultraviolet radiation (UVR) are more subtle and may be detrimental to the eye and vision than previously assumed.[32, 33] The eyelids, cornea, conjunctiva, crystalline lens, and retina are all impacted by this condition.

Photokeratitis is corneal epithelial damage caused by UV radiation (UVR) from either natural or artificial causes.[34] Examples include welding arcs (arc eye, welder's eye) and reflection off snow (snow blindness). Common clinical symptoms include conjunctival injection and punctate erosions of the corneal epithelium with an intrapalpebral distribution. Burns from UV radiation on the exposed skin around the eyes are another remarkable discovery. When photokeratitis symptoms are addressed, the condition usually resolves on its own within 24 to 48 hours.[34] Light reflections off snow, particularly at high elevations, and arc welding remain the most well-known causes of photokeratitis, but there are several more recognized causes. Photokeratitis can be caused by arc welding, snow reflections, other recreational sunlight exposure, sun lamps, tanning beds, germicidal or laboratory UV lights, damaged metal halide lamps (common in gymnasiums), and halogen lamp bursts.[35]

Pterygium

Pterygium, sometimes known as "surfer's eye," is a benign conjunctival growth that spreads to the cornea, causing discomfort, redness, and reduced vision. Pterygium is defined by the gradual invasion of fibrovascular tissue into the cornea, which can cause vision loss, discomfort, and esthetic issues.[36] While the specific pathophysiology is unknown, prolonged exposure to UV radiation, particularly UV-B rays, is a well-known risk factor. UV exposure causes oxidative stress and inflammation in conjunctival and corneal epithelial cells, which promotes fibroblast growth and the development of pterygium.[37] Chronic discomfort from wind, dust, and dry environments are other significant causes. Pterygium is projected to become more common and severe as climate change increases UV radiation levels and changes environmental circumstances. As global temperatures rise, individuals will spend more time outside, increasing their exposure to UV radiation. This behavioral adjustment is especially important in areas where heatwaves occur more frequently and intensely. Outdoor leisure activities, agricultural activity, and other types of outdoor labor increase the risk of UV exposure, which contributes to the formation and advancement of pterygium.[38] Climate change can also exacerbate environmental factors including increased wind, dust, and dry air, all of which are known to aggravate pterygium. Pterygium prevalence varies greatly across geographic locations, with larger occurrences seen toward the equator, where UV radiation levels are naturally higher. Pterygium is more prevalent in low latitude places because the atmosphere is thinner and less capable of absorbing UV radiation.[39]

Pinguecula

Pinguecula appears as a yellowish, elevated lesion on the conjunctiva, commonly in the sclera near the cornea. These lesions are made up of degraded collagen fibers and elastin, and they are frequently caused by long-term exposure to environmental toxins.[40] Pinguecula is normally asymptomatic and not malignant, although it can cause pain, dryness, and

irritation. Long-term exposure to UV radiation, wind, and dust are the key risk factors for pinguecula development, all of which are greatly impacted by climate change.[41] As a result of sun-altered fibroblasts and elastic material changes, abnormal elastic material accumulates in the connective tissue underlying the limbal conjunctival epithelium on both sides of the cornea, creating pinguecula, a degenerative connective tissue condition. Pinguecula infections can spread more swiftly in the elderly. It is more prevalent among men, most likely as a result of occupational exposure to sunshine or UV rays. Trauma, wind, dust, sand, and prolonged outside employment are all additional risk factors for illness development.[42]

Public Health Implications

The rising occurrence of OSDs as a result of climate change has serious public health consequences. OSDs can result in high healthcare expenditures, lost productivity, and a worse quality of life. Environmental variables that contribute to an increase in OSDs must be addressed in public health policies. This involves monitoring and controlling air pollution, advocating for UV protection, and increasing awareness about the possible impact of climate change on ocular health.[43] To maintain population health, eye health issues must be included into larger climate change adaptation and mitigation plans. Addressing the link between climate change and ocular surface disorders is critical for implementing effective public health measures and reducing the effects on affected communities. Understanding the complicated relationships between environmental variables and ocular health needs a multidisciplinary approach that includes ophthalmologists, environmental scientists, and public health professionals.[44] Furthermore, increasing understanding of the ocular health consequences of climate change can lead to improved preventative and management techniques, eventually enhancing the quality of life for people afflicted.

Conclusion

The link between climate change and ocular surface disorders exemplifies the complicated interplay of environmental variables and human health. As climate change continues to impact our planet, the hazards linked with increasing UV radiation exposure, environmental irritants, and air pollution are expected to worsen, contributing to an increase in the prevalence of OSDs. To prevent these dangers and protect ocular health, proactive measures such as public health education, environmental protection regulations, technology advancements, and community participation must be implemented. By tackling the underlying causes of climate change and strengthening preventative measures, we can lessen the burden of OSDs and assure a healthy future for everybody.

