EYE-SUN PROTECTION FACTOR. A NEW UV PROTECTION LABEL FOR EYEWEAR

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__*INTRODUCTION / ABSTRACT*

Ultraviolet radiation (UVR) potentially damages the skin, the immune system and structures of the eye.

Today there is no reliable and universal method to assess and compare protective properties of lenses.

Sunglasses as well as clear lenses can reduce transmission of UV effectively, however, an important share of the UV burden is attributed to reflection from the backside of the lenses.

To provide reliable labelling of the UV protection offered by lenses, an Eye-Sun Protection Factor (E-SPF™) has been developed by Essilor, encompassing both transmission and reflection.

A group of experts: ophthalmologists, optometrists and dermatologist, from 5 European countries reviewed existing literature on UV dangers and evaluated the relevance of E-SPF™.

Scientific articles have been submitted to Clinical Journal in Ophthalmology and Dermatology. [1,2]

__1- THE EYE AND UV EXPOSURE

UV definition

Ultraviolet radiation is defined by the wavelengths 100 to 400nm. UV-C (100-280nm) is essentially absorbed within the atmosphere. Of the UVR reaching earth UV-B (280-315nm) accounts for 5% and UV-A (315nm and above) up to 95%.

The shorter the wavelength, the more spectral energy increases, and the higher the potential damage. The potential biological damage at 300nm is 600 times greater than at 325 nm for example. (Fig.1)

Sources of UV

The main source of UVR is sunlight. Artificial lighting contributes to a lesser extent but may increase with the advent of energy efficient light sources. [3]

Ambient UV: direct radiation, scatter, and reflection

Direct sunlight only partly contributes to ambient UV. Under average conditions, more than 50% of ocular exposure comes from scattering and reflection from clouds and the ground.

The average annual UV dose is estimated to be 20,000 to 30,000 J/m2 for Americans, [4] 10,000 to 20,000 J/m^2 for Europeans, and 20,000 to 50,000 J/m^2 for Australians. Vacations can add more than 30% to the UV dose.

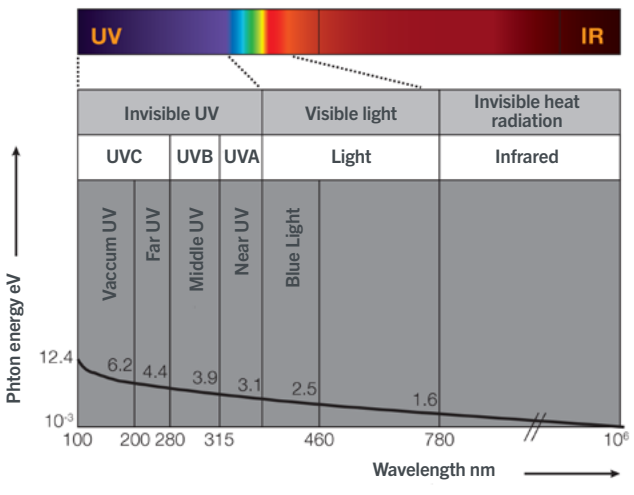

FIG. 1 | Radiation as a function of increasing photon energy.

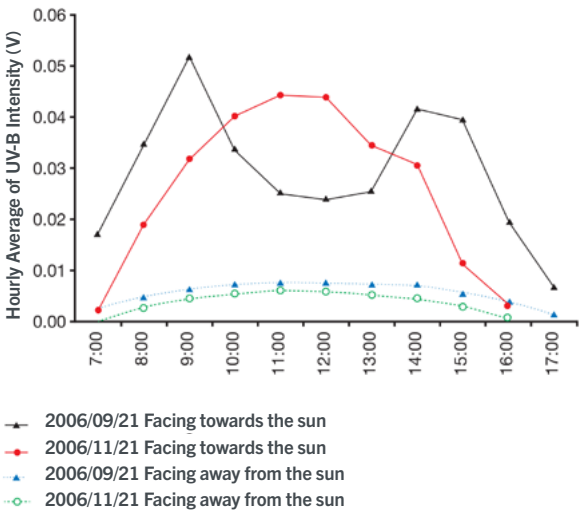

FIG. 2 | Hourly average of UV intensity in the eye when facing towards and away from the sun [Volt][5]

PRINCIPAL HARM TO THE EYE AND THE AREA AROUND THE EYE CAUSED BY UV EXPOSURE

Eyelids and area around the eye
Wrinkles: UV rays are the main cause of premature skin ageing, sun burn, cancer: between 5 and 10% of skin cancers appear in the area around the eye (actinic keratosis, spinocellular carcinoma and basal cell carcinoma, malignant melanoma).

