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We're All Healthier Under a Starry Sky

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Abstract

A star-filled sky has long been a source of awe and inspiration, and its loss adversely affects human, nonhuman, and environmental health. In one generation, this majestic nighttime overstory has been lost due to national and international overuse of light-emitting diodes lighting. This article canvasses ill health effects of excessive light at night. Blue wavelengths of light are damaging to many forms of life, and glare from unshielded light compromises road safety and infiltrates bedrooms, suppressing melatonin production, undermining sleep quality and duration, and exacerbating susceptibility to many kinds of illness.

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Adverse Health Effects of Light at Night

For all of human existence, people have been inspired by the beauty of the night sky and marveled at the majesty of the Milky Way above their heads. Yet, in just one generation's lifetime—a blink of an eye—ever present and increasingly omnipresent outdoor light at night (LAN) has hidden this nighttime spectacle behind a veil of excessive outdoor illumination.^{1,2,3} This tragic loss is especially prevalent in industrialized nations, where very few can now see the sky in all its majesty. With the proliferation of very efficient, inexpensive, and brighter light-emitting diodes (LED) lighting, this trend has markedly accelerated over the past few years, along with the harms of excessive blue LED emission.^{2,4,5,6} In particular, there are significant adverse health effects of excessive outdoor LAN that have been documented by a plethora of studies over the past 30 years.

Suppression of melatonin production. There are, of course, strong economic and climate-related arguments for using LED street lighting, such as energy efficiency, since LED lighting uses less energy than incandescent lighting. However, not all LED lighting is optimal. Some LED lighting fixtures produce excessive blue light emission, which is harmful to human health as well as the environment. “Cool” color-correlated temperature (CCT) LED streetlights have a spectrum that spikes in the blue wavelengths, which are more effective at suppressing melatonin production during the night than red wavelengths.⁷ CCT LED lighting above 3000 Kelvin (K) has excessive blue light (about

21% blue for 3000 K, rising to 32% blue for 4000 K). By comparison, 2700 K LED lighting is around 15% blue.^{8,9} It is slightly amber in color but not as harsh to the human eye. In dense urban environments where most people live, unshielded streetlights shine into bedrooms at night, and even small amounts are enough to suppress melatonin production.^{7,10}

The American Medical Association (AMA) led the way by alerting the world to the dangers of excess LAN back in 2012 with a report titled “Light Pollution: Adverse Health Effects of Nighttime Lighting” and a second report in 2016 titled “Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting.”^{11,12,13} Since then, 16 states and many cities and towns across the United States and in Europe have adopted the AMA recommendation to keep outdoor lighting below 3000 K.^{14,15} Some companies, such as Apple, have even incorporated this recommendation in its products; the iPhone and iPad night shift setting limits blue **light from screens after sunset**.¹⁶ However, implementation of the AMA recommendation to date has been sporadic in other companies and products.

Glare. In addition to suppressing melatonin production, improperly designed and poorly shielded light fixtures can result in glare and create a road hazard condition. Indeed, “glare is the most common health safety problem resulting from poorly designed outdoor lighting,”¹⁷ as intense blue LED lighting leads to discomfort and disability glare. As I have noted elsewhere:

Over time, calcifications build up in the lenses of our eyes, which eventually develop into a cataract. These calcifications and other lens and eye imperfections scatter light in a similar fashion to a dirty windshield. This effect grows more severe with age, and is the primary reason why the elderly have a difficult time driving at night under poorly designed street lights.¹⁷

Recognizing that our streets could be safer places at night, the AMA adopted a policy in 2009 that urges full shielding for all public street lighting.¹⁸

Glare can be greatly mitigated by proper design, shielding, and installation so that no light shines above 80 degrees from the horizontal. The visual hazard posed by these very intense point sources is further magnified by cooler CCT LEDs, because blue light scatters more in the human eye than warmer wavelengths, leading to increased disability glare.^{8,19}

It is most unfortunate that some car headlights are manufactured with CCT as high as 6000 K. Such a high CCT blinds oncoming drivers and is a severe safety hazard. The energy efficiency of 3000 K lighting is “virtually the same” as that of 4000 K lighting.²⁰ due to the coatings used, and this very small efficiency loss is more than compensated for by light emission that is more pleasing and environmentally friendly.

