Too Much Ado About Blue?

Determining the right amount of concern about
high-energy visible ("blue") light and prescribing eyewear accordingly

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INTRODUCTION

High-energy visible (HEV) light has become one of the hottest trending topics in eye care in the past few years.

There are at least three reasons for this growing interest in HEV, or "blue" light:

1. Though HEV light has less energy than ultraviolet (UV) radiation, HEV rays aren't filtered by the Earth's ozone layer or the cornea and lens of the human eye like UV rays are. Instead, they penetrate deep into the eye, all the way to the retina. Risks to the retina that once were believed to be associated with UV exposure may in fact be caused by cumulative exposure to HEV light instead — or a combination of UV and HEV rays.
2. The use of notebook computers, tablets, smart phones and other portable electronic devices has exploded in the past twenty years. The potential eye health implications of this trend are not fully understood, and since these devices emit blue light, many eye care providers are concerned.
3. Incandescent light bulbs for residential use are being phased out and replaced by light-emitting diode (LED) bulbs, which use up to 85 percent less energy and can last up to 20 years longer than incandescent light sources. But LED bulbs emit significantly more HEV light than incandescent light bulbs, which also is fueling concern about potential eye health concerns from blue light exposure.

OBJECTIVES

The purpose of this paper is to give the reader a better understanding of:

1. The nature of HEV (blue) light, including potential health risks and benefits.
2. The significantly greater amount of emittance of HEV light from sunlight versus man-made sources, including computers, smart phones, and other portable electronic devices.
3. Recent research concerning the potential eye health risks from blue light exposure.
4. The most effective way to protect patients from the dangers associated with high-energy visible radiation.

WHAT IS HEV LIGHT?

As its name describes, high-energy visible (HEV) light is electromagnetic radiation that is both "high-energy" (and thereby has potential to cause harmful changes in living tissues) and is visible.

In contrast, ultraviolet (UV) "light" is high-energy radiation that is invisible. Because of the non-visible nature of UV, many eye care professionals and scientists avoid using the term "UV light," and prefer "UV radiation" instead.

The energy of electromagnetic radiation (including UV and HEV) is inversely related to its wavelength. Rays with shorter wavelengths have higher energy; those with longer wavelengths have lower energy.

UV radiation has shorter wavelengths and therefore more energy than visible light. The portion of the visible light spectrum that is closest to the UV band comprises violet and blue light rays. Because these rays have shorter wavelengths and higher energy than other visible light, they are classified as "high-energy visible" (HEV) light.

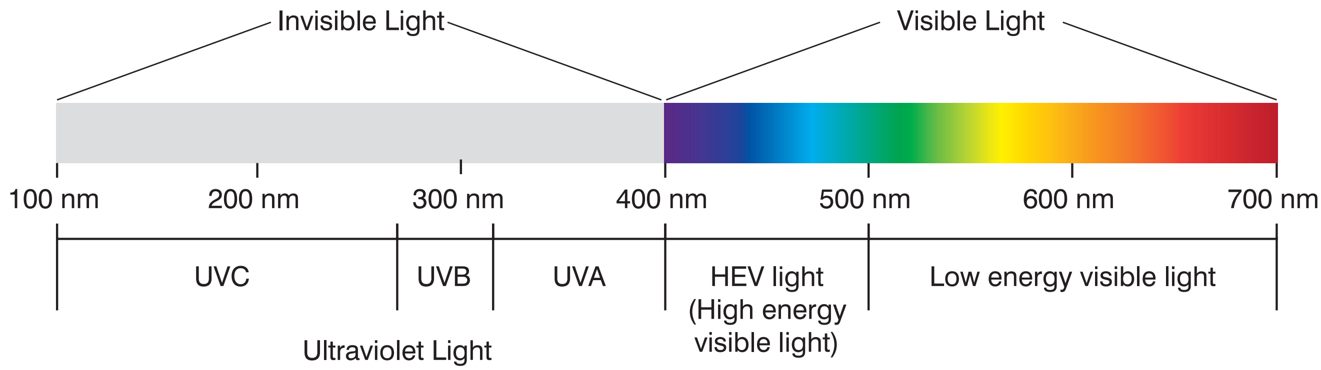
There is some disagreement regarding the exact boundary between UVA radiation (the segment of the UV spectrum with the longest wavelengths) and HEV light. Most sources, however, say this occurs at a wavelength of 380 nanometers (nm), creating these categories:

- **UVA** — invisible electromagnetic rays with wavelengths ranging from 315 to 380 nm
- **HEV** — visible light rays with wavelengths ranging from 380 to 500 nm

Some sources place the cut-off between UVA and HEV light at 400 nm. If this criterion is used, the definitions change to:

- **UVA** — invisible rays with wavelengths ranging from 315 to 400 nm
- **HEV** — visible light rays with wavelengths ranging from 400 to 500 nm

The entire UV spectrum has wavelengths ranging from 100 nm to 380-400 nm. Visible light has wavelengths ranging from 380-400 nm to approximately 700 nm.



