The Blue Light Hazard – A Risk Oddity?

Prof. Dino Pisaniello
School of Public Health
University of Adelaide

RACP Congress 2016
The Health Problem

Photochemical damage to visual sensory cells
Mum said

“Don’t look at the sun”
“Eyes are not designed to look directly at light — they are designed to see *with* light”

Dr Celia Sánchez-Ramos
Complutense University, Madrid
Transmission of Light  

Young children > Adults  
(Gaillard et al., 2000)
Blue light effects (photochemical only)

- Lesion: photoreceptor deterioration
- Physiology: “hyperactivity” of Wald’s visual cycle (photoreversal of bleaching)
- Damage evidence (histological etc.): accumulation of lipofuscin (cellular debris) and of A2E in the retinal pigment epithelium
- Probable increase of drüsen prevalence
A2E (2-[2,6-dimethyl-8-(2,6,6-trimethyl-1-cyclohexen-1-yl)-1E,3E,5E,7E-octatetraenyl]-1-(2-hydroxyethyl)-4-[4-methyl-6-(2,6,6-trimethyl-1-cyclohexen-1-yl)-1E,3E,5E-hexatrienyl]-pyridinium) is a blue-absorbing molecular constituent of human ocular lipofuscin and contributes to the golden-yellow emission of this pigment.
Bursts of blue light are thought to contribute to age-related macular degeneration at the individual level
Conclusion: The epidemiological literature published to date indicates that individuals with more sunlight exposure are at a significantly increased risk of AMD.
AMD is already an (increasing) problem at the population level, probably due to an ageing population.

https://nei.nih.gov/eyedata/amd
>60,000 Australians with AMD in 2009

From 1990 - 2010 an increase from 6.6 to 8% in moderate and severe vision impairment attributable to AMD
Will it increase in the future?
**CONCLUSION:** Our results raise questions about adverse effects on the retina from chronic exposure to LED light compared with other light sources that have less blue light. Thus, we suggest a precautionary approach with regard to the use of blue-rich “white” LEDs for general lighting.
Is this an occupational health problem?
In the Chesapeake Bay Waterman Study, which analyzed fishermen exposed to bright light reflected off the water every day, blue light exposure was found to increase the risk of age-related macular degeneration (AMD).

This conclusion, while suggestive, is not definitive, since it is difficult to quantify light exposure.

# Blue light issues (from ACGIH TLV booklet 2016)

<table>
<thead>
<tr>
<th>Source type</th>
<th>Arc Sources</th>
<th>Discharge Lamps</th>
<th>Fluorescent Lamps and LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arc welding; Arc lamps; Xenon arc searchlights</td>
<td></td>
<td>White-light and “black-light” fluorescent lamps; Visible or UV-A LEDs</td>
</tr>
<tr>
<td>likely</td>
<td>likely</td>
<td>possible</td>
<td></td>
</tr>
</tbody>
</table>
Older workforce – less resistance to oxidative stress in visual system

Some jobs have intense blue light sources in the visual field. Generally more exposure to blue-rich white light?

Greater variety of bright light sources
A professional photographer

Two lamps HMI da 2500 W – CCT ≈ 5150 K
One Xenon flash lamp – CCT ~ 5500 °K (flash duration = 0.001 s)
Metal halide lamps for shop lighting

HQI-TS 70W NDL - Reflection coefficient ~ 75%

~135 mW/cm² · sr
(max/die = 1.3 min)

~9 mW/cm² · sr
(max/die = 171 min)
SHOP ASSISTANT
FOVEAL
PROJECTION:
THE METAL HALIDE
LAMP IS INCLUDED

HQI-TS 70W NDL
Max/die = 0.9 min
Max/die = 128 min
Infant Phototherapy Equipment
“main radiation spectrum in the range between 400 nm and 550 nm for reducing the concentration of bilirubin in the body of infants.”

Regardless of LED color, Cree advises users to not look directly at any operating LED component. Further, Cree recommends that any manufacturer that is incorporating Cree® LED components into its lighting products make an assessment of how these components could create a light exposure risk to its employees during the manufacturing process.

Issues

- Although there is good animal evidence for acute risks, there is a shortage of evidence for longer term risks.
- This has been acknowledged by all researchers since the 1960s.

Read this to mean

*Absence of evidence is not evidence of absence*

- There have been few robust exposure studies internationally, and essentially all of these could be classified as screening studies based on acute risk criteria.
- No Australian studies, and no real guidance for practical risk assessment.
Take home messages

- Metal Halide, Mercury Vapor, Xenon Arc and Sodium Vapour lamps can result in blue weighted radiance levels exceeding the TLVs promulgated by ICNIRP and ACGIH.

- In some occupational contexts these kinds of lamps are in the line of vision (Occupational Visual Field), exceeding the TLV after only a few minutes of exposure.

- Since this adverse agent is poorly considered by OHS professionals, neither Risk Assessment nor Health Surveillance measures are properly implemented on a regular basis.

- Some literature suggests that subacute effects may be mitigated by (post-exposure) antioxidant treatment.
Time for some regulation?
## Comparison of hazards: blue light and noise

<table>
<thead>
<tr>
<th></th>
<th>Blue Light</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age-related background (cumulative) effects</strong></td>
<td>Yes (age-related macula degeneration)</td>
<td>Yes (age-related hearing loss)</td>
</tr>
<tr>
<td><strong>Frequency dependence</strong></td>
<td>Yes – highly dependent (Blue light hazard function)</td>
<td>Not thought to be important in audible frequency range</td>
</tr>
<tr>
<td><strong>Energy dependence</strong></td>
<td>Yes – damage increases with total energy.</td>
<td>Yes – damage increases with total energy</td>
</tr>
<tr>
<td></td>
<td>Threshold for irreversible damage about 100 J/cm² (looking at sun for 1 minute)</td>
<td>Threshold for irreversible damage about 100 J/cm²? (160 dB for 100 sec)</td>
</tr>
<tr>
<td><strong>Sensory organ response protective mechanism</strong></td>
<td>Yes – aversion response, pupil restriction, closing of eye lids</td>
<td>No</td>
</tr>
<tr>
<td><strong>Directionality of the hazard</strong></td>
<td>Highly directional, due to the anatomy of the eye</td>
<td>Partially directional, depending on frequency and distance from the noise source</td>
</tr>
</tbody>
</table>
The photochemical damage to the retina is very wavelength-specific. The risk is related to the radiance (brightness) of the light source as well as the size of the image of the source that is projected onto the retina.