The Impact of Single Family NICU Rooms

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PR SHORT ABSTRACT FOR CHER NICU RESEARCH (word count 245)

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A recent trend in the design of neonatal intensive care facilities has been to increase the number of private patient rooms. Several factors have contributed to the recent popularity of single-family rooms (SFRs): 1) supportive data on infant outcomes, 2) increased understanding of the impact of family-centered care, 3) the hospital-wide trend toward private rooms, 4) the success of innovative prototypes, and 5) the need to comply with the Health Insurance Portability and Accountability Act (HIPAA). The purpose of this study was to explore the implications of SFRs relative to open-bay arrangements.

The settings included eleven single family room, open-bay, combination and double occupancy Level III NICUs. The research design used plan reviews, site visits and behavioral observation. Construction cost data were evaluated based on first costs adjusted to 2005 values and normalized to the National City Average as described by R. S. Means Building Construction Cost Data, 63rd Annual Edition. Anonymous personal health information was collected to compare patient medical outcomes. Surveys with NICU medical staff and parents explored preferences.

Based on the results of this study, it is suggested that SFR NICU design provides solutions for increasing parent privacy and presence, supporting HIPAA compliance, minimizing undesirable beds, increasing staff and parent satisfaction, and reducing nursing staff stress. Potential limitations of the SFR design are reduced parent-to-parent social contact and the potential for isolation of both parents and staff. In the projects reviewed in this study, construction cost difference between open-bay and SFR was 3%.

THE IMPACT OF SINGLE FAMILY NICU ROOMS

Executive Summary

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THE IMPACT OF SINGLE FAMILY NICU ROOMS

Executive Summary

Purpose

This research project explores the implications of single family room care in neonatal intensive care units (NICUs). The settings for this investigation included both private and open units and allowed for a comparison regarding (1) neonatal outcomes; (2) family needs and preferences; (3) staff behavior, needs, and preferences; and (4) construction and operational costs. The findings are translated into design guidelines. This study is an initial, comprehensive effort, the purpose of which is to spawn future, narrower, in-depth studies focused on neonatal intensive care unit design.

A recent trend in the design of neonatal intensive care facilities has been to increase the number of private patient rooms for neonates and their families. Several factors have contributed to the popularity of single family rooms: (1) data on the positive impact of developmentally-appropriate care on infant outcomes (Als, et al., 1994); (2) increased understanding of the value of breastfeeding and kangaroo care (Ferber & Makhoul, 2004); (3) the hospital-wide trend toward private rooms; and (4) the success of innovative prototypes. The implementation of the Health Insurance Portability and Accountability Act (HIPAA) has also influenced the design of NICUs due to the need to provide patient privacy (Mathur, 2004).

Infants are affected both directly by their environment and indirectly by their caregivers, who are also influenced by the environment. A broad range of outcome measures must be incorporated, including patient outcomes, construction costs, and the impact on staff and families. Research addressing the physical and psychosocial benefits and costs to families, neonates, and medical staff; and the monetary and organizational implications regarding construction and hospital systems is needed to provide the tools for planning new NICUs. These results, in turn, must be translated into design guidelines to make them accessible to practitioners.

Literature Review

Current Research on Single Family Room Design

Research on single family room design is very limited. Because of this, a net must be cast broadly to obtain information related to this topic. The following literature review addresses the history of pediatric health design research and NICU research, and recent studies focusing on NICUs, which do not specifically address single room care. Literature on single room maternity care is summarized, as some issues may be similar to NICUs. The brief body of literature pertaining to single family rooms is also summarized.

A literature review of administrative, construction cost, and plan review research follows the discussion of single family room studies. So little research has been published on this subject, works in progress, texts and conference proceedings were included to provide additional information to the reader.

History

It is useful to examine NICU studies in the context of research regarding pediatric health design. Pediatric health design research by mid-1987 included 257 articles focusing on general facilities, ambulatory care, emergency rooms, inpatient units, play spaces/lounges, and psychiatric facilities. Thirty-two of these articles addressed pediatric intensive care units (PICUs) and NICUs. In the subsequent decade, 190 studies were conducted focusing on similar topics; however, 72 of them addressed PICU/NICU settings. This represents a growth in the literature on PICUs and NICUs from 12.5% to 39%. The cause of this growth is uncertain, although several factors probably contribute to the high interest level. One is the perceived vulnerability of the population. Another might be the awareness that children who receive good medical care will have fewer problems in the future. A third reason might be the specificity of the architectural setting. Lastly, PICUs and NICUs are a relatively new space type and therefore generate significant interest.

