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Editorial

EDITORIAL

Do no harm: the beginning of the age of healthy hospital lighting

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Anyone who has spent several nights in a hospital can appreciate that, while recovering, they are simultaneously undergoing what feels like sleep deprivation torture. There are the machines that go "bing" incessantly. There are also, more insidiously, the lights [1]. The lighting in a typical hospital is a challenge to our bodies' expectation of bright days and dark nights [2]. Typical hospital lights are highly irregular, too dim in the day, and too bright at night [3, 4]. Though it is not obvious to us, even at relatively low levels, the light we are exposed to in the evening can have a powerful effect on the circadian clock [5], suppress the release of the sleep-promoting hormone melatonin [6, 7], and reduce the amount and depth of our sleep [8, 9]. In this issue, Vethe *et al.* [10] demonstrate that simply changing the lighting in a hospital setting to more closely track the natural light/dark cycle can have a beneficial impact on sleep and the circadian system.

We are approaching a quarter of a century since the discovery of melanopsin [11], the circadian photoreceptor that is "exquisitely" sensitive to short-wavelength (blue) light [7]. Long before that, we knew that the circadian system was most sensitive to this type of light. Hastings *et al.* [12] demonstrated this over 60 years ago in the single-celled *Gonyaulax polyedra* in 1960 and Takahashi *et al.* [13] showed the same in hamsters in 1984. One could say paying more attention to the type of lights we use has been a long time coming.

Vethe *et al.* [10] took advantage of a newly constructed hospital with two identical wards that differed only in the lighting used. One had typical hospital lighting and the other used blue-depleted lighting in the evening. Both had the same photopic illuminance, meaning that they maintained similar visual brightness. This is an important control from the stance of safety, especially for patients who may have limited mobility or vision and rely on a sufficiently bright environment to move around. Healthy individuals were studied, and the lighting was meticulously controlled, including the light from TVs and personal devices.

As anticipated, the investigators found that under the blue-depleted light, melatonin was less suppressed, circadian timing was more advanced (due to less phase-delaying evening light), and total sleep time was increased. What was found was expected, according to circadian principles. What is important and new is that this simple change in ambient lighting has clear, measurable benefits, even when participants were free to move through a multiroom complex. Any complex with 24/7 residents could and should consider doing the same.

When the sun was our only source of bright light, we worshipped it as a god. We have now conquered light. It is our servant and we summon its presence with a listless flick. We are accustomed to not thinking light is important. How can it be? We purchase light bulbs for a few dollars and pick them up at the supermarket…in the same aisle as toilet paper. "Let there be light?" Big deal.

We may not respect the control of light, but we appear to love consuming it. We overlight our homes at night [9] and create light pollution outside. The use of handheld blue-enriched light emitters is nearly universal. Even if we are not consciously aware of it, light makes us feel more alert, safe, and happy. Beyond its essential impact on the circadian clock, we now know that melanopsin-containing retinal ganglion cells project to regions of the brain involved in emotional regulation [14]. When light was only naturally available to us, the drive to consume light (which might have been beneficial in stabilizing and boosting circadian rhythms) had no ill effects. We now have unlimited access to light and are driven to consume as much as we can. Our blue-enriched lights are like our readily accessible carbohydrate-rich junk food. We did not evolve to make good

decisions about consumption when these formerly limited resources became constantly available.

The way in which circadian clocks keep our physiology ticking is now acknowledged not only within our own field but also by a recent Nobel Committee. Yet, there is very limited utilization of this knowledge in the healthcare field. It seems likely that, eventually, almost all hospitals will employ smart lighting based on circadian principles. This lighting would promote better sleep and healthier circadian rhythms, both of which would improve healing. Although Vethe *et al.* [10] only studied healthy participants, it is reasonable to assume that the benefits of healthy lighting will be greatest for people who are most vulnerable to the effects of circadian disruption, such as individuals recovering from surgery or individuals whose health conditions are exacerbated by circadian disruption, including metabolic and psychiatric disorders [15]. We look forward to future studies in these populations.

How rapidly we arrive at this envisaged future of smart-lit hospitals will depend on our ability to convince medical staff, architects, lighting engineers, and governments that this is the right thing to do. Clear messages and a strong evidence base are needed. We need more well-executed studies such as Vethe *et al.* [10] present in this issue. Vethe *et al.* [10] controlled all the light their participants were exposed to, including the light from devices. The circadian system is highly sensitive and it does not take much light at the wrong time of day to have a negative effect [7]. A phone screen or tablet that is not appropriately dimmed can easily undermine any control of ambient light. While these controls require additional effort to implement in a real-world setting, the data show that they are essential. When studies fail to control the light, false conclusions about the value of light interventions may be reached. This leads to confusing messages and a seemingly equivocal evidence base for "human centric lighting." It is precisely because light has powerful effects that poor control has led to confusion.

While this study is an excellent starting point, more work is needed to make smart lighting a universal reality. As Vethe *et al.* [10] note, when their lights were blue-depleted, there was poorer color discrimination. In a clinical setting, this could impair visual detection of typical clinical signs, such as skin discoloration. Potential solutions to this issue are possible. For example, metameric lighting systems are under development [16], which can cleverly manipulate the spectrum of light to modulate the impact of light on melanopsin while maintaining the same visual perception. Smart lighting is still in its infancy and will only get smarter in the future.

Beyond human clinical studies, there is much scope for basic research in this area, which could help to demonstrate the importance of lighting for inpatient settings. We would love to see a study done in which real light exposure patterns within a hospital (perhaps from a unit in which patients are recovering from cardiac surgery) are reproduced in an animal model of recovery from surgery. Back in 2007, Martino *et al.* [17] demonstrated that simply disrupting the light/dark cycle (using a 20-hour "day") led to organ dysfunction in a mouse model of pressure overload cardiac hypertrophy. Reproducing both the poorly lit days, overlit nights, and irregularity of a real hospital on the recovery from surgery in an animal model might be just the type of thing needed to show that real light environments are actively impeding recovery.

The Hippocratic Oath states "first, do no harm." The current lighting in hospitals may break that oath. We need to do better and Vethe *et al.* [10] show what doing better could look like. We are at the beginning of an age of "Circadian Medicine," in which we understand that optimizing our circadian rhythms will lead to better health and healing. The ease with which we control our lights is a double-edged sword: it can not only easily cause harm but also be easily harnessed for good.

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