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A Research-Based Environment: A NICU That Feels Like Home

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The modern, highly technical neonatal intensive care unit (NICU) is credited with significant increases in survival rates of premature infants. But, current research indicates that these units, with continuous activity, bright lights and high noise levels, create potentially detrimental effects on an infant's short- and long-term development. This environment also alienates the family. Environmentally sensitive units have shown to decrease stressors, therefore enhancing growth, leading to shorter hospital stays, reducing hospital charges, and encouraging participation of the families in an infant's care (Als, 1994).

The NICU at The Children's Medical Center Dayton, Ohio, is a level III, 31 bed regional referral center for a 20 county service area. In 1997 the unit was renovated using research and data concerning the effect of the environment on neonatal development. This knowledge base was used to guide the vision, justify the expense, and serve as a basis for decision making throughout the project.

Creating an environmentally sensitive unit encompassed every design aspect from overall space planning to locating outlets. The well designed space plan enhances efficiency for staff and provides privacy for infants and families. Using indirect light and individually controlled bedside lighting lowered overall light levels. Including exterior windows provided for the diurnal cycling of light. Using sound absorbing materials aided in bringing down decibel levels. Technically advanced carpets and fabrics were used in areas that would not have been acceptable a few years ago. This carefully designed environment is helping to counter balance the realities of the harsh clinical setting.

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Over the last decade, advances in health care have accounted for significant increases in survival rates for infants of very low birth weight. The traditional neonatal intensive care unit (NICU) in which these infants develop and grow typically is characterized by sterile, bright, loud environments. Research has shown that this type of environment can actually have a detrimental effect on an infant's development, and that an environmentally sensitive unit can enhance growth, shorten stays, and reduce hospital costs.

The newborn intensive care unit at The Children's Medical Center (CMC) in Dayton, Ohio is a 31-bed, Level III nursery licensed by the Ohio Department of Health. Staffed by five full-time, board-certified neonatalogists, the unit is a regional referral center for low-birth-weight and sick newborns for a 20-county service area. All infants are transported to the facility by a regional neonatal transport team staffed by CMC.

The existing neonatal intensive care unit at CMC was built in 1982, during the introduction of new technologies to save infants of very low birth weight. The primary focus on medical intervention led to the sterile, highly technical, brightly lit, and noisy environment prevalent in most NICUs today. The nursery was visually enclosed and visitors, upon arrival, spoke to staff through an intercom in a solid wall. The impact of this environment on the infants' sensory and cognitive and on their families' well being and interaction were secondary to purely medical concerns.

After 15 years the existing unit did not meet new requirements outlined in the "1997 State of Ohio Quality Rules" or the "Report of the Consensus Conference on Newborn ICU Design: Recommended Standards of Newborn ICU Design, 1996." The possibility of moving to a new location was ruled out, due to a lack of options within the hospital. Additional square footage in the existing location was achieved by closing off a through-corridor and allocating administrative spaces to patient care.

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THE EXISTING ENVIRONMENT

Increasingly, research shows a relationship between the NICU environment and the physiological and neurological development of the infants. During the past two decades, light intensities recorded in hospital neonatal units have increased by five- to tenfold (Robinson et al. 1990). This environment generates stress and is intrusive and often painful to premature infants, frequently interrupting cycles of much-needed rest.

The stresses encountered by neonates have been shown to cause physiological changes that impede their progress (Als 1996). The *Journal of the American Medical Association* reported that infants who were provided with developmentally supportive care through control of the environment and individualized attention were found to benefit from a significantly shorter duration of mechanical ventilation and supplemental oxygen support, earlier oral feeding, reduced incidence of complications, improved daily weight gain, shorter hospital stays, and reduced hospital charges, compared with infants not provided this type of care in the control group (Als et al. 1994).

