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The Effects of Cycled Versus Noncycled Lighting on Growth and Development in Preterm Infants

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Little is known about the effects of ambient lighting on infant growth and development. Although some studies suggest that cycled lighting is beneficial to infants in the neonatal intensive care unit (NICU), research has been needed to examine the long-term effects of lighting on infants as well as the impact of lighting on NICU staff behavior. In this study, 41 preterm infants in structurally identical critical care units were provided either cycled or noncycled lighting during a lengthy hospital stay. The study examined the relationship of lighting, in conjunction with infant birth status (birth weight, gestational age, 5-min Apgar), to multiple aspects of infant development, and staff behavior. Compared to infants in the noncycled lighting condition, infants assigned to the cycled lighting condition had a greater rate of weight gain, were able to be fed orally sooner, spent fewer days on the ventilator and on phototherapy, and displayed enhanced motor coordination. Thus, infants who were exposed to diurnally cycled lighting while in intensive care experienced both physical and behavioral developmental benefits. Findings emphasize the critical effects that the newborn ICU environment can have on the development of premature infants.

environmental risk lighting low birth weight neonatal prematurity

During the past 2 decades, there has been increasing concern about the quality of the physical and social environments to which preterm infants are exposed in neonatal intensive care units (NICU; Blackburn, 1982; Gottfried, 1985; Graven et al., 1992; High & Gorski, 1985; Kellman, 1980; Lawson, Daum, & Turkewitz, 1977; Linn, Horowitz, & Fox, 1985; Wolke, 1987). Increasingly, research suggests that the social and physical hazards associated with medical care, such as inappropriately applied medical interventions, electromagnetic hazards, noise levels, and intense continuous lighting, are all potential environmental stressors which can negatively affect infant health and development (Gaiter, 1985; Kellman, 1980; Peabody & Lewis, 1985). Critically ill preterm infants, because of their more fragile biological status, may be especially susceptible to these environmental stressors.

A variety of research has raised particularly serious concerns about the impact of general lighting conditions in hospitals and other settings (Baker, 1984; Gottfried, 1985; Gottfried, Wallace-Lande, Sherman-Brown, King, & Coen, 1981; Kellman, 1980; Lawson et al., 1977; Wolke, 1987). Continuous bright lighting has been found to be linked to numerous problems in both animals and adult humans, including retinal pathology, disruption of circadian rhythms, reduced melatonin secretion, insomnia, fatigue, affective disorders, and performance problems (Glass et al., 1985; Lewy, Wehr, Goodwin, Newsome, & Markey, 1980; Marshall, 1979; Messner, Maisels, & Leure-DuPree, 1978; Wurtman, Baum, & Potts, 1985). In contrast, cyclical lighting has been postulated to be a more appropriate type of sensory stimulation, preventing many of the prob-

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lems associated with continuous lighting (Blackburn & Patterson, 1991; Grauer, 1989; Mirmiran & Kok, 1991).

Although the effect of lighting cycles on adults has been extensively studied, little is known about how lighting cycles affect infant development. Research suggests that diurnal variations in lighting in the NICU environment establish a biological rhythmicity critical for normal growth and development (Lawson et al., 1977). Grauer (1989), studying the influence of constant and intermittent light on newborn infants, found intermittent lighting to increase sleep states in infants and decrease cortisol levels, an indicator of the general stress state. Shiroiwa et al. (1986) similarly found that preterm infants, when blindfolded, displayed lower activity levels and more stable respiration rates. Moseley, Thompson, Levene, and Fielder (1988) found that increased levels of illumination reduced the time preterm infants spend with their eyelids open.

Despite the fact that thousands of preterm infants are treated in either cycled or noncycled lighting environments, only one study has systematically investigated the impact of continuous versus cycled lighting on preterm infant development in a NICU setting for a prolonged period. Mann, Haddow, Stokes, Goodley, and Rutter (1986) compared the effects on healthy preterm infants of a day–night nursery, in which there were nighttime reductions in both light and noise, with a nursery in which there was no diurnal variation in light and noise. The infants in the day–night nursery were found to sleep more, to spend less time feeding, and to gain more weight than their counterparts in the continuous lighting group. This latter effect was not noted at the time of discharge but became apparent at the expected date of delivery and more pronounced at subsequent follow-up visits. The authors also noted that preterm infants' eyelid opening increased slightly under conditions of reduced illumination.