ACKNOWLEDGEMENTS

I thank the editing staff and reviewers for improving the clarity and consistency of this research work.

Conflict of interest- NIL

Source of Funding: NONE

Ethics Approval and Consent to Participate- Not Applicable

Authors' Contribution: All authors contributed equally.

REFERENCES

1. Abbass K, Qasim MZ, Song H, Murshed M, Mahmood H, Younis I. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environ Sci Pollut Res. 2022;29(28):42539-59.
2. Rice MB, Thurston GD, Balmes JR, Pinkerton KE. Climate change. A global threat to cardiopulmonary health. Am J Respir Crit care Med. 2014;189(5):512-9.
3. RELEASE P. 2019 concludes a decade of exceptional global heat and high-impact weather: World Meteorological Organization; 02 December 2019 [7/16/2024]. Available from: https://wmo.int/news/media-centre/2019-concludes-decade-of-exceptional-global-heat-and-high-impact-weather#:~:text=The%20global%20mean%20temperature%20for,period%20and%20decade%20on%20record.
4. Mandell JT, Idarraga M, Kumar N, Galor A. Impact of air pollution and weather on dry eye. J Clin Med. 2020;9(11):3740.
5. Davidson HJ, Kuonen VJ. The tear film and ocular mucins. Vet Ophthalmol. 2004;7(2):71-7.
6. Ting DSJ, Ho CS, Deshmukh R, Said DG, Dua HS. Infectious keratitis: an update on epidemiology, causative microorganisms, risk factors, and antimicrobial resistance. Eye (Lond). 2021;35(4):1084-101.
7. Abusharha AA, Pearce EI, Fagehi R. Effect of ambient temperature on the human tear film. Eye Contact Lens. 2016;42(5):308-12.
8. Abusharha AA, Pearce EI. The effect of low humidity on the human tear film. Cornea. 2013;32(4):429-34.
9. Lin C-C, Chiu C-C, Lee P-Y, Chen K-J, He C-X, Hsu S-K, et al. The adverse effects of air pollution on the eye: a review. Int J Environ Res Public Health. 2022;19(3):1186.
10. Galor A, Britten-Jones AC, Feng Y, Ferrari G, Goldblum D, Gupta PK, et al. TFOS Lifestyle: Impact of lifestyle challenges on the ocular surface. Ocul Surf. 2023;28:262-303.
11. Zeghnoun A, Ravault C, Fabres B, Lecadet J, Quénel P, Thibaudon M, et al. Short-term effects of airborne pollen on the risk of allergic rhinoconjunctivitis. Arch Environ Occup Health. 2005;60(3):170-6.
12. Nebbioso M, Del Regno P, Gharbiya M, Sacchetti M, Plateroti R, Lambiase A. Analysis of the pathogenic factors and management of dry eye in ocular surface disorders. Int J Mol Sci. 2017;18(8):1764.
13. Um S-B, Kim NH, Lee HK, Song JS, Kim HC. Spatial epidemiology of dry eye disease: findings from South Korea. Int J Health Geogr. 2014;13:1-9.
14. Yang D-L, Zhang Z-N, Liu H, Yang Z-Y, Liu M-M, Zheng Q-X, et al. Indoor air pollution and human ocular diseases: associated contaminants and underlying pathological mechanisms. Chemosphere. 2023;311:137037.

