Introduction

The typical NICU has progressed from a moderately lit special care area alongside the main nursery in the 1960’s; to a brightly-lit, large room with many babies in the 1980’s; to smaller, more dimly-lit modules, pods, or individual rooms as the new millennium arrived. The move to brightly-lit, large rooms was largely driven by a need to keep a large number of critically-ill infants under constant observation, and by an assumption that such an environment was well-tolerated by infants. As it became clear that this environment had potential hazards to the developing premature infant, and monitoring techniques improved to the point that constant observation was no longer necessary for most babies, the move back to smaller, quieter, more dimly-lit rooms began. We are still in an evolutionary phase of NICU design in this regard because the optimal lighting environment has not yet been defined for the premature infant.

Somewhat lost in the concern about exposure of babies to excessive lighting levels was the recognition that caregivers were affected by changes in the ambient lighting level of the NICU as well, especially at night. While caregivers are generally willing to make any compromise necessary to assure the well being of the babies they care for, some very-dim-lighting situations may actually be disadvantageous for both babies and their caregivers, having been based more on theory than on evidence. Perhaps the most important body of data which pertains to this question is the recent work examining the effect of diurnal lighting cycles on both babies and their caregivers. A brief summary of much of this data is included in the FAQs below, and we welcome your questions and comments on other facets of this issue!
What is the evidence that diurnal cycling of light is necessary or helpful for babies?

The first study to look at the effect of a diurnal lighting cycle on premature infants was done by Mann and colleagues.\(^1\) In this study, both light and noise were reduced at night for convalescing premature infants, who then grew and slept better after discharge than their counterparts who were cared for in a nursery where bright lighting and noise were not reduced at night.

Our group also looked at this question\(^2\) with some differences in the study protocol. We looked at intensive care babies admitted into the control or experimental environment immediately after birth, and manipulated only the lighting environment, with sound levels the same in both rooms. We showed that weight gain, length of stay, and scores on the Brazelton motor cluster were improved at the time of discharge for the group cared for in the room where lighting levels were reduced at night.

This data has subsequently been replicated by additional groups, confirming that diurnal cycling of light is advantageous to premature infants compared to a continuously bright environment. Nevertheless, it is unclear that diurnal cycling itself produces a direct beneficial effect for the baby. A number of alternative explanations are available; for example, if lowering the lighting level at any time enhances infant sleep in an ICU setting and therefore subsequent growth and development, results similar to these would be obtained independent of any particular diurnal cycling. Another potential confounding effect could be the response of the nursing staff to the lowered lighting level – did they interfere with infant sleep less, or do their work better in some way, since they were exposed to the same lighting environment the babies received?

What we can conclude so far, then, is that exposing premature infants to continuous bright lighting in the NICU is inappropriate; recommendations to do so which were prevalent in the 1980s have long since been revised. While the current practice in many nurseries is to keep babies in continuous near-darkness, this also deprives them of any diurnal cycling, and should be carefully evaluated before routine adoption of this practice.

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Why isn't continuous darkness, such as the fetus would ordinarily experience in utero, the optimal lighting environment for premature infants?

Continuous near-darkness could be the optimal environment for very immature babies for several reasons:

1) It is the environment most like what the baby’s eyes would be exposed to in utero.

2) The eyelids of very small babies are very thin, and many babies become so easily fatigued that they cannot close their eyes consistently until they approach 32 weeks, so they are defenseless against bright light in their eyes.

3) Limiting visual stimulation during a period when other competing sensory information is being presented to the baby (in the form of sound and touch particularly) may avoid sensory interference during crucial developmental stages.¹

On the other hand, we know that the fetus is ordinarily exposed to diurnal cycles of a number of maternal hormones and activity, which could act as a zeitgeber ("time-giver") to synchronize its own developing diurnal cycles of hormones and activities. When the maternal zeitgeber is removed, it may be advantageous to the premature infant to have an external zeitgeber available. For the older infant, child, and adult, that zeitgeber is usually light, and recent work by Rivkees’ group² suggests that the fetus is probably sensitive to the zeitgeber function of light by 32 weeks’ gestation.

It may be, then, that continuous near-darkness is the best environment for very premature infants, whereas those who are approaching 32 weeks’ gestation would benefit from a diurnally cycled lighting environment. Hopefully, we will have data in the next few years that gives us better insight into this question.


