OCULAR LIGHT TOXICITY
AND THE REQUIREMENT FOR PROTECTION

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INTRODUCTION

In November of 2016, a panel of eight international eye health experts with a diverse range of professional and geographic backgrounds (North America and four European countries), met in Paris to discuss blue light toxicity. The panel captured a wide range of domains in eye health care, including academic and applied research in both the preclinical and clinical settings, as well as patient management in surgery and private practice. The meeting was driven by an increasingly pressing need to deepen knowledge among our eye health professionals on the biohazards of light exposure – and specifically on the dangers of and need for protection from blue light. The aim of the meeting was to share personal experience in this field, identify areas to focus on, and explore solutions for managing potential blue light toxicity. The discussion was held in the critical context brought to the table by Prof. Dot who opened the session with “the duality of blue light [...] raises the question of the need for selective protection – an issue which is currently not well known by ophthalmologists”.

Acknowledgments
The round table discussion was facilitated by Essilor International, who would like to thank all Experts for their active participation in the stimulating and fruitful discussion on this fundamental aspect of future eye health care, as well as their reactivity, frankness, and enthusiasm both during the meeting and the follow-up in the preparation of this position paper.
The electromagnetic spectrum covers a continuum of electromagnetic waves from radio waves through to gamma-rays, with increasing photon energy as wavelength decreases [Figure 1]. Within this range, UV radiation covers 100-380 nm and visible radiation covers 380-780 nm. High energy visible (HEV) light (380-500 nm), commonly known as blue light, accounts for 25 to 30% of the sunlight within the visible range. Blue light is located at the beginning of the visible spectrum and includes harmful blue-violet radiations (415-455 nm) as well as beneficial blue-turquoise radiations (465-495 nm), involved in normal metabolic functioning in humans (circadian rhythms and effective endocrine activity).

Figure 1: Visible light (380-780 nm) in the electromagnetic spectrum. HEV, high energy visible; LEV, low energy visible.
While the sun is the major source of blue light, it is also found in increasing proportions in indoor lighting.  

“Our exposure to indoor blue light is unprecedented in human history”, “we don’t know whether it’s bad or it’s good, but we need to be aware of it.” These statements by Dr. Tolentino reflect growing concern over the unknown nature of the long-term effects of blue light exposure on the retina. Driving these concerns is the fact that what we have on our hands today is a new and rapidly-evolving scenario; a large proportion of the first-world society (and to some extent developing countries) is experiencing dramatically increasing exposure to artificial blue light from both cold-white light emitting diodes (LEDs) and fluorescent light sources. The widespread success of these forms of lighting is a result of their enhanced performance compared to incandescent bulbs. Figure 2 highlights the changing blue light emission spectrum with the shift from incandescent lighting towards cold-white LEDs.

Figure 2: Emission spectrum of various light sources including cold-white LED (from Smick et al., 2013)
Added to this changing exposure profile is a shift in the population’s habits with the widespread availability of various digital technologies, reflected in a move towards screen exposure at both increasingly younger ages and for increasingly longer time periods, both of which are affecting an increasing proportion of the world’s population. In the space of a single generation, we have gone from screen exposure being limited to watching a couple of television programs, to hours of professional, recreational and educational time spent staring at a screen. While data on the impact of LED blue light exposure are currently sparse, confirmation of the trend towards different and continually changing digital habits is emerging in the literature. Two recent surveys carried out by the US Vision Council and IPSOS evaluating more than 13 000 participants from Brazil, China, France, and the US, support the hypothesis that any issues arising from blue light effects will concern a large proportion of the population. One of the surveys (in over 4000 individuals) reported that more than 90% of individuals questioned use a computer or watch TV on a daily basis, while 70% of participants use a smartphone, almost all of whom use it daily. Furthermore computer use was intensive with approximately 60% of users spending more than 4 to 5 hours a day on their device. The US survey (in nearly 10 000 individuals) reported that almost 30% of participants spend over 9 hours a day. Reports also attest to a rapid change in habits towards increasing exposure, with 89% of the population spending more time on digital devices than 2 years ago and 65% looking at digital devices at a closer distance compared to 2 years ago.

