Analysis of Staff Behavior in a Neonatal Intensive Care Unit

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This study provides data on behavior associated with the redesign of a neonatal intensive care unit (NICU). The unit was designed to reduce the amount of time staff spent walking, so they could focus on activities supporting infants and their families. Access to natural light and windows were also provided in response to research indicating that exposure to natural light and views impacts health outcomes. Staff behavior was examined utilizing predesign research (PDR) and post-occupancy evaluation (POE) techniques. Researchers gathered 124 hours of predesign and postconstruction behavioral mapping data, distributed questionnaires and conducted interviews. The hypothesis that walking would be reduced in the new design was not supported, although when the data were weighted to reflect the impact of the size of the large unit, the ratio of time spent walking to total unit area was found to be less in the open plan. Trends in the data supported the hypothesis that staff in the remodeled unit would spend more time with infants and families, and the number of transactions with families increased significantly. Interviews and questionnaires confirmed the effectiveness of family spaces and the positive impact of natural light. Generally, the new, open plan allowed the medical staff to achieve their pre-design goals.

Introduction

The number of neonatal intensive care units (NICUs) has increased rapidly. The original "baby wards" were developed in Paris, Canada, and Chicago in the early 1900s and focused primarily on intensive respiratory care. Although the official profession of neonatology began as recently as the 1960s, there are currently more than 3,000 neonatalogists in the United States alone. Similarly, while the first full-blown NICU was founded as recently as 1965 (Yale-New Haven Hospital in Connecticut), there are currently more than 800 units in the U.S. The causes for the growth in the size and number of units is likely the result of two developments: advances in medical science that have positively impacted mortality rates and an increase in the number of sick newborns resulting from contemporary "illnesses" such as drug dependence.

The design of these units is therefore a relatively new art. Some of the major issues impacting the architecture of NICUs are: homelike environment (residential-appearing versus durable finishes), scale (large or small unit), patient density (private rooms versus wards), supervision (direct versus remote), location relative to other hospital functions (near Labor/Delivery versus near pediatric intensive care), location of storage (centralized versus decentralized), amount of light required for infants (natural versus electric), access to nature (how much and for whom), configuration efficiency (internal component adjacency)

and provision of family-centered care (on-unit versus off-unit sleep spaces).

Neonatal intensive care studies have dominated the literature on healthcare environments for children and their families (Shepley, Fournier & McDougal, 1998). Of the 84 studies identified in Rubin, Owens & Golden's 1998 survey of substantive research addressing the impact of the physical environment on patient outcomes, 23 involved NICU settings. In addition to these, Table 1 summarizes 15 post-1998 research publications not included in the Rubin survey. Regardless, these combined 38 studies are insufficient to support the design process. The primary focus of recent literature is limited noise and light with isolated contributions addressing family-centered care and maternal perceptions of caregiver support and attachment to infant.

Bibliographic Information	Environment	Outcomes	Findings
Berens, R. & Weigle, C., (1996). Cost analysis of ceiling tile replacement for noise abatement. *Journal of perinatology, 16(3)*, 199-201.	Acoustic ceiling tile and noise level	Bedside acuity score, unit acuity score, noisy devices, decibels, visual analog	Decrease in decibel level found after replacement of acoustic ceiling in open NICU; decrease not perceived by observers.
Blackburn, S., (1998). Environmental impact of the NICU on developmental outcomes. *Journal of pediatric nursing, 13(5)*, 279-289.			General descriptions and recommendations from review of literature.
Charpak, N., Ruiz, J., Calume, Z., (2000). Humanizing neonatal care. *Acta paediatrica, 89*, 501-502.			Commentary
Fournier, M-A. (1999). Impact of a Family-Centered-Care Approach on the Design of Neonatal Intensive Care Units. Dissertation, Texas A&M Univ. College Station, TX	NICU family-centered care environment	Plan analysis, observations, care-giver interviews and family questionnaires	4 themes emerged regarding the environment and families/ caregivers: 1) privacy and intimacy; 2) social support; 3) comfort/ image; and 4) functionality.
Graven, S., (1997). Clinical research data illuminating the relationship between the physical environment and patient medical outcomes. *Journal of healthcare design, 9*, 15-19.			General guidelines.
Graven, S., (2000). Sound and the developing infant in the NICU: conclusions and recommendations for care. *Journal of perinatology, 20*, S88-S93.			Recommendations developed from literature review.
Guimaraes, H., Oliveira, A., Spratley, J., et al., (1996). Analysis of noise in a neonatal intensive care unit. Acta paediatrica, 3, 1065-68.	Noise level	Noise level	The surrounding noise level varied between 61 and 67 dB with spikes over 100 dB.
Mirmiran, M., & Ariagno, R., (2000). Influence of light in the NICU on the development of circadian rhythms in preterm infants. *Seminars in perinatology, 24(4)*, 247-257.			Review related other articles.
Miller, C., White, R., Whitman, T., et al., (1995). The effects of cycled versus noncycled lighting on growth and development in preterm infants. *Infant behavior development, 18*, 87-95.	Cycled lighting NICU vs. noncycled lighting NICU	Weight gain, time to oral feeding, days spent on ventilator and on phototherapy, and motor coordination	Infants assigned to cycled lighting unit had greater weight gain, fed orally sooner, spent fewer days on ventilator and phototherapy and displayed enhanced motor coordination.

