

HEALTHCARE

The impact of lighting in Healthcare

BIOCENTRIC LIGHTING IN HEALTHCARE

Sleep is an important factor to promote the wellbeing and recovery of patients. Impaired sleep is a known hospital stressor, and hospitalized patients struggle to get sufficient sleep at night due to factors like discomfort, worries, noise, inappropriate light exposure and pain.

Irregular 24 h light/dark cycles with night-time light exposure and a low day-time amplitude are disruptive for sleep, mood and circadian rhythms. Nevertheless such lighting conditions are quite common in medical care facilities.

Proper timing of light is important as excessive light exposure during the evening or night can cause disruptive effect on sleep and brighter daytime light is associated with improved sleep quality and better mood.

In many healthcare facilities access to daylight is limited. One study investigating lighting levels in acute care medical patients, found that patients were dwelling in low levels of light daytime¹ and patient's 24-hour light/dark cycle has been found to be extremely weak and phase delayed relative to the solar cycle². No seasonal difference in light intensity of patient rooms was found in one study, indicating only low levels of daylight exposure.

Current standards and guidelines for lighting systems within normal patient rooms specify horizontal illuminance thresholds in the range of 100–300 lux³, a level insufficient to generate the same benefits as the outdoor illuminance (2000–100 000 lux) under which we have evolved.

Not surprisingly, circadian dysrhythmias are often found⁴ and hospitalized patients often suffer from sleep and circadian rhythm disruption⁵. Also higher use of hypnotics (25 %) compared to the general population (3 %)

and a usage of hypnotics among patients that normally don't use drugs for sleep is often found among hospitalized patients⁵.

Resetting the circadian clocks takes time and sudden environmental changes result in cellular rhythms being out of sync with demands imposed by the environment.

Clocks in different tissues adapt to disturbances at different speed, which leads to internal desynchrony much like an orchestra where instruments are played independently.

Moreover, earlier bed and wake time in hospitals may disrupt the sleep rhythm depending on the patient's chronotype. Knowledge of a patient's chronotype may be useful in tailoring the timing of light and other zeitgebers such as food, exercise and sleep during hospital stay in order to preserve the patient's natural circadian rhythm⁶.

Effect of light on melatonin, mood and sleep

The use of light daytime and ear plugs and eye masks at night have demonstrated beneficial effects in influencing melatonin levels.

In one study, mimicking natural light pattern with an enhanced blue-enriched luminance before noon, rendered 30 min longer sleep compared to conventional light conditions⁷.

A study involving 99 inpatients showed that those whose beds were located closer to the window (distance < 1 m) in the patients' room slept better, compared to those lying further away from the window⁸.

Another study found that circadian rhythms typically were phase delayed and that implementing enhanced light exposure during morning hours improved circadian synchronization and shifted it to an earlier time⁹.

In yet another study, even though the brightest rooms provided very low light exposure, still a correlation between mood and light and fatigue and light respectively was seen such that higher light exposure was associated with less fatigue and pain¹.

Effect of light on length of stay and mortality

Daytime exposure to high illuminances, from either sunlight or a few hours of bright-light therapy, is known to have beneficial effects on clinical parameters such as recovery, length of stay (LOS), depression, anxiety and use of pain medication.

In a study investigating the hospital environment, inpatients had over 3 days shorter stay when admitted to rooms facing east compared to those in rooms facing west¹⁰.

The rooms facing west received brighter natural light. Another study found that LOS was reduced by 7.3 hours per 100 lx increase of daylight inside¹¹.

Moreover, in a study involving 1057 patients from internal, otolaryngology, surgery, and gynecology wards it was found that patients located in southwest facing rooms had a 29 % shorter average LOS, compared to patients in the north-west facing rooms¹² and in another study mortality after myocardial infarction was higher in dull rooms¹³.

Low lit workplace

In many situations there is a demand for reduced lighting. Several examination procedures are favorable, done under dim lighting

conditions such as gastroscopy, colonoscopy and also clinical examination of eyes and ears.

Also surgical procedures under microscope or laparoscopic procedures where the operation theatre is dimly lit can sometimes have the result that not only the surgeon but also whole staff only get a small fraction of the light they need.

The need of lighting in between tasks, for example “light showers”, might be appropriate to retain the circadian rhythm.

Neonatal care

Every year, an estimated 15 million babies are born preterm in the world (around 520 000 in the US) and this number is rising. They may face a range of health problems and may need to stay in the hospital longer and sometimes in the hospital’s neonatal intensive care unit (NICU).