Beyond these changing behavioral habits, long-term exposure is increasing as exposure to LED-backlit screens is starting from an earlier age. Combine this with the fact that not only have the older generations taken enthusiastically to the use of electronic devices, but in addition life expectancy is increasing with a gain of 1 year every 5 years, and it is evident that given these cumulative factors, our blue light exposure is expanding on all fronts.

**Pedagogy around blue light terminology**

An important issue was raised by the panel, highlighting the need for care in the choice of blue light terminology to ensure successful pedagogy. As highlighted by Prof. Dot, “the blue light range is dual, the beginning is harmful and the end is beneficial for physiological functioning”. For the wider public, the term “blue light” is increasingly associated with well-being and other health benefits, such as the use of blue light therapy to put manage depression, seasonal affective disorder, skin problems etc. Prof. Wolffsohn pointed out that, passing the message that ‘blue light’ is a source of harm may be doing the ‘push for protection’ a disservice as it may well lead to controversy in the eyes of the public “as some parties are telling us it’s good and some are saying it’s bad”. A terminology consensus was reached for the public education arena with the choice of ‘harmful blue-violet light’ versus ‘beneficial blue-turquoise’.
CURRENT CHALLENGES IN THE FACE OF INCREASING BLUE LIGHT EXPOSURE

What we don’t know about blue light exposure

Knowledge of the challenges we are facing in terms of the consequences of potential harm from blue light exposure is alarmingly inadequate. The potential problems associated with the current changing blue light exposure profile are fueled by the gap in our knowledge in several areas of this domain. As a very recent concern, the developed world is effectively a ‘living experiment’ as to the effects of blue light exposure. To assess the level of risk from blue-violet light exposure – and protect against it if necessary – we need more clinical data. In order to minimize the potential damage of blue light exposure in a large proportion of our population, our challenge is to get answers to these questions as soon as possible.

The essence of the problem is succinctly stated by the words of Prof. Wolffsohn, “it’s very difficult to measure exactly how much light we are receiving.” While the sun is the major source of blue light and “sunlight damages because of its pure intensity”, chronic exposure to artificial LED lighting is a very recent and rapidly-changing phenomenon. It is “a very different concept with lower intensity, longer duration and a very different balance across the spectrum”.

This was crystalized in a comment made by Dr. Tolentino, “How many people stare at the sun outside? … It’s difficult to measure how much light we are receiving; the problem with screens is that we stare at them and the light goes straight to the macula. The power may be less (than the sun) but the time frame is much longer.” Given that “radiation exposure is a matter of power over time”, long-term exposure is a major issue being faced.

Other important parameters impacting exposure were raised by Dr. Orduna and Dr. Picaud. Night time viewing of screens and the intensity of LED lighting is likely to affect the extent of pupil dilation, which is important in terms of potential harm to the retina. With LED illumination, the turquoise light is much dimmer and affects the pupil reflex, meaning it dilates to a greater extent therefore allowing more harmful blue-violet light into the eye.

Further complicating the scenario is the fact that the spectrum of exposure is dynamic, varying considerably with age, personal, and professional environments, as well as with continuous technologic developments; as a result each individual has a personalized risk profile.

Pressing questions needing answers

In addition to the primary question of how do we evaluate how much blue light exposure we are getting, other important parameters include, what is the impact of different types of exposure (artificial lighting, screen viewing vs sunlight), of pupil adaptation (night-time screen viewing and blue/turquoise balance), light intensity, and proximity to source?