SOURCES OF HEV LIGHT

The primary source of HEV light outdoors is the sun. An estimated 25 to 30 percent of sunlight consists of HEV light rays.

The primary sources of HEV light indoors include:

- Residential and commercial lighting
- Desktop computer screens
- Laptop computer screens
- Tablet computer and e-reader screens
- Smart phone screens

Residential and commercial lighting includes LED light bulbs, compact fluorescent light (CFL) bulbs, halogen light bulbs, fluorescent tubes and incandescent light bulbs. Of these, LED bulbs emit the highest amount of HEV rays (about 10 percent of total light output), followed by CFL bulbs. Incandescent light bulbs typically emit less than 5 percent HEV light.

The amount of HEV emitted by computers and portable electronic devices may be relatively small, but users look directly at these light sources at close range, which may increase eye risks.

Still, it's important to keep blue light exposure from man-made sources —including portable electronic devices —in perspective. The following table shows the HEV exposure from these sources relative to that from natural sunlight.

From this data, it's apparent that a person spending their entire day indoors using a computer and other electronic devices will still have significantly less HEV exposure than a person spending a nominal amount of time in natural sunlight outdoors without protective sunglasses.

RELATIVE HEV EXPOSURE RISK FROM NATURAL AND MAN-MADE SOURCES

Light Source	HEV Power Output (µW/cm2)	Exposure time required to equal 15 minutes in full sun
Sunlight	1000-1500	15 min
LED lighting	270	1 hour
Compact fluorescent light	38	10 hours
Incandescent lighting	10	38 hours
Computer screen	30	13 hours
Smart phone (iPhone 6)	36	10 hours

Power values measured by BlueSpec light meter; 425-465 nm. Light source distances (approx): LED, CFL and incandescent ceiling lights (3-6 ft); computer screen (24 in); phone (12 in).

POTENTIAL HARMFUL EFFECTS OF BLUE LIGHT

Vision depends on photoreceptor cells (rods and cones) in the retina that convert visible light to signals that are transmitted to the visual cortex of the brain via the optic nerve.

The human retina has approximately 6 million cones and 120 million rods. The outer segments of these photoreceptor cells are damaged by photo-oxidative stress from light exposure and must constantly be regenerated.

The retinal pigment epithelium (RPE) is a pigmented cell layer that lies just below the photoreceptor cells and plays a critical role in the regeneration of photoreceptor outer segments (POS) that make vision possible. Without a healthy RPE, the photoreceptors cannot survive.

A defining characteristic of age-related macular degeneration (AMD) is damage to the retinal pigment epithelium and photoreceptor cells, and associations have been made between cumulative exposure to sunlight and AMD risk.

Here is a sample of studies that have implicated HEV light as a factor in retinal damage that is consistent with the possible development of macular degeneration:

In a study published in *Photochemistry and Photobiology*, researchers showed that exposing human RPE cells to blue light for up to 48 hours significantly inhibited cell growth and reduced the production of hepatocyte growth factor (HGF), a substance in RPE cells that is associated with cellular growth and survival.

In another study published in *Photochemistry and Photobiology*, researchers concluded the RPE cell death they were able to create with blue light exposure was related to the oxidative damage to the mitochondria of RPE cells caused by the HEV rays.

In a study published in *Molecular Vision*, researchers in Germany concluded that their study of the response of RPE cells to non-lethal exposures of blue light suggests HEV light exposure triggers stress responses at the cellular level that may have implications in the development of macular degeneration.

IS ALL HEV LIGHT HARMFUL?

The potential for eye damage from high-energy visible light depends on the wavelength of light involved. The closer the wavelengths are to the UV spectrum (i.e., the shorter the wavelength of the blue light being emitted), the higher the energy and the greater risk of harmful effects.