15. Purslow C, Wolffsohn JS. Ocular surface temperature: a review. Eye & contact lens. 2005;31(3):117-23.
16. Calonge M, Pinto-Fraga J, González-García MJ, Enríquez-de-Salamanca A, López-de la Rosa A, Fernández I, et al. Effects of the external environment on dry eye disease. Int Ophthalmol Clin. 2017;57(2):23-40.
17. HOLLY FJ. Artificial tear formulations. Int Ophthalmol Clin. 1980;20(3):171-84.
18. Snibson G, Greaves J, Soper N, Tiffany J, Wilson C, Bron A. Ocular surface residence times of artificial tear solutions. Cornea. 1992;11(4):288-93.
19. Gomes PJ. Trends in prevalence and treatment of ocular allergy. Curr Opin Allergy Clin Immunol. 2014;14(5):451-6.
20. Shea KM, Truckner RT, Weber RW, Peden DB. Climate change and allergic disease. Journal of allergy and clinical immunology (JACI). 2008;122(3):443-53.
21. Fauquert JL. Diagnosing and managing allergic conjunctivitis in childhood: the allergist's perspective. Pediatr Allergy Immunol. 2019;30(4):405-14.
22. Leonardi A, Righetti G, Giovannini G, De Marchi V, Occhiuto M. Diagnostic criteria of chronic conjunctivitis: atopic keratoconjunctivitis and vernal keratoconjunctivitis. Curr Opin Allergy Clin Immunol. 2023;23(5):390-6.
23. Bielory L. Allergic and immunologic disorders of the eye. Part II: ocular allergy. Journal of Allergy and Clinical Immunology (JACI). 2000;106(6):1019-32.
24. Bielory L. Allergic diseases of the eye. Med Clin. 2006;90(1):129-48.
25. Leonardi A, Castegnaro A, Valerio ALG, Lazzarini D. Epidemiology of allergic conjunctivitis: clinical appearance and treatment patterns in a population-based study. Curr Opin Allergy Clin Immunol. 2015;15(5):482-8.
26. Kaur R, Pandey P. Air pollution, climate change, and human health in Indian Cities: a brief. The role of climate and air pollution in human health and urban chemistry in Asian cities. 2022.
27. Kumah DB, Lartey SY, Yemanyi F, Boateng EG, Awuah E. Prevalence of allergic conjunctivitis among basic school children in the Kumasi Metropolis (Ghana): a community-based cross-sectional study. BMC Ophthalmol. 2015;15:1-5.
28. Miyazaki D, Fukagawa K, Okamoto S, Fukushima A, Uchio E, Ebihara N, et al. Epidemiological aspects of allergic conjunctivitis. Allergol Int. 2020;69(4):487-95.
29. Choy CKM, Cho P, Benzie IF. Antioxidant content and ultraviolet absorption characteristics of human tears. Optom. Vis. Sci. 2011;88(4):507-11.
30. Seen S, Tong L. Dry eye disease and oxidative stress. Acta Ophthalmologica. 2018;96(4):e412-e20.
31. TAYLOR JH, Letavet A. ULTRAVIOLET, VISIBLE, AND INFRARED RAYS [1]. Foundations of Space Biology and Medicine: Ecological and physiological bases of space biology and medicine. 1975;2:453.
32. Taylor HR. Ultraviolet radiation and the eye: an epidemiologic study. Transactions of the American Ophthalmological Society. 1989;87:802.
33. Sliney DH. UV radiation ocular exposure dosimetry. Journal of Photochemistry and Photobiology B: Biology. 1995;31(1-2):69-77.
34. Izadi M, Jonaidi-Jafari N, Pourazizi M, Alemzadeh-Ansari M, Hoseinpourfard M. Photokeratitis induced by ultraviolet radiation in travelers: A major health problem. J. Postgrad. Med. 2018;64(1):40-6.
35. Moore LA, Hussey M, Ferreira J, Wu B. Review of photokeratitis: Corneal response to ultraviolet radiation (UVR) exposure. Afr. vis. eye Health. 2010;69(3):123-31.
36. Bradley JC, Yang W, Bradley RH, Reid TW, Schwab IR. The science of pterygia. British journal of ophthalmology (BJO) 2010;94(7):815-20.
37. Asokan R, Venkatasubbu RS, Velumuri L, Lingam V, George R. Prevalence and associated factors for pterygium and pinguecula in a South Indian population. Ophthalmic and Physiological Optics (OPO). 2012;32(1):39-44.
38. Maharjan I, Shreshth E, Gurung B, Karmacharya S. Prevalence of and associated risk factors for pterygium in the high altitude communities of Upper Mustang, Nepal. Nepalese J Ophthalmol. 2014;6(1):65-70.
39. Fernandes AG, Salomão SR, Ferraz NN, Mitsuhiro MH, Furtado JM, Muñoz S, et al. Pterygium in adults from the Brazilian Amazon Region: prevalence, visual status and refractive errors. British Journal of Ophthalmology (BJO). 2020;104(6):757-63.
40. Austin P, Jakobiec FA, Iwamoto T. Elastodysplasia and elastodystrophy as the pathologic bases of ocular pterygia and pinguecula. Ophthalmol. 1983;90(1):96-109.
41. Dushku N, Reid TW. P53 expression in altered limbal basal cells of pingueculae, pterygia, and limbal tumors. Curr Eye Res. 1997;16(12):1179-92.
42. Viso E, Gude F, Rodríguez-Ares M. Prevalence of pinguecula and pterygium in a general population in Spain. Eye. 2011;25(3):350-7.
43. Organization WH. Preventing disease through healthy environments: exposure to lead: a major public health concern. 2023.
44. Alves M, Asbell P, Dogru M, Giannaccare G, Grau A, Gregory D, et al. TFOS Lifestyle Report: Impact of environmental conditions on the ocular surface. The Ocular Surface. 2023;29:1-52.