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JOHNS HOPKINS NURSING
The Institute for Johns Hopkins Nursing

eNeonatal Review

In this issue...Volume 2, Number 9

The physical environment of the NICU can be the source of considerable stress to the babies, families, and caregivers who spend a substantial and crucial portion of their lives there. While most of our current NICUs were designed to provide high levels of infection control, technology, and medical expertise, little consideration was given to the effects of lighting, noise, and family access on either the patients or their caregivers. This neglect of the physical environment is understandable since, until recently, it was believed that the immature infant had little ability to respond to external stimuli. Now, however, an extensive literature is developing that documents what in retrospect seems intuitive Ð that the physical environment does indeed play an important role in how infants grow and develop and in how their caregivers feel and function.

This evidence has developed along several lines. The fetal environment, once thought to be dark, silent, and featureless, has now been found to be rich with stimuli for the developing fetal sensory organs and cortex. In the NICU, both specific research (probing the effect of each of the sensory inputs on the preterm infant), and comprehensive efforts to control environmental stimuli (e.g., NIDCAP) have helped us better understand how complex and interrelated the sensory development of the fetus and preterm infant is. Likewise, for caregivers, the environment of the workplace has been found to have both physical as well as emotional dimensions. Much of this research, however, has been published in the psychology, anthropology, architecture, and engineering literature that is rarely read by medical professionals. In addition, caregiver needs have routinely been sacrificed in favor of the perceived needs of their patients.

Today, we are in the early stages of an era of NICU design in which attention to the physical needs of babies, their families, and their caregivers is on an equal footing with the technological aspects. Because the field is still young and there are many holes in our knowledge base, however, the potential to make design errors that may be difficult to correct during

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Recommend to a Colleague

Post-test

Learning Objectives

The Johns Hopkins University School of Medicine and The Institute for Johns Hopkins Nursing take responsibility for the content, quality, and scientific integrity of this CE activity.

At the conclusion of this activity, participants should be able to:

- Describe factors pertinent to choosing appropriate night-time ambient lighting conditions for babies and caregivers;
- Identify several considerations which have led to the increasing popularity of private rooms for NICU babies;
- Describe aspects of the physical environment of the NICU that may have an adverse impact on caregivers who work there.

Program Information

the stakes are high for design teams, as well as for those who are retrofitting existing units or adjusting care practices to reflect new scientific evidence on the impact of the physical environment.

In this month's issue, to help identify some of the more important factors to consider when updating the physical environment of a NICU, we look at the current research affecting the unit's three key constituencies — babies, families, and caregivers.

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Guest Editors of the Month

Commentary & Reviews
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Guest Faculty Disclosure
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Faculty Disclosure: No relationship with commercial supporters.

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COMMENTARY

It might seem that the effects of the physical environment on an individual could be studied by exploring their reactions in each of the five sensory domains, but the reality is much more complex. In adults, there is considerable interplay between the senses: familiar examples include the difficulty one experiences with precise visual tasks in a noisy environment, and the complementary effects of presenting learning information in multiple modes such as auditory and visual. In the preterm infant, sensory interplay is even more complicated, since crucial areas of the sensory organs and cortex develop at different and highly programmed stages. Nor is each of the senses one-dimensional: for example, light can influence both the visual and circadian neurons in the retina, and touch requires consideration of not only touch stimuli per se, but movement and pain as well. Finally, a reductionist approach may undervalue the largely intangible dimension described as caring, love, or "TLC" (tender loving care) that is an element of many intervention programs, whether by parents or by medical staff.

Even a cursory review of the current data reveals the discrepancy between the needs of infants and their caregivers. Babies need a dimly lit room at night, but their caregivers may become drowsy, cold, and error-prone. Noise is stressful for babies and may interfere with their ability to learn their mother's voice, but it is also an essential by-product of monitor alarms and nurse-to-nurse communication. These considerations, among several others, have engendered a growing interest in providing care for neonates in private rooms, where the physical environment can be individualized to each baby's needs, and which allows better separation of the patient care area from the nursing station and other medical support areas. Until recently, a private or single-family room NICU design was not feasible, but advances in wireless monitor alarms and communication systems have facilitated a rapid growth in the number of such NICUs being built.

It is likely, though, that even when an NICU is designed with the best interests of babies, families, and caregivers in mind, changes will be necessary within a few years of occupancy, as the science of the sensory environment advances rapidly, and early understandings and assumptions give way to new and unexpected conclusions - even more so when one also anticipates changes in the technological features of the next-generation NICU such as electronic medical records and increasing integration and miniaturization of medical devices. This reality means that a key element of any NICU design feature must be flexibility. The ultimate test of a well-designed NICU is not how "state-of-the-art" it is on the day of occupancy, but how state-of-the-art it still manages to be 10 years later.

