

# The Impact of Lighting, Noise, and Design on a NICU Environment

03.20.2019

University of Kentucky Healthcare  
Kentucky Children's Hospital and NICU



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## Project Team

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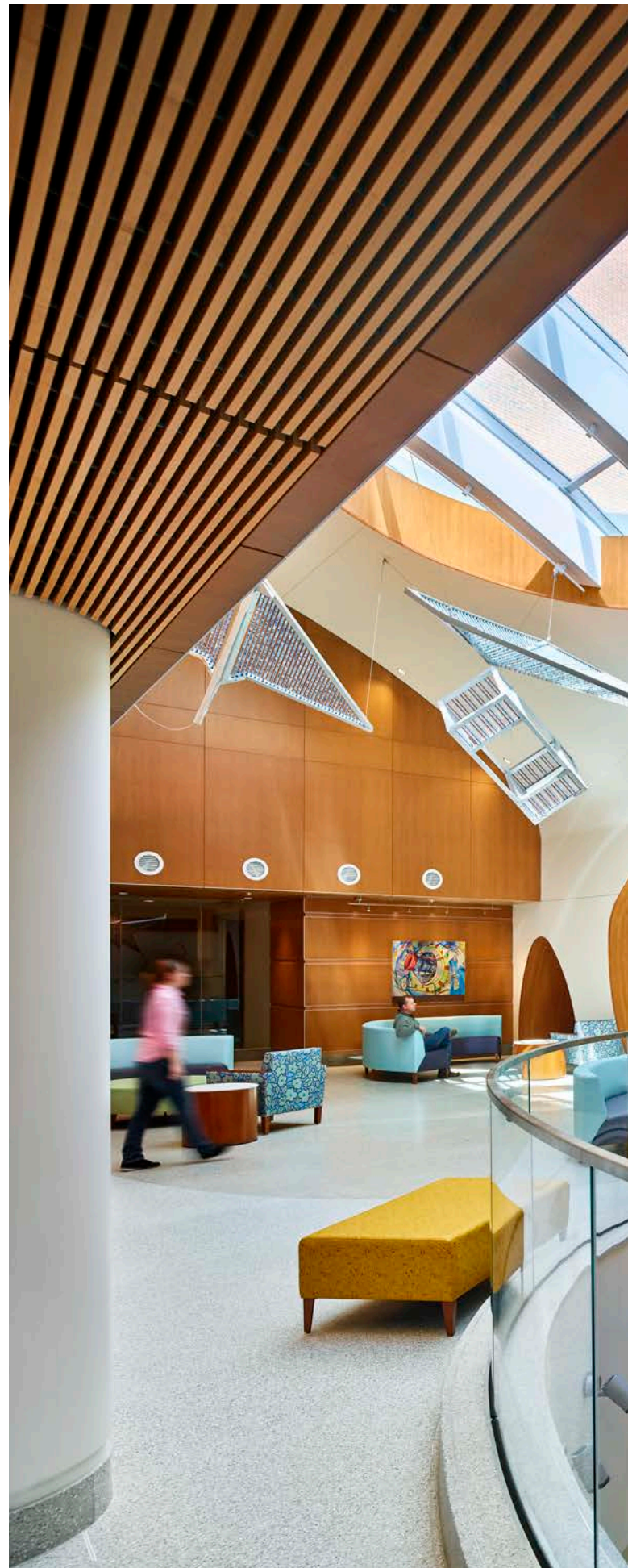
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# THE IMPACT OF LIGHTING, NOISE, AND DESIGN ON A NICU ENVIRONMENT

## STUDY SUMMARY

This research project emerged from a new construction, shell space build-out project of a neonatal intensive care unit (NICU) at a large academic medical center. Institution leadership were interested in moving from multi-bed NICU rooms (up to 6 babies in one room) to private rooms. It was acknowledged that this change would be extensive for all involved—therefore, there was a desire to use research tools to help inform design decisions and illuminate specific stakeholder needs. Following the completion of the design process and during construction—a larger professional group was engaged in discussions about research and a pre-/post-occupancy study was determined to be a high priority.

## PRE-DESIGN RESEARCH

In the pre-design study, a systematic approach was devised to collect quantitative and qualitative pre-occupancy data that truly captured the “Voice of the Customer” (VOC) for the NICU. To do this, customized questionnaires were distributed to both staff and family members to understand significant predictor variables of the indoor built environment relationship to work performance and perception of care. For example, predictor variables included noise level, lighting, amount of work surface area, and availability of work stations.