Researchers at the Stanford University Sleep Research Center hypothesized that the deficits in sensory and cognitive functions that often persist in preterm infants may be in large part due to the erratic patterns of NICU stimulation (Glotzbach et al. 1993). The environment within the NICU is completely foreign to the preterm infant who, until the time of birth, has been protected within an intrauterine environment (Avery 1989). The overwhelmingly clinical focus of the NICU environment is not conducive to development of the fragile central nervous system of infants with very low birth weight.

The study of biological rhythmic events can have important implications for neonatal health. It is known that in utero the fetal circadian system receives its cues from the mother. In most nurseries infants are exposed to intense ambient, cool, white, fluorescent lighting 24 hours per day. A premature infant, severed from a mother's cues, may receive inappropriate cues from the nursery environment. This intense and constant lighting raises concerns for resting patterns and day-night rhythms.

The American Academy of Pediatrics recommends 100-foot-candle lighting for adequate illumination and visualization of infants in a NICU (AAP 1992). In contrast, the intensity of lighting varies up to 2,500 foot-candles in an actual NICU. Abundant evidence from studies on human adults and animals indicates that both the timing and magnitude of changes in light intensity have profound effects on circadian rhythms and sleep. These effects have been the basis for recent implementation of new clinical therapies for shift work, jet lag, seasonal affective disorder, and depression (AAP 1992).

In utero, the fetus is exposed to constant and regular auditory sounds (up to 72 decibels, or dB), which are muffled by their passage through amniotic fluid (Kenner 1990). The sounds of normal adult conversation typically measure between 45 and 55 decibels (dB). Adults exposed to intermittent noise levels above 80 dB for a duration of eight hours per day in industrial settings have developed hearing loss.

Researchers have found that NICU sound levels can be compared to "light auto traffic" at 70 dB with highs up to 180 dB . Infants are often exposed to these continuous high decibel levels, with no opportunity for recovery (Vandenburg 1990). The American Academy of Pediatrics reported that hospital noise, including incubator noise, must be considered a possible cause of childhood deafness (AAP 1997). The Academy recommends consideration of sound control in renovating facilities and purchasing new equipment for NICUs.

Caregiver voices and activities are a major component of the noise created in an NICU environment. Education of staff on the stressful effects of the environment can have a measurable impact.

The stressful impact of the NICU environment on parents and families cannot be underestimated. Giving birth to a premature or sick infant is not usually the family's expectation, and the intimidating environment of the NICU can reinforce the shock and sense of loss that families feel in the face of reality. A family may feel displaced and alienated from its own infant. For the developmental health of the infant, it is critical that the parents feel comfortable in their infant’s temporary "home" and feel that they are still a primary part of their infant’s care (Harrison 1993).

Although created to save premature and sick babies, elements of the environment of the modern NICU can actually be detrimental to their recovery. Nursery design now needs to takeanother direction, emphasizing reduced light and sound levels, increased accommodation of patient and family needs, and education of staff. This new design, as seen in the renovation of The Children’s Medical Center, should be an environment based on research and scientific inquiry.

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VISION AND GOALS

To provide an environment conducive to family-centered developmental care of sick newborns, decreasing stress for the infant, the family, and the caregivers, and improving short- and long-term outcomes.

This common vision for the planning team was key to the success of the renovation. The following goals were established to reinforce the vision.

Promote family-centered care:

- Provide a welcoming, comfortable, home-like setting and decrease visiting restrictions;
- Increase family support spaces, including waiting area, overnight transition room , and lactation room;
- Increase family space and privacy at each infant's bedside; and
- Educate families on developmental care and its impact on the infant's well being.

Provide a developmentally supportive environment for infants:

- Decrease overall light levels,
- Include day-night cycling of natural light,
- Provide individually controlled light at each bed space, and
- Decrease noise level to 50 dB or less.

Reduce stress and improve efficiency of caregivers:

- Provide an efficient, organized space for staff at each infant's bedside; and
- Educate caregivers on developmental care and its impact on the infant's well being.

