Impact of lifestyle and climate change on ocular health

Introduction

With a weight of less than an ounce and a diameter of merely an inch, the eye stands as a remarkable testament to the intricacy of our sensory system. (1) I value vision, which serves as a foundation of empiricism, to be the most remarkable of our five senses. This aligns with Aristotle's assertion that "we prefer seeing to everything else". (2) Having established the significance of sight, it is important to investigate how it can be impacted both by climate change as well as lifestyle factors. Greenhouse gas levels have reached unprecedented highs, indicating that the historical theory of climate change is now manifesting as a pressing reality. (3) The anticipated increase in global temperature is predicted to detriment multiple sectors across the world, with healthcare being a major one. This will have a multifaceted effect on ocular health as well as warranting a re-evaluation in resource allocation for the affected population. Additionally, lifestyle choices we make also play a vital role in the factors affecting the health of our eyes. In this essay I will explore the collective impact of climate change and lifestyle on ocular health. I will delve into how each of the key anatomical components of the eye can be affected by these two variables, as well as the implications of this.

Anatomy

The meticulous design of the eye is something that has always fascinated me throughout my medical training. The more I study it, I realise that its complexity is truly eye-opening, discovering more and more layers, the deeper I look. However, for the scope of this essay, I will provide a simplified overview of the fundamental anatomy of the eye. The eyeball can be split into two segments, extending from the visible part at the front (anterior) to the rear (posterior). The anterior segment is formed by the cornea and sclera, the sclera being the opaque white tissue that encases the eyeball. The conjunctiva is a thin transparent membrane that lines the inner eyelids as well as portion of the sclera. With each blink, these eyelids replenish the protective tear film, made of aqueous and lipid layers. This tear film stands to protect the cornea, the transparent window at the front of the eye which allows the entry of light. The degree of light which enters through the pupil is strictly regulated by the coloured iris sphincter muscle. Just behind to this lies the ciliary body, which connects to the suspensory ligaments that hold the clear lens in place. This lens can develop opacification which is known as cataract. Together, the iris and ciliary body constitute the anterior uvea, while the vascular choroid layer forms the posterior uvea. This anterior segment can further be divided into anterior and posterior chambers, both of which contain a clear fluid called aqueous humour. Beyond the lens remains the posterior segment, which is filled which a gel-like substance called vitreous humour. Finally, at the back of the eye is the retina, which houses the pigmented cells that allow for light perception, thereby enabling vision.