Even though only a minority of hospitals will have the privilege of building a new NICU in the near future, most of the recommendations for the optimal sensory environment in the NICU derived from current research can be implemented to at least some extent in an existing NICU. Appropriate lighting can be adjusted with the help of incubator covers, for example, and there are a number of physical and procedural changes that can reduce noise levels and facilitate parental interaction with their babies.

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CIRCADIAN RHYTHMICITY IN THE PRETERM INFANT

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Examining the question: Is it affected by the environment?

The fetus has well-developed circadian rhythms of activity, heart rate, and several hormones by the third trimester, regulated by maternal signals. After delivery, in the absence of these maternal signals, day-night changes in the luminous environment of the NICU may be important to preterm neonates as a potential regulator *(zeitgeber)* of circadian rhythms. Studies performed in the 1980s demonstrated improved outcomes for infants cared for in a day/night cycled lighting environment compared to continuous bright lighting. As a result of extrapolation of these findings, an increased interest in developmental care, widespread acceptance of the intrauterine environment as the "gold standard" for the physical environment of the preterm infant, and accumulating evidence that these infants did not require visual stimulation until near term, many nurseries in the 1990s adopted continuous dim lighting, even in the absence of clinical evidence that depriving patients of a *zeitgeber* was advantageous or safe. This deficiency has been addressed by three recent randomized controlled trials.

The study by Brandon et al evaluated babies <31 weeks gestation who were randomly assigned to receive cycled lighting from birth, or continuous dim lighting from birth, then cycled lighting introduced at either 32 weeks post-conceptional age (PCA) or at 36 weeks PCA. Increased weight gain was demonstrated in those infants who were kept in a cycled lighting environment from either birth or 32 weeks PCA. The study by Mirmiran et al evaluated babies who were cared for in continuous dim lighting while in intensive care, then randomly assigned to either cycled lighting or continuous dim lighting when they were transferred to an intermediate care room. Continuous recordings of rectal temperature and sleep patterns were not different between the two groups at 36 weeks PCA, or at 1 and 3 months corrected age at home. The authors concluded that circadian rhythms developed endogenously without an effect of the lighting condition of the NICU. The study by Rivkees et al also assigned infants to either cycled or continuous dim lighting in the latter stages of their hospitalization, after being in a continuously dimly lit environment during the intensive care portion of their admission. Activity plots, or actigrams, were used to assess circadian rhythmicity, which did not differ between the groups at discharge, but did show an earlier appearance of circadian rhythms in the cycled lighting group at home, a difference that remained at follow-up at approximately one month after discharge.

It is difficult, given the varying study designs, outcome measures, follow-up periods, and results to determine if day-night lighting is preferable to continuous dim light in patient care rooms of the NICU, although it may certainly be concluded that it is not inferior. It is important to remember that the effect of lighting as a *zeitgeber* in these trials may have been blunted if other potential day-night cues in the NICU — such as caregiving interventions, temperature, and feedings — were constant throughout the 24-hour day rather than cycled. The report from 1993 by Illnerova et al showed that melatonin was present in high levels in breast milk expressed at night but absent in milk expressed during the daytime, raising the possibility that the preterm infant might need and respond to multiple *zeitgebers*, as has been postulated for the fetus. While awaiting further data, it seems appropriate to provide only dim lighting (preferably less than 100 lux) at night for babies, shielding their eyes when bright room or procedure lighting is needed, with moderate levels (300 to 500 lux) of light in the daytime. It may also be worthwhile to consider feeding breast milk at the approximate time that it was expressed, and to minimize nighttime activities done in some units such as labwork, routine X-rays, and weighing so as to further facilitate development of the circadian rhythms found in the fetus and in older infants.

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SINGLE FAMILY ROOMS — NICE OR NECESSARY?

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Data supporting the advantages of individualized care

The impetus to provide private rooms for high-risk preterm infants comes from several directions. Individualized care is difficult to provide in a large open room, as is protection from light or noise from surrounding bedsides. Private rooms are essential for true family privacy — which may facilitate skin-to-skin care, breastfeeding, intimate interaction with the baby, and confidential discussions with medical staff — and were in the process of becoming a patient right throughout the hospital even before HIPAA regulations were promulgated. Infection control considerations, which prompted the first all-private room design in Brest, France in the 1980s, remain an important justification for private rooms, both for control of hospital-acquired and community-borne infections, as demonstrated by Ng et all during the recent SARS outbreak. With NICUs everywhere experiencing the dual impacts of globalization and outbreaks of resistant organisms, providing at least several private rooms in any new NICU design has become a desirable goal.