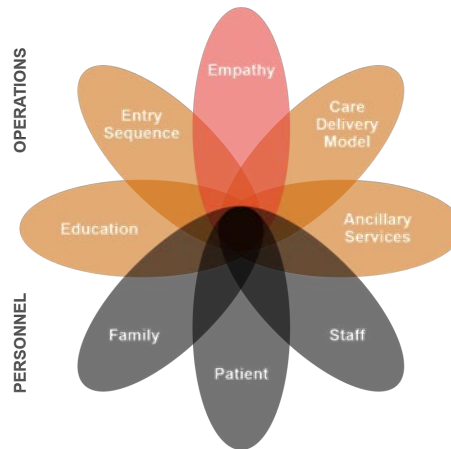
### Research Question:

1. What do the staff and family members (customers) need and want in the design of the new NICU?

### VOICE OF THE CUSTOMER

#### Attributes

- Co-location of Service Lines
- Palliative Care
- Team-based Care
- Collaborative Environment
- Patient Journey
- Safety & Security
- Emotional Experiences
- Accommodating



## PRE- & POST-OCCUPANCY RESEARCH

The pre- and post-occupancy study followed a mixed-method approach wherein surveying via questionnaires were used to evaluate user perceptions. An online survey explored both staff and family satisfaction with ten specific characteristics of unit design, sources and levels of noise and lighting, and satisfaction with patient spaces. The staff survey focused on the impact of the built environment on the performance of work duties. Families were asked how the environment affected caregiving, parent-child interactions, and the child’s ability to rest and heal.

Lighting measures and acoustic readings were used to support the questionnaire responses. Measurements of illuminance (how much light reaches a surface) and spectral reflectance distribution (SRD—how much light is reflected from surfaces) were gathered in a typical patient room. Sound readings were taken pre- and post-occupancy at nurse work areas and the infant isolette areas to gain a better understanding of sound levels and sources of peak noises throughout the unit. The mixed-method approach led to triangulation of findings and helped to inform lessons learned. Most of these methods have been previously tested for reliability and have been used during pre- and post-occupancy evaluations during other facility assessments.

## RESEARCH METHODS

| IRB EXEMPT STATUS (UKY) | PHASE 1: EXISTING DESIGN (MARCH, 2018) |                | PHASE 2: NEW DESIGN (OCTOBER, 2018) |                |
|-------------------------|--|----------------|-------------------------------------|----------------|
|                         | Staff<br>n=51                          | Parents<br>n=2 | Staff<br>n=53                       | Parents<br>n=4 |
| Research Methods        | On-line questionnaire                  |                | On-line questionnaire               |                |
|                         | Lighting Measures                      |                | Lighting Measures                   |                |
|                         | Acoustical Measures                    |                | Acoustical Measures                 |                |

**Research Questions:**

2. What is the impact of creating NICU neighborhoods on the staff’s perception of their work environment?
3. What is the impact of private patient rooms on NICU staff and family members?
4. What is the impact of the architectural lighting scheme on the NICU staff and family members?
5. What is the impact of sound levels on the NICU staff and family members?

The pre/post portion of this study received approval from the University of Kentucky IRB.

**TIMELINE & METHODS**

|                         | PRE-DESIGN           | PRE-OCCUPANCY        | POST-OCCUPANCY                                 |
|-------------------------|----------------------|----------------------|--|
| <b>RESEARCH METHODS</b> | 2015                 | April 2018           | November 2018<br>(April/May 2019 also planned) |
|                         | Staff Questionnaire  | Staff Questionnaire  | Staff Questionnaire                            |
|                         | Family Questionnaire | Family Questionnaire | Family Questionnaire                           |
|                         | Staff Focus Group    |                      |  |
|                         | Family Focus Group   |                      |  |
|                         |                      | Acoustic Readings    | Acoustic Readings                              |
|                         |                      | Light Readings       | Light Readings                                 |

Staff survey data was analyzed using descriptive statistics. Lighting data was analyzed using descriptive statistics. Family respondents were too small in number (n=2, n=4) to do a comparative analysis. Pre- occupancy acoustic readings were completed, however, post-occupancy readings are currently being evaluated. They will also be compared using t-tests.

**RESEARCH OBJECTIVES**

The main objectives of this study were to first, inform the critical to quality needs, and understand predictor variables of the users during the Design Concept phase and then to evaluate user perceptions of design elements, lighting, and acoustic characteristics of a NICU, before and after a NICU redesign (from open bay, multi-bed rooms to private patient rooms). There was also a secondary objective of triangulating perceptions of lighting and acoustics with environmental measures.

The dependent variable for the study was staff and family perceptions of the designed environment. Independent variables were changes to design, layout, lighting and acoustics.