According to WHO, preterm birth complications are the leading cause of death among children under 5 years of age¹⁴. Premature babies are vulnerable and need special care.

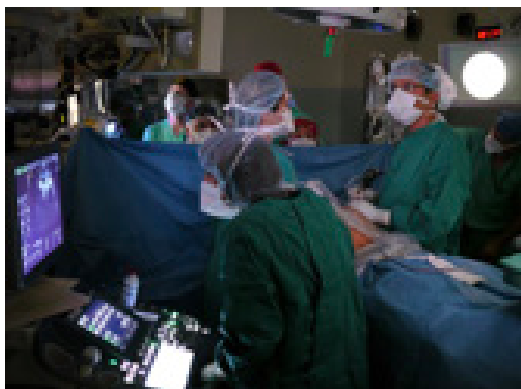
Continuous advances in neonatology have increased the chances of survival of preterm and critically ill newborn infants.

NICUs from the 80s were bright and well-lit. Nowadays, there is a trend to use lower lighting levels¹⁵. Although fetus development takes place in the dark, fetal diurnal rhythms are entrainable by maternal rhythm mediated via signals such as maternal activity, heart rate, melatonin and cortisol^{15,16}.

Keeping preterm patients in a continuously dark or continuously lit environment while in the NICU, deprives them of the circadian stimuli they would have received during gestation.

In a systematic review by the Cochrane Collaboration the authors suggested better outcomes regarding growth and length of stay with cycled light than with continuous near darkness or bright light¹⁷. This is an approach also supported by the American Academy of Pediatrics and several researchers^{18,19}.

In one study comparing cycled light for infants born ≤ 28 weeks postmenstrual age, those exposed to cycled light already at 28 weeks went home an average of 5.5 days earlier than the infants who started cycled lighting at 36 weeks²⁰. The lighting used in that study was 200-600 lux 12 h daytime



and 5–30 lux remaining time, in accordance with standards for newborn ICU design.

Light is not only for the babies. Parents and hospital staff also need good light to maintain their circadian rhythm. Furthermore, clinical examination of the baby and observation of baby and baby's skin color demands a good perception of color.

The color rendering index (CRI) allows to determine color rendering properties of a light source. Taking as a standard the natural light (CRI = 100), this index measures how “true colors” are perceived when illuminated by an artificial light source. Sources of artificial lighting in neonatal care must have a CRI greater than 80¹⁵. BCL™, as a comparison, provides a CRI of 790.

Shift work

Shift work is a vital part of healthcare as medical services require 24-hour coverage. Those working the night shift are susceptible to debilitating health effects due to lack of sleep and poor eating habits.

Shift work is associated with cardiovascular disease, diabetes and cancer. Many shift workers experience symptoms of sleep such as excessive sleepiness or insomnia and 2/3 of medical events are contributed to the third shift.

Studies have shown that exposure to high levels of bright light at night increases alertness but this has to be balanced with the effect that light has on suppression of melatonin. Emerging research has shown possible alternatives with reduction of shorter wavelengths with lower impact on melatonin

suppression while preserving the alerting effect of light. Measures of diurnal preference or chronotype might also be important in scheduling timed light exposure according to the individual's circadian rhythm^{21,22}.

Summary

- Hospital lighting is often weak and insufficient to stimulate circadian rhythm
- Hospitalized patients often suffer from sleep and circadian rhythm disruption
- Appropriate lighting can improve sleep and circadian synchronization among patients
- Amount of light can impact length of hospital stay and possibly also mortality
- The specific needs in neonatal care demands high quality and flexible lighting

One of the biggest challenges with light in healthcare is the adaptability of the light solution to a workplace where multiple activities require different solutions for different rooms.

The BioCentric Lighting™ (BCL™) system is easily customized according to the unique needs of the individual workplace. The light environment provides patients and relatives as well as staff with the light that they need each day, regardless of season. Moreover, with outstanding color rendering index, examination of vital bodily parameters are safe despite low illuminance levels.

Emerging research provide new understandings of the beneficial effects of light for improving sleep and wellbeing. The BCL™ system is easily adaptable to meet these new insights.

