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# Neonatal Intensive Care Unit (NICU) Lighting Recommendations

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## PROBLEM STATEMENT

Achieving adequate lighting in neonatal intensive care units is a major challenge. In addition to the usual considerations of visual performance, cost, energy and aesthetics, there are different biological needs of patients, healthcare providers and family members.

The communicational aspects of light, its role as a facilitator of the visual functioning of care providers, and its impacts on the newborn infant physiology and development were addressed to review the effects of light—natural and artificial—within neonatal care settings with a focus on infant development. The role of light in regulating the newborn infant circadian cycle in particular and the therapeutic use of light in general were also reviewed.

For each aspect, practical recommendations should be considered for a proper, well-lit environment in neonatal intensive care units.[1]

## INTRODUCTION

Continuous advancements in neonatology have increased the chances of survival for preterm and critically ill newborn infants. Although neonatal intensive care units (NICU) provide highly specialized medical care, they do not necessarily offer an ideal environment for the development of newborn infants.

There is a huge difference between the intrauterine environment and the NICU environment.[2] The former is an eco-niche that offers maternal protection, constant nutrient supply, stable temperature and chrono-biological cycles, while the latter is characterized by an inappropriate, non-contingent, non-reciprocal and painful stimulation patterns during a period of major structural and functional brain development.

This transition to extra uterine life imposes even greater demands, due to the physiological limitations of the patients and their restricted ability to adapt to the environment and reject unwanted stimuli. The physical environment (ie. light, temperature and sound) in the NICU is a critical issue that can affect the normal development of a newborn infant.[2] The interactive development theory indicates that the newborn baby actively responds to the environment looking for balance. These dynamics offer beneficial opportunities for preventive and therapeutic interventions.[3,4]

## LIGHTING ENVIRONMENT IN A NEONATAL INTENSIVE CARE UNIT

Both artificial and natural lighting play several roles in the NICU environment: they communicate and convey sensations, support the visual function of caregivers, affect the newborn infant's physiology and development, and regulate the circadian function.[5-8]

### Communicational Aspects of Lighting

A safe, family-centered NICU must be considered the newborn infant's "first home." It should have a comfortable atmosphere, supporting the physical and emotional needs of the young patients and their families. The intentional design of this interior environment should transform a highly technological and clinical environment into a positive and supportive healing space.[7, 9, 10]

Evidence suggests that natural light (NL) and a visual connection with nature deeply influence human health and welfare. In the clinical field, there are more studies dealing with the potential positive effects of lighting on health that have been conducted compared to the positive effects of natural landscapes seen from inside. In addition, the use of NL systems and strategies helps reduce power consumption and improves interior space quality of use.[11-15]

To maximize these benefits, NL contribution should be carefully planned as it can interfere with visual performance (ie. glaring, screen reflections, etc.), affect visual and thermal comfort, and have potential unwanted radiation (ie. infrared and ultraviolet).

### Recommendations:[1]

- Create points of interest, either by contrast or by color, emphasizing, desirable stimuli through lighting, such as photographs or artistic images.
- Create a flexible lighting system that is adjustable either individually or by areas within the NICU as to meet the varied needs of newborn infants and caregivers.
- Incorporate NL into infant care spaces, keeping bassinettes more than 36 inches away from windows.
- Provide external elements of solar control (ie. sunshades, eaves and louvers) at windows that are flexible to use and easy to clean and maintain.
- Use neutral individualized light sources of at least 2000 lux to examine the newborn infant or to perform specific procedures in short periods.
- Avoid reflections on screens by diffuse general lighting so as not to hinder the reading of important visual information, either on equipment monitors or during diagnostic procedures.
- Interior surfaces such as walls, floors and ceilings should have a matt finish so that the interior light is distributed diffusely to avoid glare.
- Sources of artificial lighting must have a CRI greater than 80 with optical reflectors having a natural finish to maintain the properties of color rendering.

## Light as Visual Function Support of Caregivers

Lighting level (measured in lux) in neonatal units has described a parabolic curve since the second half of the twentieth century. NICUs from the 80s were bright and well-lit, matching a technological burst and in highly sophisticated neonatal care.

Nowadays, there is a trend to use lower lighting levels. With the use of current monitoring systems, the need for direct observation has decreased, so it is not necessary to use intense light to monitor newborn infants. It is generally agreed that newborn infants are more stable and consume less energy in low light conditions, which are also necessary for procedures such as echocardiograms or trans illumination.[17]

Moreover, in a NICU, speed and accuracy are essential for task performance. Higher levels of lighting allow greater visual acuity and improve the signal—noise ratio for visual tasks and visual functions speed.[5]

A good perception of color is crucial for the clinical examination of newborn patients. The color rendering index (CRI) allows us to determine the color rendering properties of a light source. Taking as a standard the NL (CRI = 100), this index measures how "natural" colors are perceived when illuminated by an artificial light source.