Nystrom, K., & Axelsson, K., (2002). Mothers' experience of being separated from their newborns. *Journal of obstetric, gynecologic, and neonatal nursing, 31*, 275-282.	Mothers' experiences related to separation from their newborns in NICU	Tape-recorded interviews	Mothers' experiences of being separated from their newborns caused them emotional strain and anxiety.
Raman, T, (1997). NICU environment: A need for change. *Indian pediatrics, 34*, 414-419.			Review related articles.
Riper, M., (2001). Family-provider relationships and well-being in families with preterm infants in the	Maternal perceptions of family-provider	1. Family-Provider Relationships	Mothers who depicted positive relationship with health care providers in NICU reported
NICU. Heart & lung, 30(1), 74-84.	relationships in the NICU and well-being in families with preterm infants	Instrument-NICU 2. Ruff's psychologic well-being measure 3. General Scale of Family Assessment Measure	more satisfaction. Mothers who reported a discrepancy were less satisfied with care received.
Robertson, A., Cooper-Peel, C., & Vos, P., (1999). Contribution of heating, ventilation, and air conditioning airflow and conversation to the ambient sound in a neonatal intensive care unit. *Journal of perinatology, 19(5), 362-366.*	Conversation, HVAC airflow, day, & Location	Sound pressure level (dBA)	The reduction in sound by stopping conversation was greater than the reduction caused by stopping HVAC airflow.
Slevin, M., Farrington, N., Duffy, G., Daly, L., & Murphy, J., (2000). Altering the NICU and measuring infants' responses. Acta paediatrica, 89, 577-581.	Light, sound, alarms, staff conversation, staff activity, and infant handling	Infants' heart rate, blood pressure, oxygen saturation, and movement responses	Changes (switch off lights, pull down blinds, no slamming drawers, dustbins or dragging chairs, whispering) associated with reduced diastolic blood pressure and decrease in infant movements.
Thomas, K., & Martin, P., (2000). NICU sound environment and the potential problems for caregivers. Journal of perinatology,20, S94-9			Review related other articles.
Walsh-Sukys, M., Reitenbach, A., Hudson-Barr. D., DePompei, P., (2001). Reducing light and sound in the neonatal intensive care unit: an evaluation of patient safety, staff satisfaction and costs. *Journal of perinatology, 21, 230-5*	Reduced light and sound levels (weather stripping, rubber cans, incubator covers, carpet, acoustic material, and spotlights)	- Light level - Sound level - Severity assessment - Staff satisfaction questionnaire with a 5-part Likert response scale	- Light and sound levels reduced with modifications that incurred modest costs. - Reduced light or sound levels did not influence patient safety negatively. - Staff members were highly satisfied with reductions in sound levels.
Zahr, L., & Balian, S., (1995). Responses of premature infants to routine nursing interventions and noise in the NICU. *Nursing research, 44, 179-185.*	Noise events	Heart rate, respiratory rate, oxygen saturation, sleep and wake states	Noise resulted in fall in oxygen saturation, rise in heart rate, and rise in respiratory rate in 12-18% of infants. 78% of infants changed behavioral state in response to noise, usually from sleep to fussy/crying.

Table 1: Studies on Neonatal Intensive Care Unit Environments (1993-2003)
Shaded areas represent references identified in Rubin, H., Owens, A. & Golden, G. (1998). Status report : An investigation to determine whether the built environment affects patients' medical outcomes. Martinez, CA: The Center for Health Design.

The study described here was undertaken to help designers who are involved in the design of new or remodeled NICU units. The opportunity to conduct this research was the result of a design project with which the researcher was involved ten years ago. At that time, a new, a Level III[1] neonatal intensive care unit was proposed for a major public hospital in Northern California. Although many issues were to be addressed during the design process, two of the primary objectives were to make the unit efficient and to support family-centered care. These two issues were inextricably related. An efficient floor plan allows nurses to spend more time with families and patients, rather than waste time moving from one location to another, searching for supplies or other staff members. Regarding family-centered care, it is well documented that parents in NICU settings suffer a high level of stress (Goldson, 1992). The physical appearance of the environment, including the high-tech equipment (Miles, Funk & Kasper, 1991) and high temperature (Raeside, 1997) may intimidate and undermine families.

The issues of efficient design and family-centered care were examined in this study utilizing predesign research (PDR) and post-occupancy evaluation (POE) techniques. The three primary objectives of this evaluation and others generated by this researcher (e.g., Shepley, 1995; Shepley & Wilson, 1999; Shepley, Bryant & Frohman, 1995) were to 1) provide new information for other designers, 2) provide an evaluation for hospital administration and staff and 3) confirm that the design intentions were realized.