References

1. Bernhofer EI, Higgins PA, Daly BJ, Burant CJ, Hornick TR. Hospital lighting and its association with sleep, mood and pain in medical inpatients. *J Adv Nurs*. 2014;70(5):1164–1173. doi:10.1111/jan.12282
2. Danielson SJ, Rappaport CA, Loher MK, Gehlbach BK. Looking for light in the din: An examination of the circadian-disrupting properties of a medical intensive care unit. *Intensive Crit Care Nurs*. 2018;46:57–63. doi:10.1016/j.iccn.2017.12.006
3. CEN IES. 2011.
4. Billings ME. Circadian Dysrhythmias in the Intensive Care Unit. 2019;31(2015):393–402.
5. Tan X, van Egmond L, Partinen M, Lange T, Benedict C. A narrative review of interventions for improving sleep and reducing circadian disruption in medical inpatients. *Sleep Med*. 2019;59:42–50. doi:10.1016/j.sleep.2018.08.007
6. McKenna H, van der Horst GTJ, Reiss I, Martin D. Clinical chronobiology: A timely consideration in critical care medicine. *Crit Care*. 2018;22(1):1–11. doi:10.1186/s13054-018-2041-x
7. Giménez MC, Geerdinck LM, Versteylen M, et al. Patient room lighting influences on sleep, appraisal and mood in hospitalized people. *J Sleep Res*. 2017;26(2):236–246. doi:10.1111/jsr.12470
8. Bano M, Chiaromanni F, Corrias M, et al. The influence of environmental factors on sleep quality in hospitalized medical patients. *Front Neurol*. 2014;5(DEC):1–8. doi:10.3389/fneur.2014.00267
9. Gehlbach BK, Patel SB, Van Cauter E, Pohlman AS,



Hall JB, Zabner J. The effects of timed light exposure in critically ill patients: A randomized controlled pilot clinical trial. *Am J Respir Crit Care Med*. 2018;198(2):275-278. doi:10.1164/rccm.201801-0170LE

10. Taguchi T, Yano M, Kido Y. Influence of bright light therapy on postoperative patients: A pilot study. *Intensive Crit Care Nurs*. 2007;23(5):289-297. doi:10.1016/j.iccn.2007.04.004

11. Joarder AR, Price A. Impact of daylight illumination on reducing patient length of stay in hospital after coronary artery bypass graft surgery. *Light Res Technol*. 2013;45(4):435-449. doi:10.1177/1477153512455940

12. Choi JH, Beltran LO, Kim HS. Impacts of indoor daylight environments on patient average length of stay (ALOS) in a healthcare facility. *Build Environ*. 2012;50:65-75. doi:10.1016/j.buildenv.2011.10.010

13. Beauchemin KM, Hays P. Dying in the dark: Sunshine, gender and outcomes in myocardial infarction. *JR Soc Med*. 1998;91(7):352-354. doi:10.1177/014107689809100703

14. WHO Recommendations on Interventions to Improve Preterm Birth Outcomes November; 2015.

15. Rodríguez RG, Ph D, Pattini AE, Ph D. Neonatal intensive care unit lighting: update and recommendations. *Arch Argent Pediatr*. 2016;114(04):361-367. doi:10.5546/aap.2016.eng.361

16. Mirmiran M, Ariagno RL. <Schulze - Unknown - Enhancement of Mechanical Ventilation of Neonates by Computer Technology.pdf>. 2000;24(4):247-257. doi:10.1053/sper

17. Morag I, Ohlsson A. Cycled light in the intensive care unit for preterm and low birth weight infants. *Cochrane Database Syst Rev*. 2016;2016(8). doi:10.1002/14651858.CD006982.pub4

18. McKenna H, Reiss IKM. The case for a chronobiological approach to neonatal care. *Early Hum Dev*. 2018;126:1-5. doi:10.1016/j.earlhumdev.2018.08.012

19. Vásquez-Ruiz S, Maya-Barrios JA, Torres-Narváez P, et al. A light/dark cycle in the NICU accelerates body weight gain and shortens time to discharge in preterm infants. *Early Hum Dev*. 2014;90(9):535-540. doi:10.1016/j.earlhumdev.2014.04.015

20. Brandon DH, Silva SG, Park J, Malcolm W, Kamhawy H, Holditch-Davis D. Timing for the Introduction of Cycled Light for Extremely Preterm Infants: A Randomized Controlled Trial. *Res Nurs Heal*. 2017. doi:10.1002/nur.21797

21. Bhatti, Parveen; Mirick, Dana; Davis S. The Impact of Chronotype on Melatonin Levels Among Shift Workers. *Occup Environ Med*. 2014;71(3):195-200. doi:10.1136/oemed-2013-101730

22. Lowden A, Öztürk G, Reynolds A, Bjorvatn B. Working Time Society consensus statements: Evidence based interventions using light to improve circadian adaptation to working hours. *Ind Health*. 2019;57(2):213-227. doi:10.2486/indhealth.SW-9

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