

LED Lights May Harm Your Health

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Studies are finding several health consequences from LED light exposure. With their installation continuing apace in homes and cityscapes, critics are calling for clinical trials along with greater diligence from the lighting industry.

Ever since the discovery of fire, people have been drawn to light. Our attraction is so strong that whenever we discover a new means of illumination we tend to embrace it with enthusiasm. The ingrained belief that light is good and dark is bad has kept our love affair with light burning brightly, but this desire for light has blinded us from acknowledging the downsides to indiscriminately illuminating our nights.

With the advent of the electric light bulb in 1879, artificial light enabled us to extend the day, increasing productivity, social activities and economic growth. Darkness was banished with the flick of a switch, and the habit of lighting up the environment pretty went unquestioned until the early 20th century, when astronomers first observed the negative impact of ALAN – artificial light at night. Although their early warnings went unheeded, awareness slowly increased until concerns were raised by doctors and ecologists. The disconcerting truth is that ALAN has all sorts of undesirable repercussions that hinge on one irrefutable fact.

Like most living organisms, humans evolved with an exquisite sensitivity to light that includes a complex and sophisticated light/dark sleep/wake cycle, and ALAN is disrupting it. “We’re living in an illuminated environment unprecedented in the history of Earth, and we cannot argue against 3.6 billion years of evolution,” says Dr Therésa Jones, Senior Lecturer in Behaviour and Evolutionary Ecology at The University of

Melbourne in an interview. “We have all these vital biological processes underpinned by light and darkness. Scientific evidence is accumulating, and we can no longer deny the negative impact of artificial lighting. For instance, without adequate darkness at night we lose our capacity to repair ourselves and more.”

ALAN not only disrupts processes on a cellular level, it can also deregulate circadian genes. So while we embrace the convenience of day-like nights, we are instead hurting ourselves. We might brush aside the more immediate and inconvenient symptoms of daytime sleepiness, poor concentration and reduced productivity, but the potential long-term health consequences should not be ignored.

ALAN has become even more of a health hazard with the modern deployment of energy-efficient, high-intensity white LED lighting. Unfortunately, the most energy-efficient luminaires emit disruptive blue wavelengths of light. “The blue emission peak in the output of many white-light LEDs could hardly be in a more damaging place in the spectrum,” warned Dr Barry Clark, Director of Outdoor Lighting Improvement for the Astronomical Society of Victoria at the Australian Dark Sky Conference at Siding Spring Observatory last year.

In 2001 a third non-image-forming photoreceptor in the eye was identified by Dr Russell Foster’s team at Oxford University (<https://goo.gl/CGLvFG>). These retinal ganglion cells help to entrain circadian rhythms via exposure to the blue wavelengths of light present in sunlight. However, blue light at night



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tricks the body into thinking it's daytime, so melatonin production is suppressed when we need it most.

Melatonin doesn't just mediate the quality and duration of sleep. Melatonin suppression can also disrupt several biological systems, from metabolism to immunity, so it's no wonder exposure to blue-rich light is now linked to a myriad of modern illnesses including depression, diabetes, heart disease, obesity, poor immunity and cancer. Dr Maya Babu of Massachusetts General Hospital told the Australian Dark Sky Conference: "We don't want to wait 30 years and then tell people, 'Guess what? We changed all the light sources, and there might be a lot of harm from them.'"

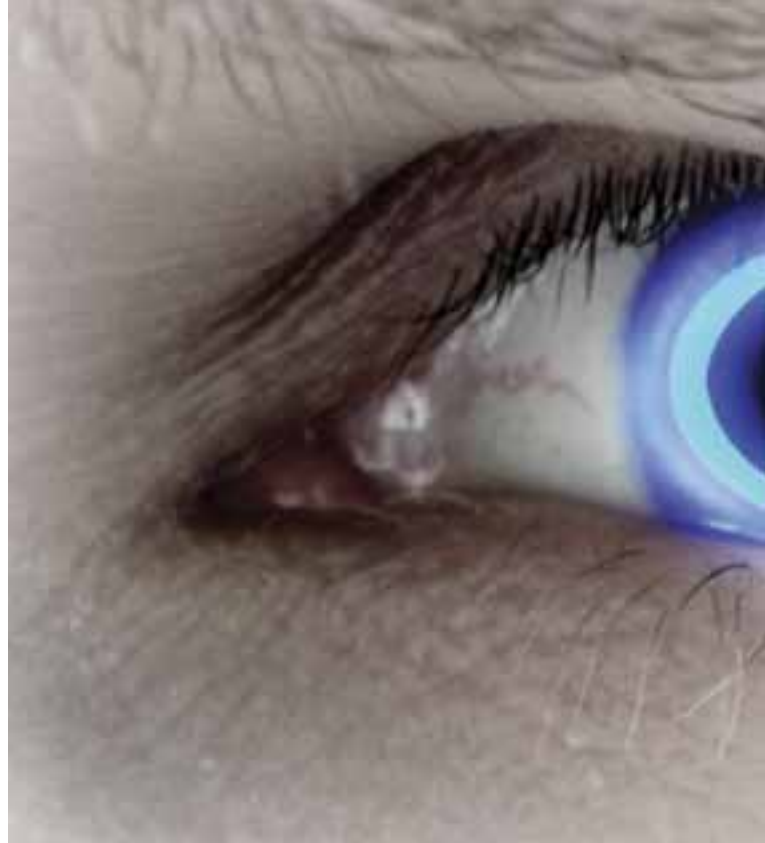
There's now widespread acknowledgment of their detrimental impact beyond health, extending to safety and security, visibility of the night sky and harm to ecosystems. "There is no such thing as environmentally friendly lighting," Jones says. "Calling it that implies it's OK, which is misleading."

