



**Our Title:** Health and Safety Implications of Nighttime Artificial Lighting

**Author's Title:** Report 4 of the Council on Science and Public Health (A-12): Light Pollution: Adverse Health Effects of Nighttime Lighting

**Author:** David Blask, George Brainard, Ronald Gibbons, Steven Lockley, Richard Stevens, and Mario Motta

**Year of Publication:** 2012

**Design Issue:**

**Purpose:** This referenced position paper examined the implications of the increase in nighttime artificial light on human health, environmental health, and driving safety. Recommendations for further exploration and analysis were made.

**Rationale:**

- The natural balance of daylight and darkness within a 24-hour timespan helps the human body maintain optimal health via circadian rhythms and related activity of the pineal gland that produces melatonin, activity of the central nervous system, and general biological processes. Sleep is important to well-being, but it does not control circadian rhythm; darkness is required.
- When artificial lighting (whether low or high levels) enables nighttime activities including work, the human body is negatively affected as the release of melatonin is suppressed. Long-term disruption of the natural sleep cycle and exposure to nighttime lighting, typical of shift work, have also been related to an elevated risk of cancer.
- There appears to be a link between the interruption of normal bodily functions caused by nighttime lighting and other types of cancers, obesity, diabetes, metabolic syndrome, gastrointestinal and digestive function, and reproductive function, as well as depression and mood disorders, but further study is needed to establish a causal relationship.

**Design Criteria:**

*The authors identified the following design criteria:*

- Light sources that minimize circadian rhythm disruptions should be developed and used at home and at work.
- Using dim red light sources in bedrooms where light is needed will diminish nighttime lighting disruptions.
- Be aware that light sources can produce both a lack of ability to see objects, as well as discomfort in viewing them, such as eye fatigue adjusting to bright street lighting or headlights approaching and then the darkness that occurs between them. The challenges glare presents are cumulative.
- Use flat glass light fixtures for overhead lighting on roads that contain a horizontal cut off of light to minimize glare for the driver; but be aware that that type of lighting is best for pedestrians. Using both systems of lighting might provide the best visibility for both drivers and pedestrians using the street and sidewalk, respectively.



- Consider use of headlights in vehicles that have the ability to shield part of the beam facing the oncoming car and/or that can swivel when an oncoming car approaches to reduce glare for the other driver.

*InformeDesign identified the following design criteria based on this report, but related to correctional facility design:*

- Consider the health effects on prisoners in maximum or supermaximum housing units in correctional facilities who might be exposed to artificial lighting 24 hours a day in their cells and who may not have access to daylight but a few hours per week.
- Be aware of the health effects on prison staff who work during the nighttime in artificial light due to the impact it has on their melatonin production and circadian rhythms.

#### **Key Concepts:**

- Human physiology has been the focus of much study as people are affected by nighttime light relative to the function of the circadian clock as it is regulated by the suprachiasmatic nuclei (SCN) of the hypothalamus of the brain and is signaled by a balance of light and darkness. “Non-24 hour sleep-wake disorder” can result when the day-night exposure to light is off schedule. Symptoms include inconsistent ability to sleep at night from good to poor and/or a need for daytime naps .
- Studies of health effects of nighttime lighting have been primarily from epidemiological investigations and observations as well as animal testing in laboratories. From testing on mice and rats, as well as the influence of human (female) blood samples on breast cancer xenografts, there appears to be a relationship between the growth of breast cancer (the area of greatest research) when nocturnal melatonin is suppressed or absent; reverse testing also shows reverse results. Presence of melatonin in the body during the darkness of night seems to act as a cancer suppressive on normal cells.
- A 2007 study by the International Agency for Research on Cancer (IARC) found that there was evidence of a link between nighttime shift work and the resulting irregular circadian rhythms and the increased likelihood of a carcinogenic effect on humans. However, studies that have come since that time have had mixed results in terms of establishing that link, partially due to the fact that everyone is exposed to nighttime lighting to different extents.
- Nighttime light exposure happens most obviously in shift work, but all persons are exposed to light after dark to varying degrees of duration, quality (wavelength, color), and quantity (lux); it has been difficult to measure the effects. Worker fatigue, workplace light levels, and melatonin supplement guidelines prepared by the American College of Occupational and Environmental Medicine address some of the nightlight-related challenges of shift-work.
- Existing American Medical Association (AMA) policies call for control of the use of artificial light at night both from the standpoint of light pollution and energy conservation. However, the use of nighttime lighting has continued to expand to meet societal, commercial, and personal demands.



- Of worldwide consumption of electricity, 19% of it is for lighting. It is estimated that the United States wastes 30% of its night lighting, as it goes out into the sky, which is also considered a negative as it obviates the ability to see the night sky and could be altering the biological functioning of animals, especially those that are nocturnal (30% of vertebrates, 60% of invertebrates). It is also surmised that plant biology is being impacted relative to pollination that occurs after dark.
- Light-emitting diodes (LEDs) used in exterior lighting for roads have greater lux output, but also produce more disability glare than other types of sources. When used in vehicle headlights, both LED and xenon sources produce similar issues with glare, and blue headlights produce the most visual discomfort.
- People are spending more time indoors increasing their exposure to artificial light that is far dimmer (fewer lux, the measure of the brightness of light) and of a more limited range of wavelengths (the color of light) as compared to daylight. It is possible that the lack of exposure to sunlight is rendering a person's exposure to light to be similar both during the daytime and the nighttime, suppressing melatonin, which is needed for sleep. Daylight can be as bright as 32,000-130,000 lux whereas office lighting is significantly lower (325-500 lux), and home lighting is typically lower yet (50 lux).
- It has been found that somewhat dim monochromatic green lighting (5-17 lux) or broad wavelength white light at a moderate level of illumination (100 lux) can both interfere with melatonin production. Low levels of blue light (459-484 nm) have a greater suppression level, and melatonin was found to be most suppressed when the person experienced light in the 446-477 nm wavelength range (violet-blue); whereas red light has no influence on melatonin production.
- Perception and comfort with adapting to nighttime artificial light varies by individual and as a person ages, the eye's ability to process light needed for sight diminishes. Difficulty in processing bright lights at night, especially when driving, involve both physiological and psychological responses and placement, spacing, and brightness of light fixtures. Poorly designed and/or oriented bright lighting sources can enhance glare (veiling luminance; disallowing a person to see the object due to light cast in front of it) to the level of disabling the viewer.
- Acknowledging the link between the growing use of media (electronics with screens) for expanded periods, including during the dark hours of the night, the American Academy of Pediatrics recommends that children and adolescents do not have these devices in their bedrooms.

**Research Method:**

- A review of PubMed literature (1995-March 2012) was augmented with literature provided by experts in the related fields under study.
- Key concepts, definitions, and research findings were reviewed relative to human, animal, and environmental health, and recommendations were compiled based on the findings of the literature review.



### **Limitations of the Study:**

- The authors did not identify any limitations.

**Commentary:** Authors note that understanding the individual roles of sleep versus melatonin release due to darkness requires further study. Additionally, health effects (cancer and other chronic diseases) and environmental effects need further research, conducted in a multidisciplinary manner. The authors define lighting terminology and functional details of the eye as it reacts to light.

### **Adapted From:**

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