The study conducted by Mann and his colleagues (1986) highlights the potential benefits of a cyclically lighted environment and raises questions concerning the biological and behavioral costs to stable, healthy preterm infants who must cope with a continuously lit environment. However, definitive conclusions about the specific effects of lighting cycles in this study were impossible due to the simultaneous manipulation of lighting and noise levels. The study was also limited by the fact that individual differences in the infants' response to the experimental conditions were not systematically examined. Moreover, critically ill infants were not included in the sample. Finally, the study did not evaluate the relationship of lighting to staff behavior or examine whether lighting effects on infants may have been mediated by changes in staff behavior. Thus, although an increasing number of newborn intensive care facilities have introduced cycled lighting arrangements due to the concerns about continuous lighting, empirical support for the advisability of this practice is still sparse (Frank, Maurer, & Shepherd, 1991; Sheridan, 1983).

In contrast to previous research, this study examined the effects of cycled versus noncycled lighting on preterm infant health and development over a longer time span. Multiple aspects of infant development were evaluated in a repeated fashion to conduct a more precise investigation of lighting and infant relationships. A critical assumption underlying this study is that lighting effects on development cannot be fully understood without considering the initial physical status of the infants. For this reason, infants differing widely in their birth status were studied to evaluate whether certain infants are more vulnerable to the deleterious effects of lighting. Finally, in contrast to previous studies, this study also attempted to manipulate and monitor more precisely the lighting intervention.

The following specific questions and hypotheses were addressed. How does cycled versus noncycled lighting affect the growth and medical status of preterm infants in the newborn ICU? To what extent are such lighting effects moderated by (i.e., interact with) the biological status of the infant at birth? It was hypothesized that infants exposed to cycled lighting, in contrast to those exposed to noncycled lighting, would display enhanced growth. Moreover, it was hypothesized that the effects of the lighting condition would interact with the infants' initial birth status, such that the lower the birth status (birth weight and gestational age) of infants in a noncycled lighting condition, the greater the risk for delayed development compared to similar-status infants in the cycled lighting condition. In addition, questions concerning the effects of lighting condition on the amount and type of care delivered by the staff as well as whether lighting effects on infants were mediated by staff behavior were examined.

METHOD

Subjects

The infant sample consisted of 41 preterm infants. Inclusion criteria for this study required infants to weigh less than 2500 gms at birth, to be less than 37 weeks gestational age, and to be free of major congenital malformations. Infants were assigned to either the cycled lighting condition (n = 20) or the noncycled lighting condition (n = 21), subject to the availability of space and staff. Given the limitations stemming from the need to maintain efficient operation of the unit, this was felt to be the closest procedure possible to true randomization. Although no systematic biases appeared to be operating under this assignment procedure, all analyses controlled for birth status, specifically, birth weight, gestational age, and 5-min Apgar. At birth, infants in the two lighting conditions were not significantly different in either their individual or social-familial characteristics, with the exception of 5-min Apgar scores (see Table 1). The cultural and racial breakdown of families of the infants was as follows: 86.5% Caucasian and 13.5% African American. Families were primarily from lower to lower-middle socioeconomic levels (Hollingshead scale, Department of Sociology, Yale University, New Haven, CT). Nurses, 84 females and 1 male (N = 85), were also observed during the study. The nursing staff had a mean age of 31.5 years, with an average of 6.84 years experience in the field of neonatal intensive care. The overall nurse-to-infant ratio was 1:2. Only nurses and the infants from whom or for whom informed consent was obtained were included in the study.

TABLE 1
Individual and Social-Familial Characteristics of Infants in Cycled and Noncycled Lighting Conditions

	Cycled Condition (n = 20) SD	Noncycled Condition (n = 21) SD
Birth Weight	1151 ± (360)	1049 ± (330)
Gestational Age	28.0 ± (2.2)	28.0 ± (2.1)
Apgar (1 min)	6.0 ± (2.2)	5.0 ± (3.0)
Apgar (5 min)	8.0 ± (1.7)	7.0 ± (2.3)*
Maternal Education	12.0 ± (2.1)	13.0 ± (2.0)
Maternal Age	23.0 ± (5.2)	26.0 ± (5.6)

*$p < .05$.