Whatever light we do use must be as sensitive to the environment and biology as possible, but since the vast majority of energy-efficient LED lighting is cheaper, brighter and supposed to last longer, we use more of it, illuminating places that weren't even lit before. The unfortunate consequence is that we're not just consuming more energy, we're now adding more lighting, which is increasing light pollution.

Despite shielding, the light from white LEDs can cause more light pollution as the high-energy, short blue wavelengths of light scatter readily. Even when directed downwards they bounce back off the ground into the atmosphere.

Increased light pollution around the world has been confirmed by satellite imaging, with a 2017 study published in *Science Advances* (<https://goo.gl/QyFMnV>) finding "that from 2012 to 2016, Earth's artificially lit outdoor area grew by 2.2% per year, with a total radiance growth of 1.8% per year... These data are not consistent with global scale energy reductions, but rather indicate increased light pollution, with corresponding negative consequences for flora, fauna and human well-being."

Unlike other conventional forms of lighting we've used in the past, LED technology has unique properties and characteristics that are posing all sorts of unexpected problems. One major drawback is that the blue-rich light from white LEDs can cause oxidative damage, inflammation and cell death in the eyes. A 2018 study published in the *International Journal of Ophthalmology* (<https://goo.gl/YvU8hAq>) stated that "harmful blue light-induced effects on human eyes should not



be ignored". Furthermore, the authors of a 2014 paper in *Environmental Health Perspectives* (<https://goo.gl/nJRpuF>) recommended "a precautionary approach with regard to the use of blue-rich 'white' LEDs for general lighting". Significantly, recent research suggests retinal toxicity may occur at occupational domestic illuminance.

"We need to be aware of the oxidation changes caused by blue light in the human eye, and that production of protective enzymes such as superoxidase dismutase 1 decrease as we age," explains Babu, who in 2016 helped to develop American Medical Association guidelines advising that high-intensity blue-rich LED lighting should be minimised at night. "For safer lighting, rather than rely on lighting terms, it's helpful to use terminology that recognises the impact light may have on biology. For instance, the melanopic content of a light source indicates the amount of visible blue light detected by non-imaging-forming cell receptors of the eye."

Another obvious optical issue is glare, which is perhaps most noticeable with white LED streetlighting. Luminaires with exposed modules produce excess luminance, so too much light falls on the eye. This causes a veiling effect that compromises visual acuity and safety.

The glare from LEDs is also damaging to eyesight. While some lighting manufacturers are developing improved optical systems that minimise glare and cover the modules, it's far from standard practice.

We must also take into account how the properties and complexities of LED lighting have rendered existing lighting metrics inadequate. "Better measures of blue light content exist, such as spectral power distribution, but correlated colour temperature has already gained marketplace acceptance," Clark explains.

However, correlated colour temperature is an insufficient metric because it only gives an indication of the perceived



Eye health is at risk from the phototoxic blue-rich light and excess luminance emitted from many LED light sources.

warmth or coolness of light emitted by an LED. To better gauge the biological impact of an LED we need information about the various wavelengths of light it emits.

With increased awareness of the impact of blue light on biology, metrics such as melatonin suppression index, melanopic content and circadian action factor are being developed, but unless adequate research is undertaken to establish their accuracy and usefulness they may also turn out to be deficient. For instance, it's now known that green wavelengths of light can also disrupt circadian rhythms.

Light is such a powerful external cue that it is finding its way into clinical use. Light therapy is already being used to treat bulimia nervosa, depression, seasonal affective disorder, cognitive and fatigue resulting from chemotherapy, senile dementia, traumatic brain injury, mood disorders in Alzheimer patients as well as some skin conditions. "Light works as if it's a drug, except it's not a drug at all," neurologist Dr George Brainard told the *New York Times* (<https://goo.gl/tJpCWJ>). "While much has been discovered, we are still in the infancy of understanding the capacity of light to produce beneficial effects in medical applications or in people's daily lives."

If we acknowledge the complexity of the human body and how little we understand about its responses to artificial light, why aren't we applying far more restraint with the installation of LED lighting? In an interview with *arc Lighting in Architecture* (<https://goo.gl/9ZuDiR>) Dr Karolina Zielinska-Dabkowska of Gdansk University of Technology admitted: "Many experts in this area of research are aware that their knowledge is still fragmented, that they don't have the whole picture and thus, are unable to draw final conclusions that can guide the design and implementation of responsible LED lighting".

Despite this, the lighting industry is now marketing "circadian" or "human-centric" LED lighting, which promises to

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improve alertness, focus and productivity. However, in an interview with *E&T* Foster cautioned: "We can't develop human-centric lighting until we know what impact light has upon human biology across the day and night cycle" (<https://goo.gl/VFn7VE>).

Zielinska-Dabkowska added in a Comment published in *Nature* (<https://goo.gl/ArLemr>): "The risks of adverse effects remain because there is still too little understanding of the link between light stimuli and non-visual responses. Research is needed to find out more and to firm up standards accordingly."

While humans benefit in many ways from exposure to natural daylight and sunshine, the light produced by white LEDs is different. Ironically, the closest match to daylight from an artificial source is the light produced by incandescent bulbs, which have been banned. Implying similarity between natural and LED light is misleading, and encouraging its use based on this is remiss.

LED lighting is now being adopted without clinical trials and testing to ensure its safety or appropriateness. Jones says the lighting industry has a responsibility to apply due diligence and do no harm, yet it appears to be failing on both counts. "Absolute honesty and transparency from the lighting industry is required," she urges.

In an interview for this article Prof Abraham Haim of Haifa University summed up: "Attitudes should be adopted towards sustainable-illumination in which economy, sociology and the environment are all equally important. Such an approach will bring about the development of light sources with minimal health risk whilst decreasing light pollution."

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