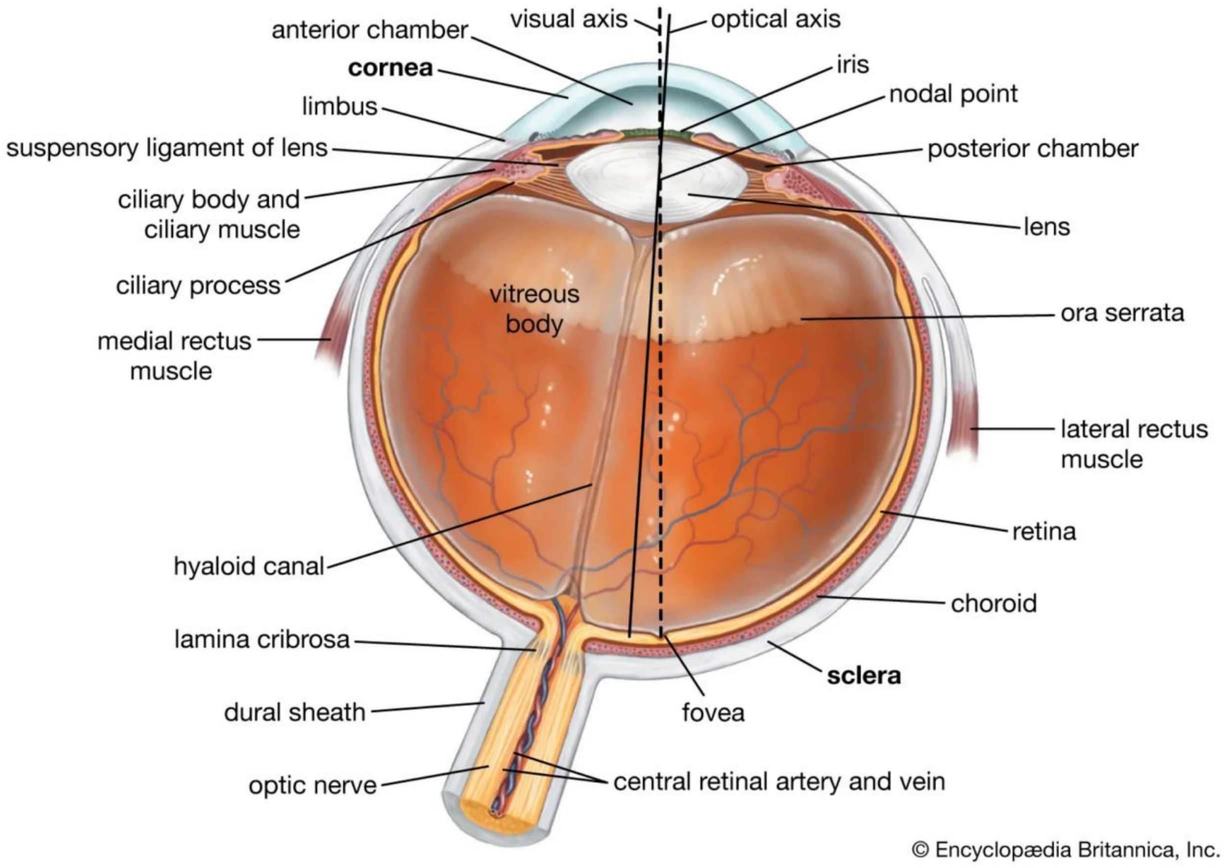

Figure 1. Anatomy of the Eye (1)

Climate Change

Before beginning to address the drastic implications of climate change upon ocular health, we must understand the meaning of climate change. Climate change refers to the long-term alteration in climate patterns, including a change in temperature. (4) Currently, the Earth is experiencing a trend of increasing temperatures, known as global warming, which is a significant part of climate change. This is attributed to the emission of greenhouse gases, which additionally deplete the ozone layer, thus increasing penetration of ultraviolet (UV) radiation onto the Earth. Now the question arises: how does this impact our eyes?

A comprehensive literature review conducted by Hamba et al. displayed the damaging histopathological effects of UV radiation on pertinent structures within the eye. (5) With the cornea being at the forefront of the eye, it is exposed to the harsh surroundings of UV radiation, 90% of which it absorbs. This causes thinning of multiple corneal layers as well as oedema and cellular death. It also causes an irregularity in the growth of the stromal layer of the cornea. These factors all contribute to the cumulative development of photokeratitis, symptoms of which include redness, photophobia and excessive tearing. Also, 92% of lenses that were subject to low dose radiation three times per week for almost a year subsequently developed cortical cataracts. However, it must be noted that this study was conducted on the lens' of mice, which differ to the components of the human lens, thus reducing external validity. This places individuals who work outdoors at a significantly higher risk, particularly concerning as 3.6 billion people already live in regions vulnerable to climate change. (6) The statistic revealing a prevalence of cataracts in 100 million people pales in comparison to the alarming reality that only 17% of individuals have access to appropriate intervention measures. (7)

Now that we have established the detrimental effects of UV radiation on the eye, it is essential to consider the impact of rising temperatures. A large proportion of people, especially in the UK, are known to prefer warmer climates. Not only does it have a positive effect on their mood, but they also perceive it to have health benefits. So how damaging can a warmer summer really be for our eyes? A Spanish study by Echevarría-Lucas et al. demonstrated numerous associations between increased temperatures and ocular pathologies. (8) The way in which heat can damage the eyes is multi-fold, with dry eye and conjunctivitis being common consequences. Higher temperatures and pollutants can lead to evaporation or damage of the protective tear film, as well as disproportionality within its layers. Higher temperatures are also associated with a raised pollen count, provoking flares of allergic conjunctivitis. (9) Climate change will also broaden the risk of pterygium development, previously observed primarily in warmer countries, as it is associated with heat and UV radiation exposure. (10) Not only was there an increased incidence of ocular surface disease, but also retinal detachments, macular degeneration, glaucoma and uveal melanoma. These conditions necessitate increased medical attention and potential surgical intervention as well as painful manifestations and, in severe cases, may lead to blindness or even death. In fact, of all the environmental variables, a raised temperature demonstrated the second highest association with pathologies, with UV exposure ranking first.

From this, it can be concluded that the current climate change pandemic is going to have a mass impact on ocular health. With over 2 million people already living with sight loss in the United Kingdom, it is a pressing issue that could get much worse. (11) Naturally, this will lead to an increased demand for ophthalmology resources within healthcare sectors. Therefore, I believe it is also worthwhile to explore the sustainability of these resources, as this will evidently impact ocular outcomes, thus perpetuating the vicious cycle. The carbon footprint of the healthcare system is not a novel concern, evidenced by the NHS campaign to achieve net zero emissions by 2040. (12) Therefore, I will focus on the sustainability of ophthalmology within the National Health Service (NHS) in the UK.