Ocular surface and cornea
Pinguecula, pterygium, climatic keratopathy, ocular dryness, dysplasia, malignant tumour of the cornea or conjunctivitis.

Crystalline lens
Cortical cataract: UV rays accelerate its appearance. 20 million operations are performed every year worldwide.

Uvea
Melanoma, miosis, pigment dispersion, uveitis.

Vitreous
Liquifaction

Ocular factors: exposure geometry and anatomy
Ground reflection is a more significant factor for the eye. For the skin, greatest exposure is in the middle of the day, while for the eyes it can be early morning and later in the afternoon. (Fig.2).

Back surface reflection of antireflective coatings
UVR is reflected from the back surface of sunglasses and clear lenses into the eye. So even UVR coming from behind the wearer can reach the ocular surface (Fig. 3).

Citek demonstrated that AR coatings reflect UVR at high levels [6]. Some lenses showed up to 40% reflection of UVA and UVB.

Outdoor measurements demonstrated that UVR proportion able to reach the eyes through lens reflexion is really substantial and may represent up to 50% of not protected eye exposure. [7]

Indication of UV exposure
The World Health Organisation's solar ultraviolet index (UVI), an international index of UV burden [8] assesses risk of UV damage to the skin. Several studies have shown that this is not a valid indicator of eye protection and potentially misleading. [5]

__2- ABSORPTION AND TRANSMISSION WITHIN THE EYE

Identifying absorption and transmission of UVR within structures of the eye is key to understanding potential damage. [9]

UV transmission is strongly dependant on age. Below 9 years of age, a larger portion (2-5%) of UVA is transmitted by the cornea and the lens. Significant inter-individual differences have also been shown. [10]

__3- UV HAZARD TO EYE STRUCTURES

Acute and chronic damage to the eye by UV and visible light has been extensively studied, including epidemiological studies, with greater significance on chronic exposure. [11]

Cornea
The cornea is most exposed, with the greatest level of UVR absorption from direct irradiation. In addition oblique rays are reflected across the cornea and anterior chamber into the limbal area leading to elevated pathologies in this area. Most common diseases: Pterygium, pinguecula, climatic droplet keratopathy.

Cortical cataract
It is known that UV light induces cataracts [12] with a damage threshold at 350 nm of 60 mJ/cm^2. With growing and aging populations and other changing demographic factors the incidence and prevalence of cataracts will increase. Reducing the risks that can lead to cataracts is therefore important.

Dry eye, premature presbyopia, AMD
Decreasing tear film production linked to ageing, reduces UV absorption and antioxidant production by tears.

The association between UVR and AMD remains controversial. Blue light is a more significant contributor to development of AMD.

UV related skin aging and diseases of periorbital skin

The acute response of the skin to UV is inflammation (sunburn). Clinical symptoms include erythema, swelling, pain and pruritus. [13]

Chronic effects include photoaging and photocarcinogenesis. Some clinical signs of photoaged skin include dryness, irregular pigmentation, lentigines, wrinkling and inelasticity. The delicate periorbital skin is particularly susceptible to effects of photoaging. [14]

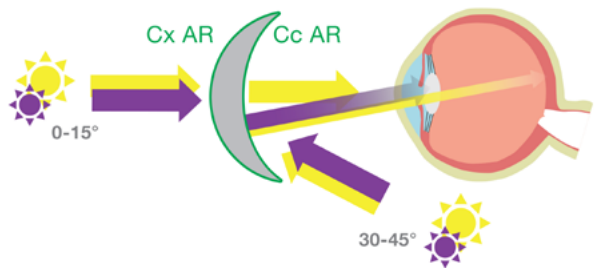

FIG. 3 | UV transmission is blocked efficiently by most lenses, but antireflective coatings increase back reflectance of UVR into the eye

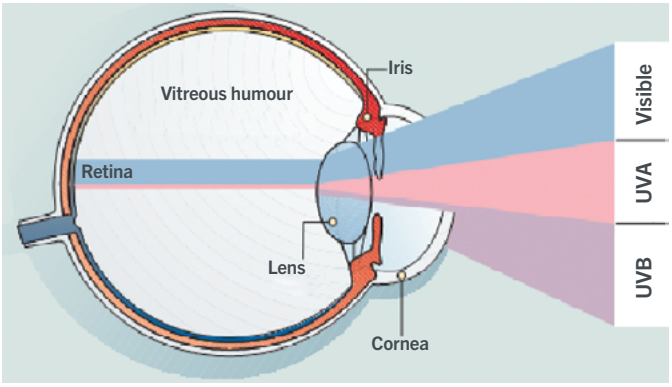

FIG. 4 | UV transmission within the eye. Visible light penetrates through to the retina, UVA is mostly absorbed by the lens, UVB is mostly absorbed by the cornea