The design goals of the project were to provide:

1. Private rooms to positively impact patient, family, and staff outcomes.
2. Enhanced architectural lighting scheme to impact patient outcomes.
3. NICU neighborhood design to increase staff efficiency, improve wayfinding and provide a sense of belonging for families.



## RESEARCH CONTEXT

Neonatal intensive care units (NICU) contain some of the most fragile and vulnerable patient populations. Many NICU babies have little ability to regulate their own bodily systems, heightening the importance of the immediate environment for development. Recent longitudinal studies have revealed that what impacts these fragile babies today, has long-lasting future effects (Pineda, et al, 2014). Add to that, an increasing concern for Neonatal Abstinence Syndrome babies whose needs are mixed, in terms of acuity and parent-child bonding (MacMullen, Dulski, & Blobaum, 2014). Support for all NICU babies is not limited to their physical and cognitive needs, but also extends to their parents, grandparents and other loved ones, along with staff, whose constant vigilance often results in missed breaks and needed self-care. So what impact does the surrounding environment have on all NICU users?

White et al. (2013) included recommendations for NICU ambient, procedure, and support area lighting. The Illuminating Engineering Society (IES) has also published limited recommendations for NICUs in the Lighting for Hospitals and Healthcare Facilities Recommended Practice RP-29-16. Both documents recommend cycled lighting for newborns at 28 weeks gestation or older. According to White [2013], there has been no demonstrated benefit of cycled light before 28 weeks.

White et al. (2013) also included recommendations for infant, staff, and parent areas to be designed to produce minimal background noise and to contain and absorb transient noise. In a review of literature, Brown (2009) concluded that lower levels of noise in the NICU may improve the physiologic stability and long-term outcomes of preterm infants.

While the recommended standards for Newborn ICU Design [White, et al., 2013] and the Facilities Guidelines Institute (2018) include recommendations for all aspects of NICU design including layout, materials, lighting, and acoustics, most of these recommendations are based on design and operations best practices. Few studies exist to enable evidence-based design decision-making in this environment. This pre/post study of the redesign of an open bay NICU to a private room NICU presents the opportunity to evaluate some elements of existing standards. Specific areas of interest were layout, design elements, lighting, and acoustics.

# RESEARCH METHODOLOGY

## PRE-DESIGN STUDY

In the pre-design study (2015), a systematic approach was devised to collect quantitative and qualitative pre-occupancy data that truly represented the voice of the NICU users (VOC). To do this, customized questionnaires were distributed to both staff and family members to understand significant predictor variables of the indoor built environment in relationship to work performance and perception of care. For example, predictor variables included noise level, electric light, amount of work surface area, and availability of work stations.

Then, 60-minute semi-structured focus groups were conducted with three different user groups—staff, parents of previous NICU patients, and parents of current NICU patients. Focus group discussions were structured around key findings from the questionnaire. In addition, images were provided to support design concepts.

## PRE- & POST-OCCUPANCY RESEARCH

In April 2018 (pre-occupancy) and November 2018 (post-occupancy), an online survey was administered, through Qualtrics®, to explore staff and family member's level of satisfaction with the design and standardization of specific areas, such as the overall unit design, patient rooms, workstations, supply storage and medication storage.

The survey was comprised of questions focused on unit design, lighting, and acoustics. Questions about the design of the unit were drawn from a validated instrument used in previous facility evaluations. Respondents were asked to rate their satisfaction with design characteristics on a 5-point Likert-type scale. The parent survey included the same set of design questions as the staff survey but eliminated sections about work and instead focused on how aspects of the built environment affected the parent experience. The lighting questions were drawn from a survey created by a U.S. government research laboratory.

## RESULTS

Survey results were collected at two points in time. Surveys were issued about one month prior to the move and six months following the move to the new unit. There is a plan to conduct the survey again in 6 more months to evaluate any further perceptual changes. Pre move participants (n=51) and post-move participants (n=53) were largely female (n= 94%, n=96%) and the majority were nurses (n=68%; n=96%). The rest of the questions were evaluated using a 5 point Likert scale with corresponding open ended questions rounding out each category. In the work environment category, the biggest differences discovered were for noise (42% dissatisfied, 60% satisfied), speech privacy (62.16% very dissatisfied, 60% satisfied), visual privacy (48.65% very dissatisfied, 55% satisfied) and overall satisfaction with staff workstations (45.95% dissatisfied, 74% satisfied).

## FINDINGS

Findings were similar for the patient care areas/rooms. The majority of pre-move responses were very dissatisfied to dissatisfied and post-move most responses were satisfied to very satisfied. The highest under-performers pre-move were amount of space for medical equipment (59.4% very dissatisfied, 42% satisfied), amount of space to perform tasks (56.76% very dissatisfied, 43% very satisfied), amount of work surfaces/countertop (54.05% very dissatisfied, 55% satisfied), and availability of work stations (40.54% dissatisfied, 67% satisfied).