Family Experience

The literature which focuses on family experience addresses stressors affecting the mother including alternations to the traditional parent role and the infant's appearance and behavior (Miles & Frank, 1998; Bialoskurski, Cox & Wiggins, 2002). The most important need was accurate information about the baby's health status, followed by good communication with healthcare providers. Cescutti-Buttler and Galvin (2003) studied parental perception of staff competency in a NICU. Parents perceived competence based on specific factors: 1) integration in the care process; 2) control; and 3) communication. The researchers found that when parents were given a sense of control, they felt less like "guests." In terms of parental satisfaction, Conner and Nelson (1999) identified access to food and a place to rest as desirable by parents; a waiting area and overnight accommodations were deemed essential.

Noise and Light

Extensive research has focused on noise and light in NICU environments. Several studies have documented noise levels above 49 dB, which is higher than recommended noise levels for NICU units. Many studies suggest that staff conversations are the major contributor to noise levels (Kent, Tan, Levy, Woolston & Brown, 2003; Chang, Lin & Lin, 2001). Additional studies have focused on noise and the affect on the NICU patient (Gray & Philbin, 2004; Philbin, 2000; Philbin & Gray, 2002; Philbin & Klaas, 2000). Other studies have focused on implementing changes of the physical environment to decrease ambient noise levels (Berens & Weigle, 1996; Johnson, 2003).

Infection Control

In a recent report on the role of the physical environment in the hospital (Ulrich & Zimring, 2004), the authors identified more than 120 studies linking the built environment to infection in the hospital. The studies focused on sources of airborne infections, primarily air quality and natural and forced ventilation (Oren, Haddad, Finkelstein, & Rowe, 2001), as well as on the control and prevention of airborne infections using HEPA filters (Dharan & Pittet, 2002). Current literature addresses the need for increased hand washing and suggests effective education, accessible hand-washing stations and alcohol-based cleansers, and single patient rooms as strategies that

may reduce the rate of infections in patient units (Adams-Chapman & Stoll, 2002; Cohen, Saiman, Cimiotti, & Larson, 2003; Gelber & Ratner, 2002; Saiman, 2002; Ulrich & Zimring, 2004).

Cost of Care

Infants born preterm accounted for most of the $10 billion spent on neonatal care in 2003 (Cuevas, 2005). This expense is related to the requirement of highly qualified personnel to provide care to these infants, the need for expensive technology and pharmacology, and the extended time period these neonates often remain in the hospital (LaPine, Jackson, & Bennett, 1995; Merritt, Pillers, & Prows, 2003; O'Shea, Klinepeter, Goldstein, Jackson, & Dillard, 1997; Rogowski, 2003; Roth, et al., 1995). The cost of neonatal care is based on intensity of treatment and length of stay (Doyle, Murton, & Kitchen, 1989; Powell, Powell, Hollis, & Robinson, 1992). Both of these factors are inversely related to gestational age and birth weight. The smaller, sicker infants need the most intensive care and require an extended stay in the NICU. Cost of care is also directly proportional to survival. Since the survival rate of critically ill infants has increased and this trend is expected to continue, the cost of neonatal care is also expected to increase (Walker, Vohr, & Oh, 1985). In general, NICUs have high fixed costs with lower variable costs. Therefore, strategies that lower fixed costs can have a significant impact on the actual costs associated with an individual unit.

In the NICU there may be several potential areas where hospital costs can be contained without increasing either the mortality or morbidity of the neonatal patient. One such avenue that is currently being explored is the provision of developmental care. Developmental care focuses on coordination of activities to increase the amount of uninterrupted sleep, positioning to prevent disorganization and to promote self-regulation, and decreasing both light and noise in the NICU environment (Als, 1992; Als, et al., 1986, 1994). Developmental care has been shown to decrease the length of stay and the total hospital costs by $4,340–$25,670 per infant (Als, 1996; Fleisher, et al., 1995; Petryshen, Stevens, Hawkins, & Stewart, 1997). Developmental care has also been shown to decrease the risk of severe lung disease, decrease the rate of intraventricular hemorrhage, increase weight gain, and decrease the need for more intensive nursing care, all of which increase both hospital costs and length of stay (Als, 1996; Fleisher, et al., 1995; Petryshen, Stevens, Hawkins, & Stewart, 1997).