Setting

A Level 3 NICU in a middle-sized, mid-western, community hospital served as the site for this investigation. The study was conducted over a 2-year period. The lighting manipulation was initiated upon first moving into the NICU several years before beginning this study, thus minimizing the possible effects of staff bias regarding the lighting condition on infant care. The NICU, which was specifically designed for research as well as clinical purposes, had an average census of 25 infants. It was comprised of two symmetrical intensive care rooms and an intermediate/continuing care room. The interventions took place in the two intensive care rooms. The two rooms, each 28 ft by 40 ft (8.53 m × 12.20 m), had a 10-bed capacity. Natural light was admitted into each room by 14-in. (35.56-cm) tall windows running the entire length of the south wall, at approximately a 6-ft (1.83-m) height, and by one 3-ft by 8-ft (0.91-m × 2.44-m) clerestory skylight that faced north. Illuminating the center of both rooms were two banks of indirect, cool white fluorescent lights over the nurses' charting area. There was a third bank of direct fluorescent lights directly over the patient care perimeter. The bulbs were 4 ft (1.22 m) in length, each emitting 40 watts. No bed was farther than 25 ft (7.62 m) from a window. Infants were shielded from direct sunlight and protected from radiation heat loss by a monitor shelf which separated the windows from the infants. Each bed was also equipped with a high-intensity, focused quartz incandescent spotlight which was used for certain medical procedures. Controlled by a rheostat at the bedside, it provided from 150 to 200 foot-candles of light. These lights provided no measurable increase in illumination at the adjacent bedsides.

Lighting Procedure Design

Throughout the intervention, one of these rooms received noncycled (continuous) illumination, and the other received a cycled (day/night) lighting pattern. Upon discharge from one of the two intensive care rooms, each infant received cycled lighting in the continuing care room. Lighting in critical care rooms, measured with a Minolta Illuminance Meter, was assessed both from vertical and horizontal positions. The lighting manipulation occurred in three stages; from 7 a.m. until dusk, both the cycled and noncycled lighting intensive care rooms had the same amount of illumination (two banks of indirect artificial lighting plus natural lighting); from 6 p.m. until 11 p.m., an extra bank of lights was turned on in the noncycled lighting room in order to approximate daytime illumination levels; and then, at 11 p.m., one of the two banks of indirect fluorescent lights was turned off in the cycled lighting room. Random checks were made to insure that this schedule was maintained. In addition, both horizontal and vertical readings of illumination were taken at the individual infants' bedsides (see Table 2). Lighting levels were measured periodically across

TABLE 2
Intensive Care Lighting Levels in the Cycled and Noncycled Lighting Condition

Day Readings (7 a.m. to 6 p.m.)
Noncycled Condition
Horizontal plane: 232 lux (range: 50–580)
Vertical plane: 176 lux (range: 39–550)
Cycled Condition
Horizontal plane: 201 lux (range: 53–550)
Vertical plane: 156 lux (range: 50–590)
Night Readings (6 p.m. to 7 a.m.)
Noncycled Condition
Horizontal plane: 274 lux (range: 130–533)
Vertical plane: 206 lux (range: 70–500)
Cycled Condition
Horizontal plane: 32 lux (range: 12–60)
Vertical plane: 20 lux (range: 7–43)

times of day throughout the study with light meters which were held next to an infant's head. During the day, the difference in lighting levels between the rooms was visually nondetectable, and differences across days were not statistically significant. Sound levels were also measured with a Realistic sound meter in both intensive care rooms across times of day on 30 different occasions. The major sound sources emanated from staff, parents, infant activity, and medical equipment (e.g., ventilators, monitors). No statistically significant differences in decibel levels between the rooms were found.

General Procedure

This study was approved by both a university and a hospital institutional review board. Prior to the start of the study, the physician in charge of the NICU met with nursing staff to explain the study and requested their assistance. Parents were told that participation in the study was voluntary and that their decision concerning participation would not affect the care given their child. Informed consent was obtained. Infant data were taken at birth, throughout NICU treatment, and upon discharge. Staff data were taken throughout the time the infant was in the NICU.

Infant Measures

Infant birth information. The following infant information was obtained at birth by the medical staff: prenatal and newborn medical diagnoses, birth weight, head circumference, gestational age, gender, parental race, and Apgar score (Apgar, 1962). Gestational age was assessed through maternal report, obstetrical ultrasound (when available), and an assessment developed by Ballard, Novak, and Driver (1979).