“We are experiencing much more blue light exposure and long-term exposure is not fully understood in terms of its potential for damage.” (Prof. Wolffsohn)
Clinical evidence linking blue light and retinal damage

Symptoms caused by blue light lead to a conundrum; on the one hand in routine clinical practice it is rare to see patients consulting primarily for short-term complaints due to screen exposure (i.e., computer vision syndrome) as Dr. Lamoureux pointed out, while on the other hand if you ask the average person in the street if they have visual fatigue or dry eyes when using their computer or phone, the answer is almost systematically yes. In the clinic, symptoms are mostly reported by patients in the context of other pathologies. This raises the important issue of recognizing which short-term symptoms are specifically due to blue light exposure versus another ocular surface pathology. As Dr. Orduna pointed out, we need "to identify patients who have surface pathologies and distinguish which symptoms are caused by the ocular surface pathology versus those due to blue light". This is no easy task as symptoms are likely to be a combination of several factors, given that when we look at screens we are receiving more blue light (compared to reading a book for example) and at closer proximity, we are staring, and blinking less; the difficulty is differentiating between these factors. Glare - which is related to visual fatigue - is an important aspect to take into account, with blue light being the main wavelength resulting in glare. In short, many factors contribute to discomfort, blue light being just one of them. Another issue increasingly reported in the literature is the disruption of sleep and circadian rhythms associated with increased nighttime blue light exposure. The implementation and widespread acceptance of the need for protection against UV was supported by solid clinical evidence that UV exposure is linked to damage of the anterior segment of the eye with crystalline lens pathologies. While it is generally agreed that there is strong molecular and functional preclinical evidence linking blue-violet light with ocular toxicity, this is yet to be shown in the clinical context. Clinical data linking blue light and age-related macular degeneration (AMD) is currently limited to epidemiologic studies. Two studies attempted to analyze sun exposure in terms of blue light, the Chesapeake and the EUREYE. The Chesapeake study in 800 boatmen reported a borderline significant correlation between blue light exposure during the previous 20 years and development of severe AMD. The EUREYE study in 4763 individuals over the age of 65 years correlated blue light exposure and wet AMD for patients with lower antioxidant levels. Other epidemiological studies have evaluated the link between sunlight exposure and AMD. The Beaver Dam Eye Study followed 2764 individuals aged from 43 to 86 years for 10 years and found a significant association between the amount of time spent outdoors in the summer sun during their teens and 30s with the development of both early and late AMD. The Alienor Study, a population-based study of 963 residents of Bordeaux (France) aged at least 73 years, suggested that risk for early AMD is increased in
Subjects exposed to high UV radiation, but also to low UV radiation, by comparison with medium exposures. Sui et al performed a meta-analysis of 14 epidemiology studies, 12 of which reported an increased risk of AMD with greater sunlight exposure, and six of which were significant.

A study based from the EUGENDA database (The European Genetic Database) demonstrated a correlation between past sunlight exposure with the development of early and late AMD. Exposure of more than 8 hours of daily outside life resulted in an increased risk of early AMD (odds ratio 5.54) and late AMD (odds ratio 2.77). Other risk factors such as smoking, age and gender were adjusted appropriately.

Very few studies have addressed the issue of clinical symptoms associated with blue light exposure. One study in 52 patients compared clinical effects between eyes with intraocular lenses (IOLs) that filter short-wave blue light versus contralateral eyes with IOLs that did not. Improvements were seen for glare disability, heterochromatic contrast threshold, and recovery from photos stress when blue-filtering was present. An anecdotal report in five patients also suggested higher blue light emission from LED backlit tablets caused more strain to the eyes.

The risk of AMD progression following cataract surgery lends further weight to the hypothesis that blue-violet light exposure has a role in AMD pathogenesis, with a three-fold increased risk of AMD progression directly attributed to a dramatic increase in blue light exposure.

**Limitations of current clinical knowledge**

Formal clinical data exploring blue light exposure is lacking. The few reports available are restricted almost exclusively to epidemiologic studies. By their retrospective nature, such studies are inherently limited in design, while survey-based questionnaires can introduce bias. Patient populations are often restricted and rarely uncontrolled, while statistical hypotheses (notably the number of subjects) can be questionable. For meta-analyses, the presence of confounding factors is a major weakness.