The vision and goals dictated everything from the big picture down to the smallest of details. At every step of the planning process, decisions were weighed to determine how each contributed to the vision for the new unit.

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DESIGN PROCESS

Staff input was critical to the process. A team of 15 was compiled representing all layers of management and all disciplines active within the NICU. Each member brought a different perspective to the team. Listening and a commitment to the unit as a whole, beyond the scope of any member's particular interest ,were important to the success of the programming phase. In addition to the staff input, families were interviewed, other hospital departments were consulted, and new regulations were incorporated into the program.

The large size of the group and the quantity of information being coordinated dictated a regularly scheduled meeting time and organized discussion led by the architect. Written follow-up to every meeting was key to maintaining a clear and concise status for all decisions.

As part of the programming process, every aspect of an infant's stay was described, analyzed, and quantified. From transport and admission into the unit, to growing stronger and transitioning home, the space needs, storage, and logistics were discussed. Committee members related to existing spaces for comparison, and quantified needs and other space requirements by number of people and the amount of equipment involved at any given time. The architect quantified these requirements, gave scale and proportion to the spaces, and began to program space adjacencies.

Initial space planning revolved around the proportion of the patient care area and the use of existing windows for natural light. The goal for low-level lighting and the need for day-night cycles were juxtaposed. Staff needs for natural light tilted the final decision toward spanning the patient care area the full width of the unit and incorporating both the north and the south window walls. Public and private functions were grouped accordingly from this point and organized around the patient care area.

Figure 1: Floor plan.

The organizational concept of the infants' bed spaces was a key element in designing the entire unit. Traditional layouts were investigated as well as "outside the box" geometrical configurations. The original pinwheel concept represented a pure geometric form housing four infant bed spaces. This design was modified to house three bed spaces because of space limitations. Concepts were presented with a floor plan showing the layout of the patient care area and a scale model of an individual headwall

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unit. The model created a more hands-on presentation and better understanding by team members of how the bed space would function.

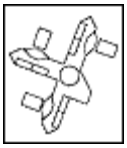

Figure 2: Diagram of pinwheel headwalls.

Acceptance of the pinwheel was not immediate. Some members of the team needed time to think through the ramifications of the new concept. But by the next meeting the consensus was to move forward with the pinwheel. For detailing purposes a commitment was made for the architect to create a full-scale cardboard mock-up of the pinwheel design.

Figure 3: Cardboard mock-up.

The team spent an entire day experimenting with placement of actual isolettes, equipment, charts, and personal items for the babies. Additional staff members not on the core committee were able to examine the unit over the span of a week. The mock-up aided in the understanding distances and sight lines for equipment and monitors, staff placement during emergencies, and overall efficiency of the space. The experience was invaluable and many revisions resulted from this session.

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The overall plan functions on several levels. On the most basic level, the unit is developed around the primary planning principle of separation of public and private functions. On a conceptual level, the unit as a whole works as a house with a front door serving families and visitors and a back door serving staff, transport, and supplies. Each infant has personal space within the house. On a larger scale each gable headwall represents a house in the neighborhood and each infant is a member of the community.

The nursery consists of six pinwheel islands, twelve window wall units, and one single-patient-room configuration. Each of the pinwheel islands contains three infant care areas and one staff area. Each linear window wall unit contains one primary infant care area and one flex-up care area. Two of the linear units are utilized in isolation rooms. Consistency of layout between the pinwheels and linear unit was critical for staff to function efficiently at either type of bed space.

Each infant care area incorporated custom casework and a custom-manufactured headwall insert. The unique collaboration of a local cabinet maker and a national headwall manufacturer was the result of an unacceptable cost estimate during schematic design. In the end, cost containment measures allowed enough surplus to justify the use of solid surface as part of the headwalls and throughout the unit.

Every detail of the headwalls was designed to maximize the surrounding floor space, manage equipment, and maximize storage and staff work spaces. Every headwall incorporates a built-in IV pole that eliminates the large bases of freestanding poles, as well as a wire management system that keeps unruly cords and tubing out of sight.