Early infant development Medical staff charted daily the following information until discharge: weight, apneic episodes, caloric intake (kcal/kg), and infant medical regimen

Discharge The following infant data were obtained at discharge: the general medical diagnosis, weight, length, head circumference, and developmental status as evaluated via the Brazelton Neonatal Behavioral Assessment Scale (1973; NBAS). The NBAS examiner was not provided information relating to the infant's lighting condition. The general medical diagnosis was in part assessed by items from the Littman and Parmelee (1978) Postnatal Complication Scale and also through physician examination. The duration of each of the following events was summarized at discharge from critical care: days on ventilator, supplemental O2, IV feeding, gavage feeding, bottle/breast feeding, phototherapy, as well as total days in the hospital. In addition, daily frequency of seizures and apneic episodes was recorded.

Caretaking behavior The frequency and type of nursing staff interventions were drawn from nursing notes twice a week. Types of caretaking behaviors included: medical procedures, general care procedures (diapering and feeding), and social contacts (staff caretaking). If a caretaker performed several procedures at one time, the procedures were clustered and recorded as a single intervention. Each intervention was categorized as either: (a) scheduled necessary: in response to caretaking schedules and physician's orders, performed independent of infant's momentary status, or (b) unscheduled necessary/protective: in response to infant's momentary status. To assess reliability, two coders independently recorded nursing staff interventions, using 30% of the available data. Agreement between coders was summarized using Brennan and Prediger's variation of Cohen's kappa (Brennan & Prediger, 1981; Cohen, 1960) Using this statistic, mean reliability was measured at .90 (range = 0.83–1.00).

RESULTS

Effects of Lighting on Infant Growth and Behavior

The effect of the lighting manipulation in conjunction with infant birth status was examined on the growth trends in weight of 41 infants through hierarchical linear modeling (HLM; Bryk & Raudenbush, 1987; Bryk, Raudenbush, Seltzer, & Congdon, 1988). In contrast to nongrowth models, the dependent variable is not a single point but instead reflects the growth trajectory over time for each infant. In this respect, HLM is similar to the random coefficients growth models discussed by Cook and Ware (1983). Parameters of within-individual growth curves are allowed to vary across individuals. A straight line growth model was adopted for this study. Thus, HLM provides an estimated slope and intercept for each infant's pattern of growth. Hierarchical linear modeling also allows between-individual correlates of the slope and intercept to be examined through a multiple regression framework.

In this study, the relationship of lighting condition and birth status with the slope of weight change was examined. For the purpose of these statistical analyses, birth weight, gestational age, and 5-min Apgar score were chosen to index initial birth status because of their strong predictive relationship with neonatal morbidity (Robertson et al., 1992). These variables were transformed to z scores and then averaged to form a single measure of birth status. Analyses controlled for birth status and also systematically investigated its effect on infant growth in conjunction with the lighting manipulation. Because growth patterns in preterm infants are not characterized by linear trends but rather by a curvlinear progression involving periods of catch-up growth (Bernbaum & Hoffman-Williamson, 1991), log transformations were conducted on infant weight data.

Infant growth. General support was found for the hypotheses that infants exposed to cycled lighting (n = 20) would display enhanced growth when compared to infants exposed to noncycled lighting (n = 21). With lighting condition and birth status in the HLM model, a statistically significant difference in weight gain was found for lighting condition, β = 0.000551, $p < .05$, indicating that infants on the cycled lighting side gained on average 9.4% of their weight over the course of a week, whereas infants on the noncycled lighting side gained on average 7.4%. There was also a significant effect of birth status on weight gain, β = 0.000827, $p < .05$. When lighting condition, birth status, and the interaction between birth status and lighting condition were entered into the model, no significant interaction was found.

Infant medical outcomes and length of hospital stay. The effect of lighting on several infant medical outcomes and length of hospital stay was also examined through a series of multiple regression analyses for the infants in the two lighting conditions. Due to the positively skewed distributions apparent in the data, log transformations were conducted on these outcome variables (Winer, Brown, & Michels, 1991). In all analyses, the effect of infant birth status was statistically controlled.

Infants from the cycled lighting condition began oral feeding significantly earlier than children from the noncycled lighting condition, on average more than 6 days sooner, β = –0.14, $p < .05$. There was also a significant interaction between lighting condition and birth status for days to first oral feeding, β = –0.14, $p < .05$. The interaction indicated that a more pronounced difference occurred between lighting conditions for higher birth status infants, with high birth status infants in the cycled lighting condition initiating oral feedings earlier than their similar-status peers in the noncycled lighting condition.