In the specific context of blue light, analysis of exposure to sunlight is difficult to quantify and vulnerable to error when collecting past exposure data. Furthermore, the rapidly changing blue light exposure profile (less sun exposure, more screen and LED lighting exposure) compared to even just 5 to 10 years ago, likely limits the relevance of conclusions drawn from older studies in the today’s setting.

In the current context of increasing artificial blue light exposure, there is an urgent need to design relevant long-term clinical trials. Planning well-controlled studies is a major challenge given that it is unfeasible to use control groups without access to technology and artificial lighting, as well as the difficulty of matching exposed with unexposed groups given the likely presence of confounding environmental factors.

But one thing is clear – if we don’t start now we will be facing the same dilemma in 10 years!

“We need more and new studies specific for today’s population in terms of food intake and screen behavior, along with the technology to examine eyes.” (Prof. Korobelnik)
A PRECLINICAL MODEL TO GUIDE THE CLINIC

Concerns are increasingly being voiced regarding ocular safety in terms of LED usage. Unlike UV for which protective measures have been implemented for some time, with public education on the importance of protecting our eyes against the dangers of UV with protective filtering glasses, visors and sun avoidance, there are currently no blue light exposure recommendations nor any regulations relating to LED exposure. In France, the public committee the Agency for Food, Environmental and Occupational Health & Safety (ANSES), highlighted the potential of an as-yet undiscovered risk for chronic all-day, life-time exposure in light of the absence of any regulations concerning the blue light in LEDs. Along with the 2014 international SSL Annex (4E Implementing Agreement), they have urged for photobiologic safety assessments for all SSL devices (LED-based) using the joint CIE S009 / IEC 62471 standard. They have also called for the implementation of a regulatory framework to develop guidelines for protecting the population against potential blue-violet light-induced hazards in terms of the production, sale and use of LEDs. Dr. Picaud, who was a member of the ANSES group, emphasized the particular need for regulations for at-risk populations – notably the young and the elderly.

Learning from past experience (sugar intake and smoking)

An interesting parallel for managing the potential for damage with blue light exposure may well be found in the case of sugar, as Dr. Tolentino and Prof. Wolffsohn recounted. Some 30 years ago the potential dangers of high sugar intake were unknown – over the last few decades the quantities of sugar ingested have increased dramatically – as has the research in parallel. With extensive clinical and preclinical investigations, the tables have turned and we now aware of the dangers of high sugar intake – a striking example can be seen in the rapidly increased rate of diabetes in aboriginals, a population previously minimally exposed to processed sugar. The history of smoking tells a similar tale of unknown dangers identified only retrospectively. For cases where we do not know if potential dangers exist for something that has undeniable immediate advantages from the end-user’s perspective, we need to make the most of hindsight and learn from past errors, notably by exploiting the advantage of the addition of molecular biology and advanced cellular models to our set of research tools – something which we can use to provide solid supporting evidence of potential physiological dangers of blue light exposure.
While it is widely acknowledged that sunlight is a risk factor for AMD, identifying unequivocally the specific link to blue-violet light and ocular damage is yet to be shown in the clinic. However, our increasing strength in molecular biology research techniques has meant that preclinical research is providing strong supportive evidence of the potential for a link between blue light and ocular toxicity.

As Dr. Tolentino highlighted, molecular biology studies over the last two decades have allowed us to identify photoxidation as the main player in terms of the apoptosis and inflammation pathways involved in development of AMD. We know from in vitro and in vivo studies in retinal pigment epithelial (RPE) cells, that blue light from LEDs disrupts regulation of inflammatory markers (VEGF-A, IL-6, IL-8 and MCP-1) and pathological cytokine signalling, causes upregulation of oxidative products, such as lipofuscin, and DNA damage, as well as loss of photoreceptors and activation of apoptosis. However, while many preclinical studies have been performed, they are generally limited in terms of modelling chronic lifelong cumulative exposure damage from blue light exposure, nor do they distinguish between the effects of blue-violet versus blue-turquoise light.