The study by Als et al is the latest in a series of reports that have documented improved outcomes of infants treated with NIDCAP, an individualized developmental care program that incorporates control of a number of elements of the physical environment, particularly lighting, sound, and parental access. High-risk preterm infants randomly assigned to receive NIDCAP intervention during the first two weeks of life subsequently were found to have more mature neurological status, both by exam and by magnetic resonance imaging, than their control counterparts. The studies from Feldman's group, again part of a large body of work on this topic, showed that skin-to-skin (kangaroo) care caused both accelerated neurological maturation and improved parental interaction when compared to matched controls treated in incubators.

It is becoming increasingly evident that private rooms for neonates can be both desirable and safe, but important design considerations remain that are only now being subjected to scientific evaluation. Chief among these is the layout of private rooms in relation to nursing stations, such that nurses can keep in touch with both their patients and their colleagues. In an open room design, especially with beds close together, these two nursing functions can be easily accomplished, but may conflict with allowing sufficient room at the bedside for families and with meeting current AAP and building code recommendations. Central nursing stations with beds or rooms arranged around a perimeter allow nurses to collaborate easily, but must include a large enough cluster of beds to accommodate the

case load of several nurses in order to avoid isolation and staffing difficulties. Satellite nursing stations keep nurses closer to their patients but separate them from one another and may limit nursing assignment options. With all models, extensive use of new wireless technology and careful design planning is essential to enable nurses to receive vital data from their patientsÕ monitors and support equipment, as well as to communicate with one another.

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CAN WE HELP BABIES BY PROVIDING A BETTER ENVIRONMENT FOR THEIR CAREGIVERS?

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Data on balancing neonate patient and caregiver needs.

Many ideas to make the work environment safe, productive, and pleasant have been introduced and studied recently, though most of this research has been performed outside of the hospital setting. Spurred by the increased focus on medical errors and the nursing shortage, however, these concepts are increasingly being introduced into hospital care. Access to daylight, background music, and aromatherapy are some examples of this "human factors" research we will not have room to discuss here.

Environmental noise creates stress (Morrison, et al) and interferes with auditory processing and work performance, a problem more important as the workforce ages (Tun, et al). The simple intervention of adding acoustical ceiling tile to an adult intensive coronary unit improved speech intelligibility and subjective reports of stress by staff (Blomkvist et al). In

the same trial, as reported in the paper presented by Hagerman et al, patients showed improved cardiovascular status, reduced rehospitalization rates, and rated staff attitude as improved compared to the period when sound-reflective ceiling tiles were in place.

Astronauts, air-traffic controllers, nuclear power plant operators, long-haul truckers, and night-shift nurses all suffer from the effects of fighting their natural urge to sleep at night. Unfortunately, the latter group has received much less research attention than they deserve, given the larger number of individuals at risk and the common practice of intermittent night shift work that prevents re-orientation of the circadian cycle. Crowley et al attempted to entrain volunteers to a night-work schedule using a 5-day intervention of bright light at night, sunglasses worn outside during the day, a fixed dark daytime sleep schedule, and administration of melatonin. Those individuals who achieved partial or complete entrainment to a night-work schedule showed improved performance with less sleepiness compared to those individuals who did not entrain, even though daytime sleep duration did not differ between the groups. Lowden et al showed a similar benefit with only bright light exposure in night-shift factory workers, an effect we have also been able to demonstrate with nurses in our NICU at Memorial Hospital of South Bend. This intervention is not without potential risk, however; Davis et al, using a case-control methodology, demonstrated an increased risk of breast cancer in night-shift workers with a dose-response relationship of increasing risk for those who worked more hours per week at night, and for those with more years of night-shift work.

Just as reducing stressors in the physical environment in babies is intuitively reasonable and now documented to improve outcomes, so reducing environmental stress in their caregivers may also lead to better patient outcomes. The challenge is to find a balance between those conditions which nurses find desirable (e.g., appropriate lighting, background music and conversation) and those that are beneficial to babies (e.g., dim light at night, minimal background noise to promote sleep and recognition of parental voices). Separating nursing work areas from the patient beds as much as possible and designing areas with the unique needs of each constituency in mind are key design principles that must be taken into consideration to provide the best physical environment for babies and their caregivers.

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Contact your state licensing board to confirm that AMA PRA category 1 credits are accepted toward fulfillment of RT requirements.

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- Dr. Nogee has indicated a financial relationship of grant/research support with Forest Laboratories and has received an honorarium from Forest Laboratories.
- Dr. Lawson has indicated a financial relationship of grant/research support from the NIH. He also receives financial/material support from Nature Publishing Group as the Editor of the Journal of Perinatology.

All other faculty have indicated that they have not received financial support for consultation, research, or evaluation, nor have financial interests relevant to this e-Newsletter.

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