Cancer. There are now voluminous peer-reviewed articles showing a higher risk of hormonally linked cancers, such as breast and prostate cancers, with melatonin suppression.^{4,21,22,23,24,25,26,27,28,29} Higher risk of thyroid and pancreatic carcinoma associated with LAN has also been reported in the literature.^{30,31,32} The root problem lies in the disruption of **circadian rhythmicity** through suppression of melatonin production by the pineal gland. We evolved to have melatonin rise at sunset, but, in the modern world, melatonin production is delayed until bedtime and lights are out. Perniciously, however, even at bedtime, light penetrates into bedrooms in urban and suburban areas, further suppressing melatonin production. Melatonin has been shown to be an

important adjuvant to the human immune system. During sleep, our immune system attacks and removes abnormal cells that are produced daily during normal cell division. If the immune system is reduced in efficiency by lack of or diminished melatonin production, then there exists an incrementally higher chance that an abnormal cell will escape detection and may proliferate as a cancer.^{33,34}

One particularly large, landmark study published in 2017, entitled “Outdoor Light at Night and Breast Cancer Incidence in the Nurses’ Health Study II,” followed 109 672 nurses from 1989 through 2013.²¹ Linking data from satellite images of Earth taken at night to the zip code of the residential address of each study participant, the researchers divided the participants into 5 cohorts. Women in the top fifth of exposure levels of outdoor LAN had an estimated 14% increased risk of breast cancer during the study period compared with women in the bottom fifth of exposure. There are now at least 20 peer-reviewed papers in the world literature that all show consistent and similar results.^{4,21,22,23,35} Artificial LAN has also been associated with sleep disturbances, depression, psychiatric disorders, and obesity with a subsequent increased incidence of diabetes.¹⁸

Adverse Environmental Effects

The detrimental effects of LAN are not limited to humans, as nearly all animals and plants are also adversely affected by it. There now exists a burgeoning and robust literature documenting the environmental damage caused by excessive outdoor LAN. Birds, insects, and mammals are especially hard hit, as I have described elsewhere.

Some 60 per cent of animals in the wild are nocturnal, and adversely affected by exposure to nighttime outdoor lighting. Many birds are known to navigate by the sky at night, and get confused by excessive lighting, leading to large numbers of bird kills. Many insects need a dark environment to procreate, the most obvious example being fireflies, that cannot ‘see’ each other because of light pollution. Many other beneficial insects are drawn to the blue-rich lighting, and circle under them until they become exhausted and die. Unshielded lighting on beach areas has led to a massive drop in turtle populations. Turtles are programmed to head to the reflection of the moon on the nearby water. The hatchlings are disoriented by artificial light and sky glow, preventing them from reaching the water safely. Even bridge lighting that is ‘too blue’ has been shown to inhibit upstream migration of certain fish species such as salmon returning to spawn. The growth of light pollution along the borders of the national parks in the USA spills light into the parks, leading to detrimental effects on their bioenvironment. Recognizing the adverse impact on nocturnal species, parks now require minimal lumens and shielded lighting whenever installed.³⁶

Partly due to excess LAN, we are witnessing a massive decline in species across the globe. The precipitous decline in insect populations is particularly dire, and it has been stated in *Nature Ecology and Evolution* that we are in the midst of an “insect apocalypse,”³⁷ with a 45% decline in insect populations in the past 40 years.³⁸ This decline has ominous implications for the food supply of many species, such as birds, and for pollination of our food supply. For example, marine plankton live in the dark but migrate every night to the surface waters to feed on algae near our shores. However, plankton are extremely averse to even the faintest rays of light and thus do not migrate up to feed near light-polluted shores. This is a dire problem, as plankton are the base of the ocean food chain, and their disappearance also allows algae to proliferate near our shores.^{39,40}

Even plant life is adversely affected by LAN. Trees that do not shed their leaves on time in late fall because they are fooled into thinking that the daylight hours are not waning have a shortened lifespan from the environmental stress.⁴¹ Open fields of soybeans

have differential maturation times if part of the field is exposed to LAN, complicating farmers' harvesting of the crop.^{41,42}

Conclusion

Thus, in a very real sense, the loss of a starry sky is directly correlated with human health risk and environmental damage. The fewer stars you see when you look up can be a marker of that risk. This is not to say that the loss of visibility of stars in the sky is causally related to human and environmental health, of course, but there exists a correlation between them that can be quantified. It behooves us to restore balance between natural and outdoor, built environments. To do so is not difficult: use outdoor lighting responsibly; use outdoor LAN only where needed, for the time needed; and don't overlight. Shield light sources from direct eye contact, and especially avoid outdoor nighttime blue light emission. These commonsense steps, if implemented, will lead to a healthier environment, help restore nature's balance, and maybe even gain back a starry sky to inspire all of us once more.