In 2011, the Paris Vision Institute and Essilor teamed up to address these issues, developing an in vitro AMD model in primary swine RPE cells and incorporating innovative cell illumination protocols. RPE cells photosensitised with A2E, a by-product of the visual pigment, were exposed to 10 nm-wide illumination bands across the blue-green range (390-520 nm) then maintained in darkness for 6 hours before analysis. Irradiances were normalized to sunlight intensities reaching the retina under real-life conditions at each wavelength. Cell necrosis (reflecting acute light toxicity) and apoptosis (reflecting long-term cumulative light toxicity) were measured. The results confirmed earlier reports of in vitro and in vivo blue light toxicity studies. However, this study identified the specific range of wavelengths of 415 to 455 nm - corresponding to blue-violet light - as the most toxic band inducing cell apoptosis [Figure 3].

These data were subsequently fine-tuned to better understand the underlying mechanisms of toxicity. Researchers at the Vision Institute have shown that in response to blue-violet light (415 to 455 nm), reactive oxygen species (ROS) production increased ($\text{H}_2\text{O}_2$, $\text{O}_2^-$), while antioxidant activity was inhibited (glutathione, SOD, catalase) and mitochondrial stress was seen. Therefore, cell death is likely to occur under blue-violet light because the cell’s self-defense mechanisms are reduced in parallel with the increased ROS production.

While the question remains open as to the applicability of these in vitro results to the clinical setting, they are strongly supportive and provide guidance for protective strategies in terms of the blue-violet bandwidths to target for filters, along with the value of prescribing antioxidants, while also ensuring that beneficial blue-turquoise light reaches the retina. While further experiments are needed, this long-term in vitro chronic AMD preclinical model offers valuable information.

**Phototoxic action spectrum on a RPE model of Age-Related Macular Degeneration (blue-violet light 415 – 455 nm)**

![Phototoxic action spectrum](image_url)
Eye health care advocates have their work laid out for them. Should we be promoting an approach to minimize exposure or pushing for protection? The reality is that reducing exposure is a minimally viable option – the pervasive role that technology has in the social, educational and professional contexts is unlikely to change, and if anything, our exposure will continue to increase.

However increasing protection is clearly associated with a fundamental challenge given that we need to optimize the risk/benefit ratio of balancing the absence of convincing clinical data linking cumulative exposure and retinal diseases against the unknown potential cost of waiting. Many questions lie behind protection; What exactly should be proposed as protection? Should protection be standard practice? How should eye health professionals be educated and how should they educate their patients?

Preventative protection is up against the difficulty of communicating the value of a potential long-term benefit, without either solid clinical proof or any immediately perceptible benefit perceived by the user. Added to this is the unknown nature of transposing in vitro photobiology results into clinical evidence. Nonetheless the beauty of blue light protection is that non-invasive no-risk solutions are available and already under exploration, as discussed by the panel and reported below.

CUMULATIVE EXPOSURE TO HARMFUL BLUE-VIOLET LIGHT:

- Cumulative over lifetime (ageing)
- Cumulative through multiple sources: sunlight, artificial lighting (LEDs, fluorescent lamps), screens

PROTECTIVE / PREVENTIVE MEASURES

Figure 4: Challenging balance: minimizing phototoxic cumulative exposure and maximizing photo-protective measures
One of the most accessible means of protecting our eyes is via the implementation of general good health habits. Several studies support the value of antioxidant supplements. The POLA study group demonstrated a protective role of xanthophylls, in particular zeaxanthin, for protection against AMD and cataracts. The AREDS study showed the value of AREDS-type supplements (vitamins C, E, and zinc with copper) for patients with intermediate risk/advanced AMD, while AREDS2 demonstrated that lutein/zeaxanthin intake with or without omega-3 slows progression to late AMD. Nonetheless, the use of antioxidants raised some contention amongst the panel, with prescribing practices varying. While most supported their use in specific at-risk populations - “I start antioxidant prescription when large drusen or advanced AMD are present” - there was debate over their value for the wider public.