The original NICU floor plan (4,100 square feet) was broken into several small rooms, linked by an interior corridor (see Figure 1). Services and offices were located on the opposite side of the corridor. There were no exterior windows in the unit. The new floor plan (6,600 square feet) had an open bay configuration (see Figure 2). Elements that were included in this design, which were not available in the previous were: a parent overnight/training room, a breast-feeding alcove, and more space around the babies. Additionally, the floor plan was extended to incorporate an exterior window wall. Nursery census ranged from 16 to 24 infants per day in 1993 in the original unit and from 11 to 31 in 1996/7 in the new unit phase. Although the average census during the behavior mapping in 1993 was 22 and the average in 1996/7 was 16, staffing totals shifted slightly to reflect the decrease in infant patients. All nursing staff available during the 1996/7 study sessions were included in the mapping.

Figure 1: Original NICU

[1] Level III neonatal intensive care units must have a full-time neonatalogist on staff, have the capacity for long -term care, and subspecialties in cardiology and surgery (Budetti, et al. 1981).

Figure 2: New NICU

Methodology

Four types of methodologies were incorporated in the study: 1) behavior mapping, 2) interviews, 3) questionnaires and 4) measures of noise and light levels. Behavior mapping data was gathered before construction was initiated and one year after construction was complete. Interviews, questionnaires, and light and noise data were collected as post-occupancy measures only.

Behavioral mapping is a common technique for measuring activity in healthcare settings (e.g., Esser, Chamberlain, Chapple & Kline, 1967; Field, Hanson, Karalis, Kennedy, Lippert & Ronco, 1971; Fisher, 1982; Ittelson, Proshansky & Rivlin, 1967; James, 1975; Kennedy, Fisher & Pearson, 1988; Trites, Galbraith, Sturdavant, & Leckwart, 1970). Nurse walking behavior, however, has only been examined in a few studies. Shepley and Davies (in review) found that nurses walked significantly less in cluster plan units than in rectangular, "race track" units. Engel, Hawkins, McCormick, and Scheve (1990) discovered that 28.9% of nursing staff time in a senior facility was spent walking. The average distance walked by a nurse was determined by Bauer and Knoblich (1978) to be 3.89 miles in a general ward and 5.13 in an intensive care ward.

The behavior mapping study involved following staff as they moved about the unit. Observers gathered information regarding the subject's location, their activity, and arrival and departure times. Data was gathered in three-hour segments for a total of 124 hours. Pedometers were used to corroborate the results of the mapping portion of the study. The usefulness of these pedometers has been suggested by Tryon, Pinto and Morrison (1991) and Sequeira, Rickenbach, Wietlisbach, Tullen and Schutz (1995).

The nine primary staff on the unit were interviewed for 20 to 60 minutes. These individuals included the head neonatalogist, unit clerk, resident, charge nurse, director, resident, social work and staff nurses. All subjects had experienced both the pre-occupancy and post-occupancy environment. Seven staff responded to the questionnaires. These questionnaires included 60 questions regarding overview, efficiency and flexibility, supervision and security, light and noise. Questions were also directed at specific unique spaces.

Results

The hypotheses of the study were that staff walking would be reduced, that staff would spend more time with infants and families, and that activities involving the procurement of supplies would take less time. These hypotheses were only partially supported. Regarding the amount of walking that took place, the total was not reduced. However, when the data was weighted to reflect the increase in area, it was found that the time traveled per square foot of unit area decreased. Regarding the amount of time staff spent with families/infants, there was a trend in the positive direction, but not to a level of statistical significance. The number of interactions with families, however, did increase significantly.

Because activities involving storage represent a significant drain on the typical day of a nurse, the impact of the new design on time spent related to storage activities was also measured. The new unit was specifically designed to reduce storage trips by placing more storage areas adjacent to the baby. As a result of the new design, it was found that time spent in storage activities did not decrease, but the transactions were quicker. A detailed summary of the results of this study is provided in Shepley (2002).

Discussion

The hypothesis that walking would be reduced in the new design was not supported, although when the data were weighted to reflect the impact of the size of the large unit, the ratio of time spent walking to total unit area was found to be less in the open plan. Trends in the data supported the hypothesis that staff in the remodeled unit would spend more time with infants and families, and the number of transactions with families increased significantly. Interviews and questionnaires confirmed the effectiveness of family spaces and the positive impact of natural light. Generally, the new, open plan allowed the medical staff to achieve their pre-design goals.

Although this research has merit as a case study, corroboration of these results in other units would help to confirm the hypotheses regarding decentralized storage and the impact of plan configuration on efficiency. Additional studies might focus on the six previously mentioned design issues: homelike environment, scale (large or small unit), patient density, supervision, location relative to other hospital functions, location of storage, amount of light required for infants, access to nature, configuration efficiency and provision of family-centered care.

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(Additional references provided in Table 1.)

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