It was part of the vision to create a "home away from home" for families and babies. The house front draws from the surrounding neighborhood, Old North Dayton, a collection of older Victorian style homes. The concept of being part of the neighborhood and the surrounding community and available for the population is a focus of the hospital. Drawing on its position in the community, the hospital used local talent for design and manufacturing of casework, and local artisans for artwork and signage.

Figure 4: House front.

The public entrance to the unit is a "house" with the waiting area becoming the "front yard." This concept is played out through a solid color carpet with a multi-color "border of flowers" and a section of wood deck. The ceiling "clouds" in the waiting area

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provide indirect light and a full-scale tree houses the TV and VCR for the children's area. Furniture consists of garden benches, planters, and wrought-iron table and chairs. The house is flanked by sections of glass etched with a picket-fence design; the glass serves as the viewing window and as the entrance into the scrub area, allowing the "house" to float between the hospital's exterior walls.

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FAMILY SPACE

The new unit provides a greatly expanded waiting area consisting of a linear series of spaces that provide families with the opportunity for both interactive and solitary groupings. The spaces allow for watching television, family eating, even looking out the window. Lockers for belongings provide a sense of personal space. A separate children's play area entertains siblings.

From the perspective of the waiting room (the "front yard"), a bay window reaches out and welcomes the family and allows for immediate face-to-face contact with a member of the staff. The use of authentic exterior materials—including brick and siding, a six-panel door, and double-hung windows with shutters and flower boxes—not only reinforces the concept, but also creates peace for families in a time of crisis, through true-to-life detailing instead of elements that would suggest a childlike playhouse.

The concept of the pinwheel creates privacy for the babies and their families without the additional square footage that would be necessary for private rooms. Meeting state guidelines for 100 square feet of space per infant justified the required footprint. The 15° angles at which the pinwheels are rotated limit sight lines across the unit from window wall to window wall to further enhance privacy. Each infant bed space has walls and/or the availability of portable custom-designed privacy screens that delineate personal space.

Through the use of the pinwheel design, the bedside offers more room for visitors. All administrative nursing functions are pulled to the side to allow greater access for visiting families. Medication and charting drawers are at 45- degree angles to the headwalls for less interruption by staff as they perform their duties. The IV poles were built into the headwall to make more efficient use of bedside floor space and to aid in minimizing the barrier of equipment between families and babies.

Figure 5: Nursery.

Parents and families have cabinets for storing personal items for baby and shelf space for stuffed animals and toys at the bedside. These personal items make the infant much more part of the family. Bulletin board space is provided for personal information, well wishes, and messages from family to staff or staff to family. This communication aids in involving parents in infant care.

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LIGHTING

A primary goal was bringing the overall foot-candle level down to acceptable levels. Adequate lighting is inherent to the basic function of a NICU but every effort was made to maintain dim lighting overall. The use of indirect lighting in both the ceiling and the headwalls provides ambient lighting throughout. High-intensity procedure lights are located directly over each bedspace and switched locally. Task lighting for caregivers is available at each bedside.

A unique feature of the lighting in the unit is a widely curved light soffit that represents clouds and appears to be floating. A lower ceiling of "clouds," necessary due to existing conditions, is balanced with higher areas of "sky" and provides for a softer indirect light. Switched for variable intensity, these lights provide a warm and interesting ambient light.

The large number of existing windows in the patient care area address the need for cycled light to serve the circadian rhythms of the infants, as well as the needs of staff and families. However, implementing this feature called for control of both light and heat gain throughout the nursery. The solution was the installation of a motorized system of roll shades. After much investigation, this product provided the ability to quickly darken areas for procedures and limit daylight as necessary, yet the translucent fabric still allowed for a view to the outside. The exposure of large quantities of glass to the south required installation of window tinting to control heat gain.