For this reason, some people describe shorter-wavelength HEV light (380 to 450 nm) as “bad” blue light and longer-wavelength HEV light (450 to 500 nm) as “good” blue light. But the rationale for this cutoff may be difficult to defend and more study is needed to determine if such a cutoff between “bad” and “good” blue light exists.

But the idea of “good” blue light is valid, since there are apparent health benefits of blue light as well as apparent risks.

BENEFITS OF BLUE LIGHT EXPOSURE

Exposure to some blue light appears to be necessary for maintenance of the body’s circadian rhythm (24-hour sleep cycle) that is essential for maintaining healthy brain wave activity, hormone production, cell regeneration, and other physiological processes.

Blue light appears to help the body release serotonin, a hormone that reduces sleepiness and contributes to a sense of well-being. When blue light is blocked completely, the body reduces production of serotonin and releases melatonin, a hormone that facilitates sleep. Both hormones are vital.

Also, blue light therapy has been proven effective for treating certain mood disorders, such as seasonal affective disorder (SAD).

HOW MUCH BLUE LIGHT PROTECTION IS ENOUGH... AND HOW MUCH IS TOO MUCH?

Because there is both 1) a reason to be concerned about the potential harm to the eyes from a cumulative lifetime overexposure to high-energy visible light as well as UV radiation, and 2) evidence exists that some degree of blue light exposure is required for good health, the question is: how much should eye care providers worry about blue light exposure, and what is the right amount of blue light protection to recommend?

According to Tailored Lighting, Inc., a leading manufacturer of light sources used for blue light therapy, 90 minutes of close exposure to the lights used for this type of therapy is the equivalent of taking a 10-minute walk outdoors at midday.

In other words, the HEV exposure from sunlight outdoors is nearly 10 times as potent as these bright indoor light sources specifically designed to emit blue light without attenuation.

While much is being discussed these days about the potential danger of blue light emitted from indoor lighting, computers and other portable electronic devices, the fact remains that the best way to significantly reduce unwanted blue light exposure is to discuss the radiation dangers of outdoor sunlight with your patients and make sure they wear protective sunglasses on a daily basis when outdoors during daytime.

And there’s plenty of room for improvement when it comes to making sure patients are adequately protecting their eyes from the sun. According to The Vision Council’s 2014 Sun Protection Survey, 27 percent of adults “rarely or never” wear sunglasses when outside — and 46 percent said they wear sunglasses “only when it’s sunny out.” Even worse, in a 2013 survey by The Vision Council, less than half of parents (48%) encourage their children to wear sunglasses outdoors.

And while it’s true HEV-blocking eyeglasses prescribed for computer use and general indoor wear will provide a limited supplemental attenuation of blue light exposure, some of these lenses can have cosmetic issues (a visible tint in the lens) that many wearer may find unsatisfactory. Also, there is no definitive answer at this time regarding how much computer eye strain is caused by blue light exposure. It’s likely accommodative fatigue, convergence stress, dry eyes, and other factors may play a larger role than blue light exposure in causing computer vision syndrome and computer eye strain symptoms.

To make the biggest impact on protecting your patients eyes from the harmful effects of the potential dangers of blue light, start with protecting their eyes from sunlight outdoors.

THE MOST EFFECTIVE WAY TO LIMIT BLUE LIGHT EXPOSURE

It’s undeniable we are exposed to more potentially harmful high-energy visible light, from more sources, than ever before. And research has demonstrated that an association exists between high levels of HEV exposure and permanent damage to the eyes.

The question is: what is the most effective way to protect our eyes from this “new” threat.

Despite recent emphasis on the potential harmful effects of HEV light emitted by portable electronic devices and other man-made sources, the greatest source of high-energy visible light exposure is natural sunlight. In fact, you would have to spend roughly an entire work day in front of a computer display (and using a smart phone) to be exposed to roughly the same level of HEV radiation as spending 20 minutes outdoors on a sunny day without protective eyewear.

The potential for eye damage and permanent vision loss from HEV light — like that caused by UV radiation — is real. The best way to protect eyes from this threat is to educate consumers about the need to consistently wear quality sunglasses that block both UV and HEV rays when outdoors.

Though HEV-blocking eyeglass lenses and lens treatments may be a valuable supplemental protection for individuals who spend long hours every day looking at computer screens and electronic devices under artificial lighting, the threat from HEV overexposure from man-made sources is several orders of magnitude less than that from natural sunlight.

The best way to protect eyes from the “new” threat of high-energy visible light is shield them from the primary source of this harmful radiation — the 800-pound gorilla of HEV — natural sunlight.