### Recommendations:

- Examining the infant, the color of their skin and mucous membranes, and their perfusion anywhere in the room, with a range of general illumination of 10—600 lux.
- Use individualized light sources of at least 2000 lux to examine the newborn infant or to perform specific procedures in short periods avoiding the exposure of nearby patients.
- Avoid reflections on screens by diffusing general lighting so as not to hinder the reading of important visual information, either on monitoring a screen or during diagnostic procedures.
- Interior surfaces such as walls, floors and ceilings should be clear with a matt finish so that the interior light is distributed diffusely to avoid glare.
- Sources of artificial lighting must have a CRI greater than 80. Their optical reflectors must have a natural finish to maintain the properties of color rendering.

## Effects of Light on the Newborn Infant Physiology and Development

A newborn infant's visual system is not fully developed at birth, and over the last trimester of pregnancy, major developments of the nervous and visual systems occur, continuing their structural and functional maturation during childhood.[16] Lighting influences postnatal development of vision and visual processes and the maturation of the visual cortex, which is affected by premature visual experiences.[6, 17-19]

Factors that regulate the amount of light reaching infants eyes are biological: eyelid opening, transmission through them, pupil diameter (starting at 30-34 weeks old after birth) and transmission features of the ocular media. Until full-term gestational age, light is not necessary for visual development, and it does not seem appropriate to subject the preterm infant to intense light when this does not occur in utero.[1,20]

Evidence indicates that exposure to very bright light can harm the immature eye. High lighting levels have been associated with adverse clinical outcomes: less weight gain, behavioral and sleep disturbances, in addition to stress in very preterm or seriously ill patients[5, 17, 21, 22]

A sudden change in the amount of light also affects the newborn infant: Shogan and Schumann reported rapid oxygen saturation declines in preterm infants after a sudden increase in lighting. Preterm newborn infants are visually more vulnerable: they get tired easily, have very thin eyelids and their immaturity prevents them from closing their eyes consistently, so they have limited internal resources for protection from light.[23, 24]

Changes in ambient lighting include temporary effects: a reduced level of lighting produces an immediate and transient opening of the eyelids, followed by a significantly longer period when this dimmer illumination is maintained. It has been published that the effects of light reduction in the NICU include a better stability of the newborn infant, including respiratory stability, decreased heart rate and respiratory rate, normalized blood pressure and motor activity, and shorter time on ventilation and oxygen support.[25]

### Recommendations:[1]

- Limit visual stimulation that competes with auditory and tactile information prevailing in a NICU to avoid sensory interference during this stage of development.
- Whenever possible, avoid direct light to the newborn infant's eyes.
- Use progressive lighting to enable a gradual dark-to-light shift to reduce the stress produced in the newborn infant by a sudden change in ambient lighting.

## Light as a Regulator of the Circadian Cycle of the Newborn Infant

Rivkees[26] notes that, although fetus development takes place in the dark, this environment is rich in auditory, tactile and kinesthetic sensory stimulation. Keeping preterm patients in a continuously dark environment while in the NICU deprives them of the circadian stimuli they would have received during gestation.[27]

The fetal biological clock is an endogenous system that generates circadian rhythms in response to maternal signals (ie. activity, heart rate, cortisol, melatonin and body temperature), at least from the third quarter of gestation.[1] The light entering the retina is the main external regulator of the human circadian system.

In 1957, the American Academy of Pediatrics suggested introducing regular cycles of day-night lighting in the NICU.[28, 29] This is to preserve life and provide proper medical care in a uterus-like environment, thus continuing as much as possible, the experience that has been interrupted at an early stage.

Research supports the importance of circadian rhythms for the fetus and the relative lack of them in preterm infants.[26, 27, 29-31] Evidence indicates that between weeks 28 and 32 of gestation, cyclical lighting has positive clinical effects on the newborn infant, but there is little information on the effect of circadian rhythm on physiological functions, and the growth and development of the central nervous system. However, there is still no consensus on how to introduce circadian cycles with artificial lighting in practice and neither is there an implementation protocol regarding cycle length and maximum/minimum lighting levels.

### Recommendations:

- Implement a cyclic lighting schedule. During the day, between 100 and 200 lux, with some natural light. At night, artificial light lower than 50 lux, with a NL-like spectral distribution.
- Day / night lighting should be capable of increases up to 600 lux with independent control for separate lights.

## CONCLUSIONS

Getting proper lighting in a NICU is a major challenge. Apart from issues related to visual performance, cost, energy and aesthetics, the wide variety of biological needs of the patients, healthcare providers and family members must be addressed.

A safe and controlled lighting environment that fosters a newborn infant's development requires relatively low-tech and fractional economic investment, especially when compared to the NICU medical equipment, but yields high-performance interventions when considering the benefits to newborn infants described by the research.[1]

A growing body of knowledge has been developed around the positive and/or negative effects of environmental factors on newborn infants, grouped in a relatively recent disciplinary field: environmental neonatology. However, there is less availability of guidelines and recommendations for the practical implementation of such scientific knowledge.[1]

These recommendations are based on several sources (ie. empirical, technical and scientific) to describe the current state of the visual environment in a NICU. This collection of research is intended to provide guidelines to rationally define lighting in a NICU environment by taking into consideration the patients, family members and care providers' complex needs.