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CONTROL OF SOUND

Both overall reduction of noise and increased use of sound-absorbent materials contribute to lower sound levels within the nursery. The clinical aspects of a NICU can generate a tremendous amount of noise from monitoring and life support equipment. This was reduced through the use of visual alarms in conjunction with low-level audible alarms. The visual alarms are creatively incorporated into a chimney at each of the bed spaces' house gables.

The idea of carpeting in an intensive care unit is diametrically opposed to the concept of a high-technology, sterile environment. However, carpeting is a very good sound absorber. Advances in carpet manufacturing have led to better products with antimicrobial properties, static control, and stain guard. Working with hospital standards, carpet squares were selected over roll goods for their ability to be readily replaced in problem locations. Carpet squares also allowed for flexibility to create patterns and reinforce design concepts, like the 15° rotation of pinwheels.

The ceiling tile used throughout the patient care area was upgraded from the hospital standard tile, with a 65 noise reduction coefficient (NRC) to an insulation-backed tile with a 95 NRC. Installation of this non-tegular tile functioned beautifully in the curvilinear "cloud" ceiling system.

Choice of equipment and furnishings also played a part in the reduction of noise throughout the unit. A wireless communication system for bedside caregivers was implemented, eliminating the need for phones and intercoms in the clinical area. Strategically placed, low-level intercoms were used for the hospital-wide emergency paging system. Porcelain sinks were used instead of standard stainless steel in the nursery and family scrub area (pedestal sinks were used at staff stations in each pinwheel to reinforce the Victorian house theme). Headwalls included fabric-covered access panels that doubled as sound absorbers and bulletin boards. Upholstered stools and rockers, as well as fabric-paneled portable privacy screens, offer additional sound absorption.

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STAFF EDUCATION

Despite all the environmental changes in the renovation, the true burden of providing developmentally supportive care and ensuring the appropriate environmental stimulation falls on the staff and direct caregivers of the NICU. The renovation of facilities without educating the staff concerning environmental stress would make the renovation ineffective and irresponsible. A comprehensive education program for staff was implemented to optimize the environmental changes in the nursery.

Wee Care Neonatal Systems, Inc. was chosen to provide this education and support. The Wee Care Team came to The Children's Medical Center to provide classroom teaching and a week of hands-on demonstration of practical skills.

The goal of the teaching program was to educate every person who would come in contact with the infants. All neonatal care providers were included in this program, including neonatologists, staff and transport nurses, neonatal nurse practitioners, clinicians, respiratory therapists, ancillary unlicensed staff, the neonatal dietician, social worker, occupational therapist, phlebotomists, radiology technicians, house-keepers, and even the project architect. This program enabled all staff members to optimize the use of the new environment, and to see the vision and future direction of the unit and all caregiving practices. This education was pivotal to the success of the nursery renovation project.

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CONCLUSION

The development of an infant who has lost the safety of the intrauterine environment before reaching term can be further threatened by elements of an erratic NICU environment, including lack of day-night cycles, ambient light, high supplemental lighting, and high noise levels. The renovation made use of current scientific research in this area to create an environmentally sensitive unit encompassing every aspect from overall space planning to locating outlets. The plan enhances efficiency for staff and provides privacy for infants and families. Using indirect light and individually controlled bedside lighting lowered overall light levels. Including exterior windows provided for day-night cycling of light. The reduction of noise factors and use of sound-absorbing materials aided in bringing down sound levels to 40-50 dB at any given time.

Occupancy has proven the success of the unit. Although not empirically documented, there is preliminary evidence of shorter infant stays. Feedback indicates families are more comfortable and appreciate the privacy and the opportunities for additional visiting. Staff are happy with the efficiency of unit layout and revised headwall configuration.

The newly designed setting has allowed for the reevaluation of standard NICU policies. In the short period of time the unit has been occupied, less restrictive visitation has been implemented and the accommodation for skin-to-skin contact has been implemented at the bedside. This carefully designed unit is helping to counterbalance the realities of the sometimes harsh clinical setting.