A comprehensive scoping review by Buchan. et al has alluded to the various areas within ophthalmology where there is potential to reduce carbon footprint. (13) Although the study contained research from multiple countries, I will only discuss the UK based studies. An area that must be addressed is the implication of using of single-use eye drops. Having personally witnessed the disposal of numerous small plastic tubes during each appointment in ophthalmology clinics, it's evident that while the single-use principle serves as an infection control measure, its environmental impact is significant. The study revealed that only 5% of these tubes cultured Staphylococcus bacteria, prompting the need for further research to ascertain the clinical significance of this statistic. Implementing a minor change such as the double use of these tubes could potentially save 12.7 tonnes of plastic waste. This is also the case for tonometer prisms and gonioscopy lenses which are used in the investigation workup for glaucoma.

Due to the mass of patients receiving ophthalmology care, even the most intricate procedures can have damaging effects on the climate, once scaled up. A notable example of this is the use of SF6 (sulphur hexafluoride) gas injections into the eye following vitreoretinal surgery, potentially after a retinal detachment or tear. This gas is used to establish a positive pressure within the eye to stabilise a previously detached retina in place and facilitate its complete healing. However, it also exhibits a greenhouse gas effect. Although it is used in very small volumes, the increasing prevalence of retinal detachments is demanding a higher volume of these procedures, thus exacerbating the environmental impact. Some studies have compared the use of air to replace SF6; however, the evidence is either inconclusive or points towards better post-operative outcomes with SF6. Finding an alternative high-density gas with similar efficacy is an avenue that could be explored.

Buchan. et al also advocates for the utilisation of manual small incision cataract surgery (MSICS) technique over phacoemulsification for cataract operations, due to the slightly reduced waste involved. Once again, however, a meta-analysis demonstrated the superiority of phacoemulsification over MSICS in terms of uncorrected vision outcomes and surgically induced astigmatism. (14) This presents an ethical dilemma of providing the optimal care for the singular patient or minimising the potential environmental harm on the wider population. This could warrant the introduction of a system that limits the use of unsustainable procedures, in which high priority cases can receive additional consideration. Though a major drawback of this could be that it impinges upon the NHS principle of healthcare access being based solely on clinical need. Nonetheless, a feasible change that could be implemented is the reduction in the packaging of these operating materials. During my ophthalmology placement, I remember being astounded by the excessive packaging accompanying the relatively small intraocular lens that was used in cataract surgery.

In summary, as the globe warms up, our eyes are facing a myriad of negative effects. The rising levels of UV radiation, particulate matter pollution and warmer climates are all contributing to the damage of key ocular structures, resulting in multiple pathologies. This is increasing the demand for ophthalmology resources, thereby exacerbating their carbon footprint. This cyclical relationship shows that targeting both the aspect of climate change as well as sustainability within ophthalmology is the most efficient way to save ocular health.

Lifestyle Factors

Having recognised the consequences of our surrounding environment, I will now delve into exploring if the way we act, impacts our ability to refract. Undoubtedly, the average person’s screen time has soared in recent years, particularly after the COVID pandemic prompted a shift to remote education and work. Additionally, we are all guilty of scrolling endlessly on our mobile phones, but this could come at a significant cost to our health. Apart from the blue light emission, which is known to interrupt our natural circadian rhythm, there are also ocular impacts of screens. A broad systematic review aimed to investigate the relationship between screen use (both mobiles and computers) and development of myopia (increased axial length of the eyeball) in children and adults up to 33. (15) The study suggested a possible correlation between the increased use of screens, particularly for near work activities, and the subsequent development of myopia. Remarkably, two studies even suggested an eightfold increased risk with the combined use of mobile and computer screens. However, the study had multiple limitations, such as no objective measure of myopia as well as the use of self-reported screen time measures. They also included observational studies within their analysis, for which it can be argued that a causal relationship between screen time and myopia cannot be inferred. To combat this, the conduction of a randomised control trial would be beneficial in providing more conclusive evidence as to whether there is a causal relationship.