What is the optimal lighting environment for night shift caregivers, for their own well-being, and for optimizing their job performance?

A simple answer to this question would have to assume that night-shift caregivers are a homogenous group, which is clearly not the case. Lowering the lighting levels at night affects people in many different ways – it causes some to become drowsy, and others to become calm. It causes eye strain for some, and relieves it for others. It may have a different effect on those who are used to working at night than on those who aren’t. Our studies and others¹ have demonstrated that exposing night-shift workers to a bright light source for at least part of their shift is advantageous in terms of moderating the body temperature decline that normally happens at night, leading to a better sense of well-being, and perhaps better performance. This effect is almost surely mediated by melatonin, but interfering with the normal diurnal melatonin cycle could have other, potentially harmful effects.

Our current suggestion, therefore, is that the ambient lighting level in the NICU be sufficiently bright so that nurses can do their work comfortably and accurately. Babies can be protected from lighting levels that might be optimal for nurses but too bright for them to sleep by covering their eyes or incubators. Nurses should also have access to a bright light source (“light shower”) of at least 2500 lux (~250 footcandles) in their lounge or work area for at least 15 minutes at the start and middle of their shift, if they find it useful.

¹ Figuero MG et al. The effects of bright light on day and night shift nurses’ performance and well-being in the NICU. Neonatal Intensive Care 2001;14:29-32.
Glossary

**Diurnal lighting cycles**
24-hour, day-night cycles with brighter lighting for a portion of the 24-hour period (usually at least 12 hours), and dimmer lighting for the remainder of the 24-hour period

**Zeitgeber**
A stimulus that "sets" the circadian clock
References

Figuero MG et al. The effects of bright light on day and night shift nurses' performance and well-being in the NICU. Neonatal Intensive Care 2001;14:29-32.


The following handouts contain handouts from The 2002 Physical and Developmental Environment of the High-Risk Infant Conference and a preview of the 2003 conference:

www.hsc.usf.edu/publichealth/conted/ie02handouts.html
www.hsc.usf.edu/publichealth/conted/highrisk03.html
I'll get this started with an observation and question. In informal surveys, it appears that most NICUs are keeping their babies in continuous dim lighting most of the time. Has the new report from Duke in the *Journal of Pediatrics* affected anyone's practice pattern in this regard?

I'm obviously not a neonatologist but in studies about lighting in the NICU that we have done at Rensselaer Polytechnic Institute (listed below in case anyone wants to read them), two things seem increasingly clear:

- infants and staff have very different needs, with infants probably benefitting from cycled light and staff benefitting from some exposure to high light levels at night
- staff are very, very motivated to providing the best possible environment for the infants - in one NICU we looked at, nurses would delamp fixtures to prevent light levels from getting too high at night!

The recent study from Duke reinforces what Mann et al. found in 1986 and what Miller et al. found in 1995, that cycled lighting seems to be 'best.'

Our work in this area is detailed in the following articles:

- Figueiro MG et al. The effects of bright light on day and night shift nurses' performance and well-being in the NICU. *Neonatal Intensive Care* 2001; 14: 29-32.
Thanks, John. Do you have any updates for us on the electromagnetic and other non-visual energy issues in the NICU that caregivers or designers should be aware of?

Sorry for the delays in responding to your followup post! I'm not aware of other work on magnetic fields in the NICU specifically, other than a 1994 article we cited in our 1996 Bioelectromagnetics paper, and another article that came out around 1996, both listed below.

I am also aware of a recent paper on magnetic fields in general and breast cancer risk in women, which concluded that there did not seem to be an increased risk of breast cancer associated with higher levels of magnetic field exposure. But its applicability to the NICU environment either for caregivers or infants is unknown.

As for other aspects, we reviewed the so-called 'blue light hazard' and it seems that at least as far as general fluorescent lighting is concerned, it is probably not an issue in terms of visual tissue damage. Of course we are seeing mounting evidence that lighting is important in managing circadian rhythms, and this factor is still the strongest known 'zeitgeiber' to the circadian system - much more so than electromagnetic fields or other variables.


A recent study on infants cared for in continuous dim lighting versus a day-night cycle:


Another study on this topic is expected to be published by Dr. Rivkees' group soon, with somewhat different outcomes, so the issue remains in need of further study!
Reply to: "Lighting Needs for Infants and Staff"