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Figure 1
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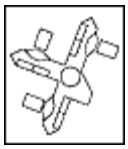

Figure 2
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Abstract

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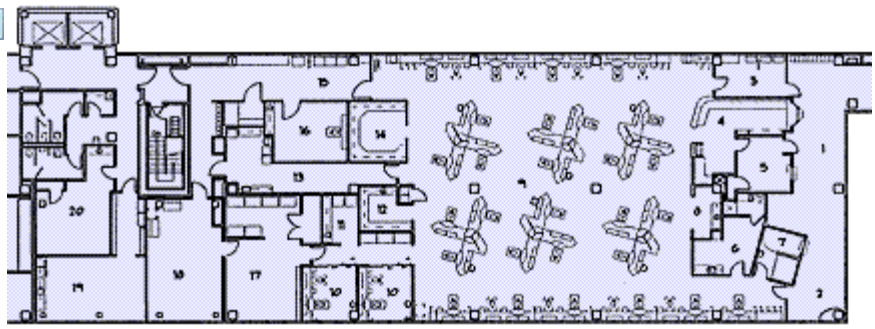

Figure 1: Floor Plan

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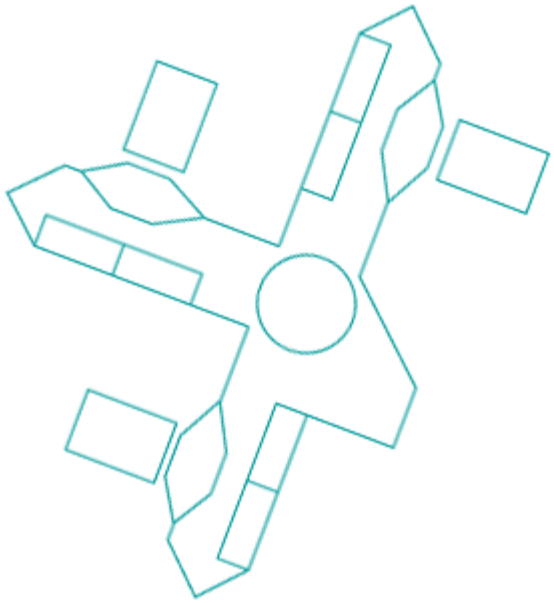

Figure 2: Diagram of Pinwheel Headwalls

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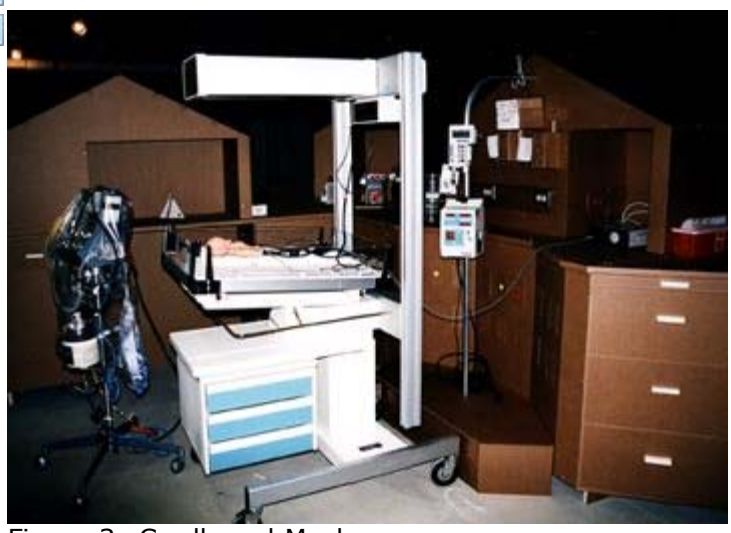

Figure 3: Cardboard Mock-up

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Figure 4: House Front

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Figure 5: Nursery

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