# REFERENCES


1. Roberto Rodriguez, PhD & Andrea Pattini, PhD. Neonatal intensive care unit lighting; update and recommendations. Arch Argent Pediatrics 2016; 114(4) 361-367
2. Pallas Alonso CR, Gutierrez Argul O. El ambiente en los cuidados intensivos neonatales. An Esp Pediatr 1997; 47(6):618-20.
3. Hunt KN. The NICU: Environmental Effects of the Neonatal Intensive Care Unit on Infants and Caregivers. Research Papers 2011. Paper 71. [Accessed on: January 12, 2016]. Available at: https://opensiuc.lib.siu.edu/cgi/viewcontent.cgi?article=1068&context=gs_rp.
4. Als H. A synactive model of neonatal behavioral organization: Framework for the assessment of neurobehavioral development in the premature infant and for support of infants and parents in the neonatal intensive care environment. Phys Ocup Ther Pediatr 1986;6(3-4):3-53.
5. Bullough J, Rea MS. Lighting for neonatal intensive care units: Some critical information for design. Light Res Technol 1996;28(4):189-98.
6. Rea M. Lighting for caregivers in the neonatal intensive care unit. Clin Prinatol 2004;31(2):229-42
7. Rizzo P, Rea M, White R. Lighting for today's neonatal intensive care unit. Newborn Infant Nurs Rev 2010;10(2):107-13.
8. Lai TT, Bearer CF. Iatrogenic environmental hazards in the neonatal intensive care unit. Clin Perinatol 2008;35(1):163-81.
9. White RD. Lighting in the neonatal intensive care unit: Practical applications of scientific principles. Clin Perinatol 2004;31(2):323-30.14.
10. Beute F, deKort YA. Salutogenic effects of the environment: Review of health protective effects of nature and daylight. Appl Psychol Health Well Being 2014;6(1):67-95.
11. Boyce P, Hunter C, Howlett O. The benefits of Daylight through Windows. Troy, New York: Rensselaer Polytechnic Institute, 2003. [Accessed on: March 01, 2016]. Available at: http://thedaylightsite.com/wp-content/uploads/papers/DaylightBenefits.pdf.
12. Leslie R. Capturing the daylight dividend in buildings: Why and how? Buil Environ 2003;38(2):381-5.
13. Joseph A. The Impact of Light on Outcomes in Healthcare Settings. Issue Paper 2, 2006. Concord, CA: The Center for Health Design. [Accessed on: January 12, 2016]. Available at: http://www.healthdesign.org/sites/default/files/C HD_Issue_Paper2.pdf.
14. Alzoubi H, Al-Rqaibat S, Bataineh RF. Pre-versus post-occupancy evaluation of daylight quality in hospitals. Buil Environ 2010;45(12):2652-65.
15. Iyendo TO, Alibaba HZ. Enhancing the Hospital Healing Environment through Art and Day-lighting for User's Therapeutic Process. IJAC 2014;3(9):101-19.
16. Birch EE, O'Connor AR. Preterm birth and visual development. Semin Neonatol 2001;6(6):487-97.
17. White RD. Recommended standards for the newborn ICU. J Perinatol 2007;27(Suppl 2):S4-19.
18. Logvinov SV, Potapov AV, Varakuta EY, Drobatulina DA. Dynamics of structural changes in the retina during long-term exposure to bright light. Bull Exp Biol Med 2003;136(4):411-4.
19. Szczepa ski M, Kamianowska M. The illumination intensity in the neonatal intensive care unit. Arch Perinat Med 2008;14(2):47-50.
20. UK Department of Health. Guidance for the design of hospital neonatal units including special care, family spaces and specialist clinical rooms. Health Building Note 03.09: Neonatal units. 2013. [Accessed on: March 01, 2016]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147879/HBN_09-03_Final.pdf.
21. Pickler RH, McGrath JM, Reyna BA, Tubbs-Cooley HL, et al. Effects of the neonatal intensive care unit environment on preterm infant oral feeding. Res Rep Neonatol 2013;2013(3):15-20.
22. Peng N, Bachman H, Jenkins R, Chen CH, Et al. Relationships between environmental stressors and stress bio behavioral responses of preterm infants in NICU. J Perinat Neonatal Nurs 2009;23(4):363-71.
23. Robinson J, Fielder AR. Pupillary diameter and reaction to light in preterm neonates. Arch Dis Child 1990;65(1 Spec No):35-8.
24. Shogan MG, Schumann LL. The effect of environmental lighting on the oxygen saturation of preterm infants in the NICU. Neonatal Netw 1993;12(5):7-13.
25. Fielder AR, Moseley MJ. Environmental Light and the Preterm Infant. Semin Perinatol 2000;24(4):291-8.