Similarly, there is a growing body of convincing evidence emphasizing the importance of avoiding smoking given the strong correlation with the development of AMD, including an increased risk with passive smoking.

Among other blue light protective measures available, yellow IOLs are associated with a level of controversy. The debate dates back over a decade, with initial studies such as the Beaver Dam/Blue Mountains study supporting a link between cataract surgery and increased risk of AMD, whereas results from more recent studies refute these claims. What can be agreed upon is that current data have limitations in terms of interpreting blue light protection in this setting, namely that the studies performed historically were not statistically designed to validate this issue, many used old technology to evaluate the eyes, follow-up is insufficient, and the use of clear and yellow IOLs is not systematic.

The panel agreed that spectacles or contact lenses filtering blue-violet light are a safe choice as a non-permanent, non-invasive protective solution which can thus be renewed in line with changing technology. The point was emphasized that here also, randomized controlled trials are needed. The first encouraging signs that this is underway are seen with the anticipated prospective Japanese CLOCK IOL study which will compare clear vs blue-blocking IOLs with an impressive planned 20-year follow-up.
FILTERING LENSES: THE LATEST ARM AGAINST BAD BLUE-VIOLET LIGHT

A more proactive form of protection comes in the form of ophthalmic lenses filtering UV and blue-violet light. Lenses have been developed to reduce blue-violet light transmission to the eye. It was suggested by some of the experts from the panel that use of such lenses is appropriate for at-risk groups. For patients suffering from retinitis pigmentosa, the use of selective filters for blue light increases visual acuity and contrast sensitivity and decreases glare, which reduce visual fatigue. From a health perspective, ophthalmic lenses are pretty much guaranteed to be without a health cost.

Patients with high-risk genetic profiles for macular degeneration would benefit from the use of protective filtering lenses. Recent genetic testing has developed a genetic algorithm that determines lifelong risk of developing macular degeneration. “Those patients with a high-risk genetic profile should strongly consider blue light filtering protection” according to Dr. Tolentino.

Although opinions were mixed as to their usefulness in the general public (i.e. a population without any known risk), the tendency of the panel favoured their prescription with the clear message - there is no known downside to their prescription. ‘Wearing protecting eyewear filtering out blue light is the simplest solution - with the advantage that it is without toxicity’.
THE PRECAUTIONARY PRINCIPLE AND RECOMMENDATIONS

The precautionary principle is a strategy to cope with possible risks where scientific understanding is incomplete, and is applicable in situations requiring risk management. In the current scenario where the potentially damaging role of blue-violet light in ocular health is up for debate, the two main standpoints are that:

1) in the absence of solid clinical data, preventative measures are not implemented, versus

2) preventative measures are recommended based on supportive preclinical and epidemiological data which provide hints fueling personal convictions of the value of protecting in the context of ‘what is the possible danger of protecting?’ and ‘learning from past mistakes’.

An important question to ask is “Who should benefit from the precautionary principle?” The population at risk can currently be defined as including both the younger and older generations (kids and the elderly), vision-compromised patients, smokers and individuals with a poor diet in terms of oxidizing agents, and a more restricted group experiencing excessive blue-violet light exposure (such as high-level blue light exposure from outdoor activities. A more difficult, but very important, group to define includes individuals with susceptible genetic backgrounds.

Based on the precautionary principle, the general recommendations of the expert panel were to protect against the modifiable risks with non-invasive solutions, by implementing:

- Good health habits (notably in high-risk patients): quit smoking, implement an antioxidant-rich healthy diet.
- Sun protection: avoid high-level exposure (altitude, reflection of water and snow), sunglasses and visors.
- Blue-violet light technology lens filters: prescription of filter protection for selected populations (kids, elderly and potentially in retinally-compromised or high-risk genetics, for whom the benefits should still be clinically demonstrated).