The last set of data reveal the story of the concern of moving from an open with multiple babies to private rooms. When asked about proximity to their patients, staff were mildly satisfied prior to the new design (37.84% satisfied). In the new design, staff were more satisfied at 62%. Similarly, when asked about proximity to other caregivers, the responses rose from 40.54% to 74% satisfied. Another important metric was in relationship to staffs' ability to concentrate without distractions, which rose from 35.14% dissatisfaction to 64% satisfaction.



While these data represent one case study, the results are compelling and largely supportive of the move to private NICU rooms and the creation of NICU neighborhoods.

Measurements of illuminance, spectral power distribution (SPD), and spectral reflectance distribution (SRD) were gathered in a typical patient room. Additional data about the response to NICU lighting was gathered through the lighting control system in the new unit, as well as lighting perceptions through surveys.

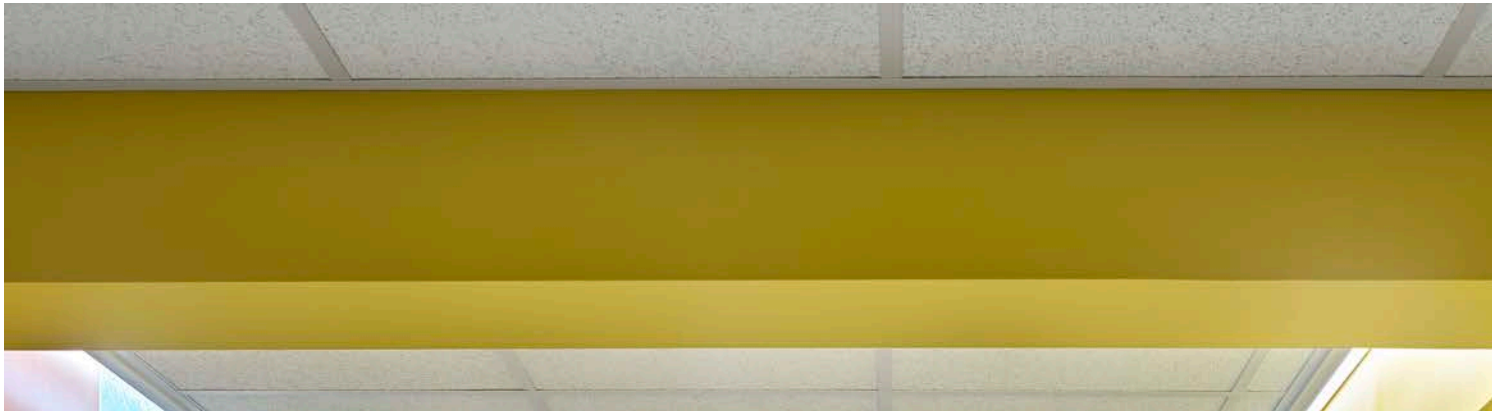
Sound levels and sources of peak noise were measured in a unit corridor, a designated nurse station/gathering spot, and a patient bay/room. At each location, decibel levels were recorded in 15-minute increments over a one- to two-week period. Post-occupancy sound analysis is ongoing at the time of this submission. Results should be illuminating.

## IMPLICATIONS FOR PRACTICE

Pre-design survey data helped to inform the critical to quality needs of the space. This related to both family and staff needs. Audio recordings of the focus groups were transcribed and coded to identify common themes and to triangulate and inform questionnaire findings. Data collected was then utilized to create a customized design criterion of themed categories that truly represents the VOC. The VOC criterion was combined with project objectives established by the design team and used to help evaluate prototypes and mock-ups.

Pre/Post Occupancy data analyzed indicate that there are positive aspects to private room NICU design. In almost all categories studied, staff were more satisfied with the new environment. While this represents a positive change for this facility, more research is needed to validate these findings and help designers and healthcare practitioners alike to make informed design decisions and to validate those designs after the move. This research is ongoing as another set of data will be collected in 6 more months to determine if the changes noted have a lasting impact on the staff and families.

The initial data shows that there were more changes to lighting control system between 8 p.m. and 8 a.m. than during the day, indicating that the programming of the lights during the day is meeting the needs of the occupants. Further analysis is needed to understand if there are changes to the lighting that could be more beneficial for the occupants during the evening hours. Initial analysis of the survey data from staff in the old NICU shows that the staff generally found the lighting to hinder their work, and that the light level and control of the lights was most important to the staff. Further analysis of the old and new NICU survey data is ongoing.



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