An interesting interpretation of these results is whether the myopia is due to the use of screens, or whether prolonged screen time signifies a reduction in outdoor activities. This leads to an essential discussion about the impact of being outdoors on the optimal development of children’s eyes. Another systematic review collated data from multiple studies which explored the association between time spent outside and myopia. (16) One of the controlled trials that was analysed found that using outdoor activity as an intervention yielded a 0.3 dioptre myopic reduction compared to the control group. It must be noted, however, that time spent outdoors must be regulated with appropriate UV protection, to prevent the issues mentioned earlier on. Another important finding of the study was that outdoor activity had insignificant effects upon eyes that were already myopic. Table 1 displays the results of the meta-analysis performed on 18 different types of studies.

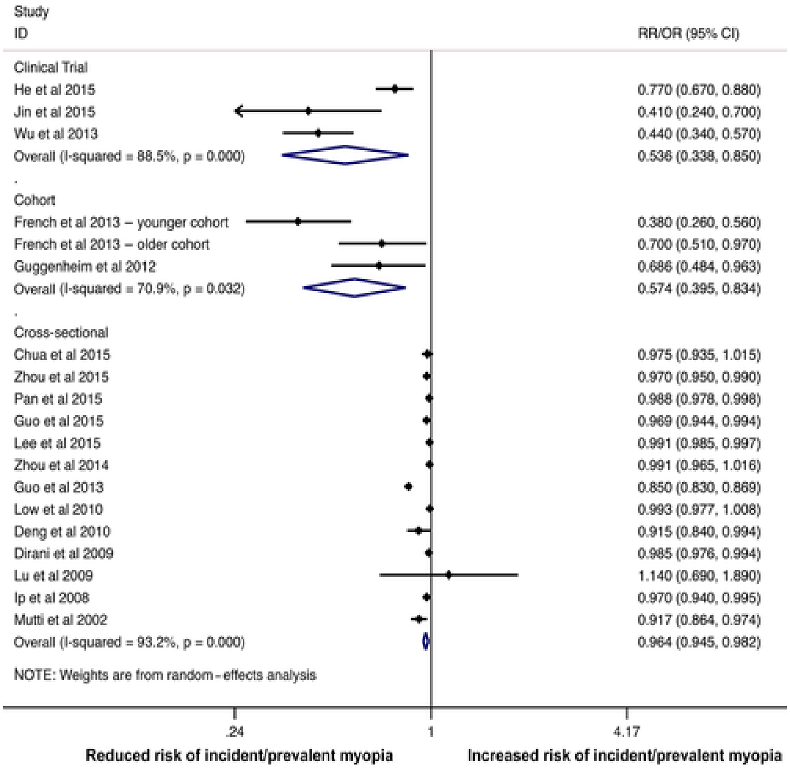

Table 1 : Forest plot showing the main random-effects meta-analysis performed to quantify the relationship between the time spent on outdoor activities and the incidence or prevalence of myopia

These results are worrying, due to the complex issue they present. As the age at which children start using phones decreases, their outdoor activity time also diminishes. This dual trend amplifies their susceptibility to developing myopia. Now that I have examined the potential factors contributing to the development of myopia, it's crucial to understand what myopia is and why its prevalence is significant. Myopia, more commonly known as ‘near sightedness’, is a refractive error due to elongation of the axial length of the eyeball. This means that the light coming into the eye is focused slightly in front of the retina, which produces blurred vision when looking at distant objects (refer to figure 2). The importance of myopia lies within its implications for ocular health, as it is a risk factor for many serious conditions. One of the more serious conditions is myopic macular degeneration, which was shown to have an association with myopia. (17) The pathological changes in myopic macular degeneration include Fuch’s spot and choroidal neovascularisation. Both changes cause a significant deterioration in central vision, due to macular involvement, and can eventually lead to blindness. Myopia was also shown to be a risk factor for one of the silent killers of vision, open angle glaucoma. This is a condition in which the intraocular pressure gradually rises until it begins to damage the optic nerve, which could eventually progress to tunnel vision if left untreated. Finally, myopia also predisposed people to retinal detachment and posterior subcapsular cataract, which are conditions requiring surgical intervention. The importance of reducing their incidence can be seen in the detrimental effects that these surgeries have on the environment, as discussed earlier.