References

1. Betz E. A new fight for the night. *Astronomy*. 2015;43(6):46-51.
2. Varela Perez AM. The increasing effects of light pollution on professional and amateur astronomy. *Science*. 2023;380(6650):1136-1140.
3. Kyba CCM, Kuester T, Sánchez de Miguel A, et al. Artificially lit surface of Earth at night increasing in radiance and extent. *Sci Adv*. 2017;3(11):e1701528.
4. Are LED lights safe for human health? European Commission. Accessed May 30, 2024. https://health.ec.europa.eu/scientific-committees/easy-read-summaries-scientific-opinions/are-led-lights-safe-human-health-2_en
5. Zielinska-Dabkowska KM, Schernhammer ES, Hanifin JP, Brainard GC. Reducing nighttime light exposure in the urban environment to benefit human health and society. *Science*. 2023;380(6650):1130-1135.
6. Brainard GC, Sliney D, Hanifin JP, et al. Sensitivity of the human circadian system to short-wavelength (420-nm) light. *J Biol Rhythms*. 2008;23(5):379-386.
7. Tosini G, Ferguson I, Tsubota K. Effects of blue light on the circadian system and eye physiology. *Mol Vis*. 2016;22:61-72.
8. Jin H, Jin S, Chen L, Cen S, Yuan K. Research on the lighting performance of LED street lights with different color temperatures. *IEEE Photonics J*. 2015;7:1-9.
9. Patel K, Perry K, Wolfe D, Sabens E. LED lights are meant to save energy. They're creating glaring problems. *Washington Post*. June 23, 2023. Accessed May 20, 2024. <https://www.washingtonpost.com/climate-environment/interactive/2023/glaring-problem-how-led-lights-worsen-light-pollution/>
10. Chepesiuk R. Missing the dark: health effects of light pollution. *Environ Health Perspect*. 2009;117(1):A20-A27.
11. Blask D, Brainard G, Gibbons R, Lockley S, Stevens R, Motta M; Council on Science and Public Health. CSAPH report 4-A-12: light pollution: adverse health effects of nighttime lighting. American Medical Association; 2024. Accessed June 28, 2024. <https://www.mariomottamd.com/wp-content/uploads/AMA-Health-Effects-Light-at-Night.pdf>
12. Kraus LJ; Council on Science and Public Health. CSAPH report 2-A-16: human and environmental effects of light emitting diode (LED) community lighting. American Medical Association; 2016. Accessed March 28, 2024.

- https://policysearch.ama-assn.org/councilreports/downloadreport?uri=/councilreports/a16_csaph2.pdf
13. Stevens RG, Brainard GC, Blask DE, Lockley SW, Motta ME. Adverse health effects of nighttime lighting: comments on American Medical Association policy statement. *Am J Prev Med.* 2013;45(3):343-346.
 14. CNN Wire. To improve health, cities are changing their streetlights. *Fox43.* September 29, 2016. Accessed May 20, 2024. <https://www.fox43.com/article/news/local/contests/to-improve-health-cities-are-changing-their-streetlights/521-194675c4-b001-4137-b01b-da16a19aa956>
 15. Stark K. Chicago dials down LED street lamp intensity—and controversy. *Energy News Network.* March 7, 2018. Accessed May 20, 2024. <https://energynews.us/2018/03/07/chicago-dials-down-led-street-lamp-intensity-and-controversy/>
 16. Use Night Shift on your iPhone, iPad, and iPod touch. Apple Support. Accessed May 20, 2024. <https://support.apple.com/en-us/118583>
 17. Motta ME. Medical effects of light pollution. Astronomers Without Borders blog. April 17, 2012. Accessed May 20, 2024. <https://archive.astronomerswithoutborders.org/global-astronomy-month-2012/184-gam2012/gam-dsa-blog/1137-medical-effects-of-light-pollution.html>
 18. Council on Science and Public Health. Light pollution: adverse health effects of nighttime lighting H-135.932. American Medical Association. Updated 2022. Accessed May 30, 2024. <https://policysearch.ama-assn.org/policyfinder/detail/135.932?uri=%2FAMADoc%2FHOD.xml-0-303.xml>
 19. Lin Y, Liu Y, Sun Y, Zhu X, Lai J, Heynderickx I. Model predicting discomfort glare caused by LED road lights. *Opt Express.* 2014;22(15):18056-18071.
 20. Colour temperature: 3000K vs 4000K. Advanced Lighting Technologies. Accessed May 20, 2024. <https://adlt.com.au/resources/colour-temperature-3000k-vs-4000k/>
 21. James P, Bertrand KA, Hart JE, Schernhammer ES, Tamimi RM, Laden F. Outdoor light at night and breast cancer incidence in the Nurses' Health Study II. *Environ Health Perspect.* 2017;125(8):087010.
 22. Garcia-Saenz A, Sánchez de Miguel A, Espinosa A, et al. Evaluating the association between artificial light-at-night exposure and breast and prostate cancer risk in Spain (MCC-Spain study). *Environ Health Perspect.* 2018;126(4):047011.
 23. Hurley S, Goldberg D, Nelson D, et al. Light at night and breast cancer risk among California teachers. *Epidemiology.* 2014;25(5):697-706.
 24. Zubidat AE, Haim A. Artificial light-at-night—a novel lifestyle risk factor for metabolic disorder and cancer morbidity. *J Basic Clin Physiol Pharmacol.* 2017;28(4):295-313.
 25. Miller S, Cajochen C, Green A, et al; International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP statement on short wavelength light exposure from indoor artificial sources and human health. *Health Phys.* 2024;126(4):241-248.
 26. Markt SC, Valdimarsdottir UA, Shui IM, et al. Circadian clock genes and risk of fatal prostate cancer. *Cancer Causes Control.* 2015;26(1):25-33.
 27. Mao L, Summers W, Xiang S, et al. Melatonin represses metastasis in Her2-positive human breast cancer cells by suppressing RSK2 expression. *Mol Cancer Res.* 2016;14(11):1159-1169.