Dr. Colombo raised an interesting point. The use of protection can have the added advantage of improving quality of life. “So we can think of lenses not only from a preventive point of view but also as a way to improve the quality of life.”
**Promoting the precautionary principle: finding an equilibrium**

While all experts agreed on the value of general preventative measures, including wearing sunglasses and a cap, a healthy diet and avoiding smoke exposure, convictions varied as to the value of systematic blue-filter lens protective measures, with a definite need restricted to specific settings such as high-level sun exposure, or specific populations such as young children or visually-compromised patients.

“I think there is probably no risk to starting prevention but maybe a risk to delaying” (Prof. Korobelnik).

“I believe everybody should have protective eye wear because there is no downside. I strongly believe that the general population should be educated about the potential dangers of blue light from computer/smart device screens and be given the choice to protect themselves.” (Dr. Tolentino)

“I believe we won’t be making a mistake. It’s a balance, we don’t want to create alarm over blue light, but it’s something we need to consider because there is strong evidence for the model” (Dr. Colombo).

The value of the precautionary principle in the setting of blue light exposure is clearly appropriate, in at least some, if not all, circumstances. But for it to work, it is essential that it is coupled with appropriate education of eye care professionals as well as the general public, using accurate communication.

Dr. Orduna took a more skeptical position about blue light protection with regard to macular degeneration and said “I still do not recommend specific blue light protection. We still don’t know what the specific weight of blue light is in the development of the disease compared to other risk factors. First the scientific community needs to clarify this point with specific research, and then I will talk about prevention in a specific population or prescribe a lens for everybody to protect them from blue light, supported by medical research.”
Complementing their recommendations, the panel also addressed areas of research to focus on in the quest for protective solutions. One of the primary domains mutually agreed on as critical to finding successful protective measures is the need to identify reliable genetic markers for identifying patients with a predisposition to eye damage (particularly for at-risk patients), with parallel implementation of widespread use of genetic markers by clinicians (currently mainly only used in clinical trials). Other tools that need to be identified are quantifiable objective parameters (eg the equivalent of cigarette pack smoking), and consideration should be given to confounding factors (environmental, social and wealth influences).

Prospective clinical studies with long-term follow-up need to be initiated now, along with the collection of specific epidemiologic data on exposure and protection. From a preclinical perspective, further studies in chronic exposure models should be promoted (i.e., furthering the Paris Vision Institute in vitro studies and moving into in vivo models).

In the clinical setting, eye health care providers need to be educated about potential dangers of chronic blue-light exposure and ongoing development of blue light filtering technology. A standard index of filtering/protection of ophthalmic lenses against blue light is likely to be useful in this context – as we have learnt with the public’s awareness of SPF protection against UV dangers.

We also need to find the optimal method of educating the public and passing on recommendations for ‘erring on the side of caution’ with promoting proactive protection given the absence of any identifiable downsides to the precautionary principle.
The November meeting allowed the international eye health experts to share knowledge and professional experience in the context of increasing exposure to harmful blue-violet light, the panel agreed that:

- The clinical consequences of chronic blue-violet light exposure in the current exposure conditions are unknown, and we urgently need to find ways of determining exactly how much blue light our eyes are being exposed to.

- There is a major gap in our clinical experience, notably the absence of well-designed clinical trials with adequate statistical strength in the current setting, and further preclinical and clinical research in this domain is essential.

- While multiple risk factors are incriminated in the pathogenesis of eye diseases such as AMD, the environmental factors (including cumulative exposure to harmful blue-violet light) are modifiable and raise interest for potential preventive measures.

- In the absence of known downsides, preventative protective measures of good health combined with use of lenses filtering blue-violet light (while allowing beneficial blue-turquoise light through) is the most reliable way forward today.

- Based on the precautionary principle, the general recommendations of experts are to apply the preventive / protective measures notably in selected populations (young children, elderly and potentially in retinally-compromised or high-risk genetics, for whom the benefits should still need to be clinically demonstrated).
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THE ROUND TABLE DISCUSSION AND POSITION PAPER PUBLICATION WERE FACILITATED BY ESSILOR INTERNATIONAL.