In addition, infants in the cycled unit also spent significantly fewer days on ventilator support, β = –0.17, $p < .05$, fewer days on phototherapy, β = –0.11, $p < .05$, and had higher levels of caloric intake, β = 5.91, $p < .05$, than children in the noncycled lighting condition (see Table 3). In contrast, no differences were found between infants in the two lighting conditions for specific medical complications (intraventricular hemorrhage, sepsis or necrotizing enterocolitis). Significant effects for birth status were also found for days on ventilator, β = –0.59, $p < .001$, and days on oxygen, β = –0.64, $p < .001$, indicating that higher birth status infants spent fewer days on ventilator and oxygen supports.

Children from the cyclically lit room spent an average of 59 days (SD = 27.7) in the hospital, whereas children from the noncyclically lit room spent an average of 75 days (SD = 25.3) in the hospital. Despite this large mean difference in days, no significant effects for lighting condition or for the interaction between lighting condition and birth status were found. There was, as expected, a significant effect for birth status on days in the hospital, which indicated that higher status infants were discharged sooner, β = –0.17, $p < .01$.

Infant behavior. The NBAS (Brazelton, 1973) was given when children were between 38 and 44 weeks postconceptual age (PCA). Data obtained from 32 (16 cycled, 16 noncycled) infants were entered into these analyses.

TABLE 3
Medical Outcomes for Infants in the Cycled and Noncycled Lighting Conditions[a]

	Cycled Condition (n = 20) *SD*	Noncycled Condition (n = 21) *SD*
Apneic episodes in critical care	42.9 ± (60.9)	40.8 ± (49.4)
Average cal/kilo/day	92.3 ± (15.8)	82.7 ± (17.2)*
Days to first oral feeding	9.9 ± (10.1)	16.7 ± (11.1)*
Days on phototherapy	1.4 ± (2.0)	2.6 ± (1.9)*
Days on oxygen	32.0 ± (34.3)	52.8 ± (42.2)
Days on ventilator	11.1 ± (16.4)	29.3 ± (25.9)*
Postnatal complications	2.8 ± (1.2)	3.6 ± (1.4)

[a]Log transformations were performed prior to conducting statistical tests; however, for interpretational simplicity, means and standard deviations are reported in terms of the original metric of each variable.

$p < .05$.

Several infants were unable to be tested by 44 weeks PCA because they were either too ill to be tested (1 cycled, 2 noncycled) or were unable to be located in time by the NBAS examiner (3 cycled, 3 noncycled). There were no significant differences between the two groups at birth in either their individual or social-familial characteristics, with the exception of 5-min Apgar. A series of regression analyses were performed on six subscales of the NBAS; specifically, the Motor, Orientation, Range of State, Regulation of State, Autonomic Stability, and Reflex subscales. Data from the Habituation subscale were not analyzed because many children were missing data due to this subscale's requirement that an infant be in a sleep state, a condition not met for a number of infants. Regression analyses examined the effect of lighting condition alone (controlling for PCA and birth status) and the moderating effect of birth status.

The analyses revealed an effect of lighting condition on the Motor subscale, $\beta = 2.83$, $p < .001$, as well as an interaction between lighting condition and birth status, $\beta = 1.70$, $p < .05$. Children who had been in the cycled lighting condition displayed better quality of movement and tone. The interaction indicated that a more pronounced difference occurred between lighting conditions for lower birth status infants, with infants who had been in the cycled lighting condition manifesting more advanced motor functioning in comparison to their similar-status peers who had been in the noncycled lighting condition. Regression analysis also revealed a significant effect for birth status on the Regulation of State subscale, $\beta = 2.68$, $p < .05$. Higher birth status infants displayed better state regulation than lower status infants. No other statistically significant effects were obtained for the other subscales.

Effects of Lighting on Staff Behavior

Three one-way between-subjects ANOVAs were conducted to examine staff interactions with 41 infants, specifically to investigate differences in the number of scheduled necessary interventions, unscheduled necessary interventions, and the total nursing interventions performed in the two lighting conditions. No significant differences in the frequency of these interventions were found as a function of lighting condition. Because significant relationships were not found between lighting condition and nursing behavior, there was no evidence that staff behaviors mediated the effects of lighting conditions.