28. Urbano T, Vinceti M, Wise LA, Filippini T. Light at night and risk of breast cancer: a systematic review and dose-response meta-analysis. *Int J Health Geogr.* 2021;20(1):44.
29. Stevens RG, Brainard GC, Blask DE, Lockley SW, Motta ME. Breast cancer and circadian disruption from electric lighting in the modern world. *CA Cancer J Clin.* 2014;64(3):207-218.
30. Tamtaji OR, Mirhosseini N, Reiter RJ, Behnamfar M, Asemi Z. Melatonin and pancreatic cancer: current knowledge and future perspectives. *J Cell Physiol.* 2019;234(5):5372-5378.
31. Xiao Q, Jones RR, James P, Stolzenberg-Solomon RZ. Light at night and risk of pancreatic cancer in the NIH-AARP Diet and Health Study. *Cancer Res.* 2021;81(6):1616-1622.
32. Zhang D, Jones RR, James P, Kitahara CM, Xiao Q. Associations between artificial light at night and risk for thyroid cancer: a large US cohort study. *Cancer.* 2021;127(9):1448-1458.
33. Vinther AG, Claësson MH. The influence of melatonin on the immune system and cancer. Article in Danish. *Ugeskr Laeger.* 2015;177(21):V10140568.
34. Carrillo-Vico A, Lardone PJ, Alvarez-Sánchez N, Rodríguez-Rodríguez A, Guerrero JM. Melatonin: buffering the immune system. *Int J Mol Sci.* 2013;14(4):8638-8683.
35. Luo Z, Liu Z, Chen H, Liu Y, Tang N, Li H. Light at night exposure and risk of breast cancer: a meta-analysis of observational studies. *Front Public Health.* 2023;11:1276290.
36. Motta ME. LED street lighting: the human and environmental effects. *Light Lines.* 2022;15(3):8-9. Accessed July 3, 2024. https://issuu.com/matrixprint/docs/sll_light_lines_may_june_2022_final
37. Crossley MS, Meier AR, Baldwin EM, et al. No net insect abundance and diversity declines across US Long Term Ecological Research sites. *Nat Ecol Evol.* 2020;4(10):1368-1376.
38. Wagner DL, Grames EM, Forister ML, Berenbaum MR, Stopak D. Insect decline in the Anthropocene: death by a thousand cuts. *Proc Natl Acad Sci U S A.* 2021;118(2):e2023989118.
39. Fobert EK, Miller CR, Swearer SE, Mayer-Pinto M. The impacts of artificial light at night on the ecology of temperate and tropical reefs. *Philos Trans R Soc Lond B Biol Sci.* 2023;378(1892):20220362.
40. Grubisic M, van Grunsven RHA, Kyba CCM, Manfrin A, Hölker F. Insect declines and agroecosystems: does light pollution matter? *Ann Appl Biol.* 2018;173(2):180-189.
41. Škvareninová J, Tuhárska M, Škvarenina J, et al. Effects of light pollution on tree phenology in the urban environment. *Moravian Geogr Rep.* 2017;25(4):282-290.
42. When nights are no longer dark: effects of artificial light at night on agroecosystems. *LED Professional.* March 26, 2019. Accessed May 20, 2024. <https://www.led-professional.com/resources-1/articles/when-nights-are-no-longer-dark-effects-of-artificial-light-at-night-on-agroecosystems>

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