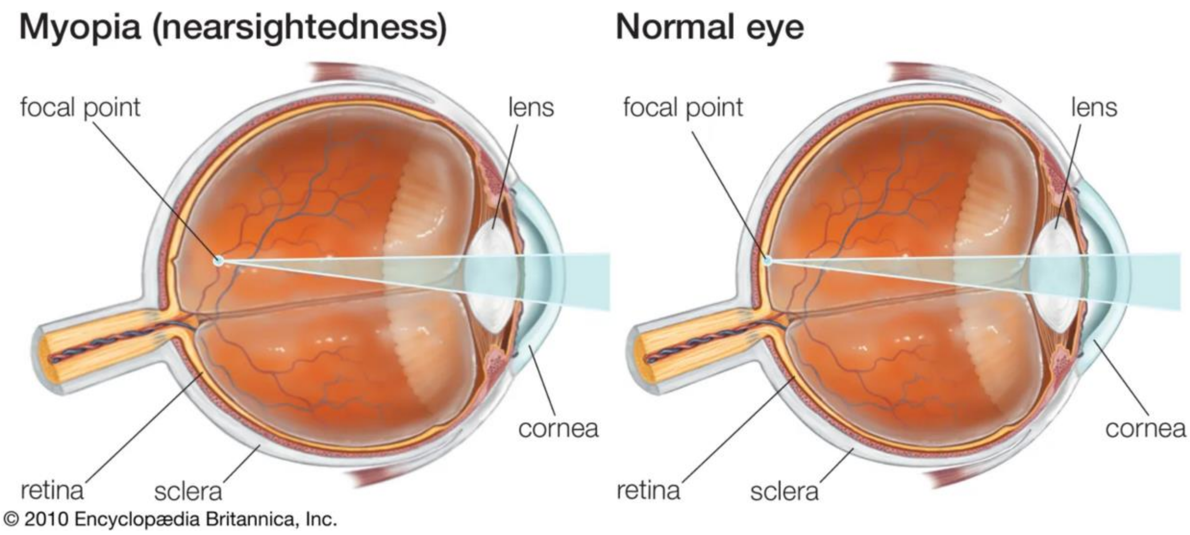

Figure 2 Visual Representation of Myopia (2).

Finally, I would like to discuss the lifestyle factors that pertain to the issue of climate change. It is well understood that the rising temperature is going to have knock on effects on health, trade, wildlife and agriculture, but what about on human behaviours? The rising temperatures associated with climate change may prompt shifts in human behaviour, particularly in colder climates where individuals may welcome warmer temperatures as an invitation to spend more time outdoors. However, without adequate eye protection, this increased outdoor activity could inadvertently accelerate the deterioration of ocular health. If the outdoor activities include swimming, this also introduces the risk of Pseudomonas Aeruginosa keratitis in contact lens wearers, a severe threat to sight. People are also more likely to take up gardening, which can lead to deposition of organic foreign bodies within their eye, leading to bacterial keratitis, as well as the potential to infect deeper structures. In the current economic turmoil we face, people may also look to taking up opportunities to work outdoors with machinery. Without ample eye protection, this poses the risk of traumatic injury to the eyes, such as perforation of the globe. Another implication worth considering is the potential impact on smokers. With the prospect of their fingers no longer at risk of going numb in colder temperatures, smokers may feel more inclined to take frequent cigarette breaks outdoors. This increased outdoor exposure, coupled with the detrimental effects of smoking on ocular health, could exacerbate existing risks and contribute to the deterioration of eye health. With smokers being four times as likely to develop age related macular degeneration as well as tar contributing to drusen formation, this could have a huge impact on the eyes. (18)

In summary, the increasing prevalence of screen time, poses a significant risk for the development of myopia, exacerbated by reduced time outdoors. Myopia not only affects visual acuity but also predisposes individuals to serious conditions like myopic macular degeneration, open-angle glaucoma, retinal detachment and cataracts. Moreover, as climate change prompts shifts in human behaviour, warmer temperatures may encourage outdoor activities, potentially increasing the risk of ocular injury and exposure to harmful environmental factors like smoke. This complex interplay between lifestyle factors and climate change underscores the importance of addressing both environmental and behavioural aspects to safeguard ocular health.

Conclusion

In conclusion, the complex structures of the eye are extremely susceptible to their surrounding environment. Given that impaired vision carries a global productivity cost of $411 billion, it is crucial to address factors that can mitigate this impact. (7) It is imperative to educate the public on safeguarding their eyes against the rising levels of greenhouse gases and temperatures. This can encompass initiatives such as promoting the use of sunglasses and protective contact lenses, as well as advocating for regular outdoor breaks for screen-engrossed children. Educating children about the detrimental effects of UV radiation on ocular health should be integrated into school curricula worldwide to avert a future crisis. Furthermore, there is a pressing need to reassess resource allocation within ophthalmology to minimize waste and break the cycle of declining eye health. Although we may not be able to see into the future, these changes must be made, to ensure that we can see clearly in the future.

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