* Myers M, Gurwood AS. Periocular malignancies and primary eye care. Optometry.2001;72(11):705-12

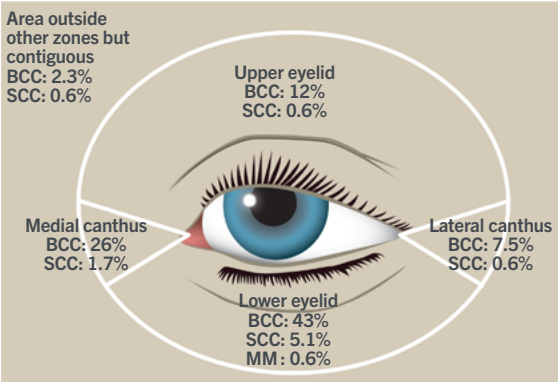

FIG. 5 | Location of eyelid malignancies. Percentages of n=174 tumors. BCC, basal cell carcinoma; SCC, squamous cell carcinoma; MM, malignant melanoma in the periorbital

Mitochondrial DNA is a chromophore for UVA and UVB and subject to damage by UVR. DNA deletions are increased by up to 10-fold in photoaged skin compared to sun-protected skin of the same individual. [15]

Photocarcinogenesis includes the development of actinic keratosis, squamous cell carcinoma, basal cell carcinoma, and malignant melanoma.
5% to 10% of skin cancers are appearing on the eyelids [17] (Fig. 5)

4- THE NEED FOR EYE PROTECTION

Populations at risk

With the increase of life expectancy and cumulative effect of UVR exposure during all the life, the protection of the eye against UVR concerns everyone, and should start at the earlier stage.
As already indicated, UV transmission to the retina is greater in children. [11]

For those spending time at higher altitudes, outdoor workers, and those spending more leisure time outdoors, ocular UV exposure is greater. [16]

Photosensitising drugs, such as psoralenes, non-steroidal anti-inflammatory drugs, antiarrhythmics, tetracyclins, and chloroquine increase susceptibility to UVR damage.

Eye-Sun Protection Factor

The clothing industry employs UPF (Ultraviolet Protection Factor) to measure garment UV transmission [18]. While in the skincare industry, UV protection is defined by SPF (Sun Protection Factor) and is applied to sunscreens and some daily creams (European Standard EN 13758).

Essilor developed an Eye-Sun Protection Factor for lenses taking into account: transmission, reflection from the back surface, protection of structures of the eye and periorbital skin.

An accepted E-SPF™ used by manufacturers, eye care professionals and consumers will enable identification and comparison of the UVR protective properties of lenses. This includes clear prescription lenses, contact lenses and sunglasses (prescription or non-prescription).

E-SPF™ figures are calculated using the following formula:

$$E-SPF^{TM} = \frac{1}{T_{UV}^{0°} + R_{UV}^{145°}}$$

E-SPF™ was defined taking into account transmission and reflection of UV and visible light at angles from 0° for light coming through the lens and from 145° incidence for light coming from the backside of the lens. It gives a clear understanding of its intrinsic ability to protect the eye.

Table 1 shows that E-SPF™ values are similar to SPF labeling for sunscreens and for the consumer this familiarity could help them easily understand the level of protection provided by spectacles and sunglasses.

Additional factors also play a role such as the spectacle frame, anatomical features of the individual, solar angle, and UVR which might enter the space between the frame and the eye.

CONCLUSION

With increasing life expectancy and changing lifestyles, the cumulative effects of UVR in the periorbital region (malignancies), at the cornea and conjunctiva (pterygia) and the crystalline lens (cataracts), are of increasing relevance to public health.

UV protection for the eye and the periorbital area is often inadequate and not well defined.
This paper proposes an E-SPF™ to deliver a unified, easily understood

Tuv	Ruv	E-SPF™
5%	5%	10
1.5%	5%	15
0%	4%	25
0%	<2%	50+

TAB. 1 | Tuv = Transmission of UV, Ruv = Reflection of UV, E-SPF™= Eye-Sun Protection factor

index of UV protection for lenses. Lens manufacturers are encouraged to adhere to a shared standard.

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