DISCUSSION

Medical advances over the past 25 years have contributed to a substantial increase in survival for children born prematurely. Despite these advances, there is continuing concern about the physical and social environments which preterm infants are exposed to in hospitals. In particular, concern has been expressed regarding lighting arrangements in NICU settings. This study, which extends the findings of Mann and his colleagues (1986), examined the specific effects of cycled and noncycled lighting in a NICU setting over a longer period of time, on a broader range of variables (including staff behavior), and with a more vulnerable population of preterm infants.

Consistent with Mann et al.'s (1986) findings, results indicated that a cycled lighting arrangement facilitated infant growth, specifically weight gain, to a significantly greater extent than a noncycled lighting arrangement. Contrary to our hypothesis, lighting did not have a differential effect on infants of varying birth status. Rather, there were direct effects of both lighting condition and birth status, indicating an additive effect. The differences in weight gain may be promoted by several potential mechanisms. One possible explanation for the relationship between lighting levels and growth is the release of growth hormone. Sisson (1982) found that constant lighting, as opposed to cycled, altered the rhythmic release of growth hormone in infants, which he hypothesized could in turn inhibit growth. Another possible explanation for the growth advantages of infants in cycled lighting is that the cycled environment was less stressful for the infants. Research has found that cycled lighting is associated with decreased activity levels and heart rates, suggesting that lighting may facilitate rest and decrease the levels of energy used (Blackburn & Patterson, 1991). The present finding regarding infant growth patterns for weight is important given weight is a critical index of infant well being (Bernbaum & Hoffman-Williamson, 1991). Lower rates of weight gain may place a child at an increased risk for ongoing nutritional and growth problems, such as failure to thrive, which are in turn associated with lasting deficits in cognitive and socioemotional functioning (Woolston, 1991).

In addition to weight gain, cycled lighting infants spent fewer days on the ventilator, began oral feedings sooner, were able to increase their levels of caloric intake, and spent fewer days receiving phototherapy. In combination, these findings suggest that the cycled lighting infants displayed improvements in their health status earlier than the noncycled lighting infants. In addition to these health indicators, infants in the cycled lighting condition spent 16 fewer days in the hospital than infants in the noncycled lighting condition. This difference, although numerically impressive, was not statistically significant, perhaps for power reasons related to the relatively small sample size. Future research needs to examine further this relationship of lighting environment and time infants spend in the hospital.

The behavioral data of infants in cycled versus noncycled lighting conditions further suggest a positive effect of cycled lighting, specifically on motor coordination. The general importance of the motor subsystem for general development has been widely acknowledged (Als, 1982; Campos, Barrett, Lamb, Goldsmith, & Sternberg, 1983; Kopp, 1982). Moreover, impairments in initial motor organization have been associated with later developmental problems. For instance, Jacobvitz and Sroufe (1987), examining early child characteristics in a group of full-term infants as they related to later behavior problems, found significant negative correlations between hyperactivity at 5 and 6 years and motor maturity as measured by the NBAS at 7 and 10 days of age. Thus, the current finding supports the idea that cycled lighting also provides a more growth-enhancing environment for preterm behavioral development. More research is clearly needed to replicate and examine further this proposition.

Although advanced medical technology has greatly decreased mortality rates over the last 30 years, there are still concerns about the impact of the NICU environment on infant health, growth, and development (Graven et al., 1992). This study generally highlights the need to further examine whether NICUs are clinically effective at the level of environmental care. The current findings lend support to the hypothesis that cycled lighting provides an optimal health care environment for infant growth and development. This study further suggests that the lighting environment of the NICU has a differential impact on the behavioral development and health of preterm infants depending on their birth status. Future research must be sensitive to how infants' individual characteristics moderate the influence of the NICU environment on developmental outcomes. It is quite possible that a variety of other infant characteristics, such as ongoing health status and temperament, may also be important variables moderating the effects of early lighting arrangements. Although no relation was found between staff behavior and infant outcomes, future research also needs to examine more systematically the relationships between lighting arrangements and nursing care, as well as nursing attitudes regarding lighting environments. Finally, the relationship between the NICU lighting environment, infant biological rhythms, and behavioral development in preterm infants needs to be explored. In combination, these research findings should provide helpful information to clinicians as they make decisions concerning the use of different lighting arrangements in infant nurseries.

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