Another potential way to decrease the cost of healthcare in the NICU is by implementing early discharge programs. Aggressive discharge planning, extensive parental education, and home healthcare have been shown to significantly decrease hospital costs in the NICU by decreasing the average length of stay by 12–30 days, resulting in a significant cost savings of up to 27% (Brooten, et al., 1986; Kotagal, et al., 1995; Merritt, Pillers, & Prows, 2003).

Construction Costs

Studies reporting construction costs related to NICU environments or acute-care facilities were not found. However, a discussion of the rising cost of constructing healthcare facilities indicates that design elements and strategies for patient-friendly healthcare environments are often the first items cut from projects during value engineering (Moon, 2005). Moon states that price increases from commodities such as oil, steel, and other construction materials, coupled with larger space requirements and

changing technology help to fuel the rising costs. Moon (2005) cites an increase of 10%–15% for many healthcare facility projects currently under construction compared to the previous year. Construction costs can vary depending upon a number of factors, such as policies of regulatory agencies; type of contract; season of the year; construction management issues; weather; building codes; availability of adequate energy, skilled labor, and building materials; owners' special requirements/restrictions; safety requirements; size of project; and location (Waier, 2005).

Methodology

The settings for this research include 11 single family room, open-bay, combination, and double occupancy Level III NICUs across the United States. Each facility provided an AutoCAD or scaled floor plan and other supportive documents related to the design and construction of the NICU. In addition, participants provided construction cost data and anonymous aggregate personal health information. Four facilities hosted site visits and provided access for post-occupancy data collection; and two hospitals participated in staff and parent surveys. The research design used several methods. In the complex healthcare environment, the use of multiple methods allows researchers to gather sufficient data about different aspects of a subject.

Plan Reviews, Site Visits and Post-occupancy Evaluations

Plan reviews, site visits and post-occupancy evaluations assessed the physical environment and impacts on the users. The physical environment was documented through architectural plans, specifications, and program. Through plan analysis, the program was extracted and compared to facilities of the same configuration and to other configuration types. The plan assessment was followed by calculating the average square feet for (1) infant space, (2) family space, (3) staff space, (4) circulation, (5) staff space at bedside, and (6) family space at bedside. Space allocated to public space and vertical circulation was excluded from the overall square feet of each unit. Once all of the plans were measured and the areas determined, the net-to-gross factor for each facility was calculated based on the non-usable square feet (wall partitions).

Construction Cost Analysis

All of the participating hospitals provided construction cost data. Since the units are located throughout the United States and were built between 1995 and 2005, it was necessary to adjust the costs for comparison. Construction costs were compared after adjusting to the year 2005 and normalizing to the national average cost. The Means Historical Cost Index was used to adjust the archival cost data from each participant to what the approximate construction cost for each facility would be in the year 2005 (Waier, 2005). After the costs were adjusted to 2005, the Means City Cost Indexes (Waier, 2005) were used to compare cost from city to city, with the end result normalized to the National City Cost Average. The cost analysis was based on the dollar value of the unit, which may in some cases have been extracted from larger projects or, in the case of expansions, extracted from the cost associated with addition to the building envelope.

Patient Medical Outcomes

Of the 11 hospital participants, only 5 were able to provide the requested hospital records data for two years prior to occupying the new unit and two years post-occupancy. The data was supplied by two SFR units and three open-bay units. The data collected focused on patient and staff data that was generally available through the healthcare systems database and was supplied to the research team by a hospital employee. The type of data collected included staff turnover, patient to staff ratios, patient transfers, admissions and discharges per year, average daily census, average length of stay, and reports of nosocomial infections.

Surveys of Healthcare Staff and Parents of NICU Patients

Surveys of NICU staff and parents of infants who had been treated in the NICUs explored the preferences and experiences of those who were providing and receiving care in open-bay units compared to single family room units and combination units. The staff surveys were distributed to two facilities: one unit had changed from open-plan to single family room; the other unit had changed from open-bay to a combination unit. One hundred sixty staff surveys were sent out, with a return rate of 47%. The parent survey was sent in two batches. A total of 21 responses were received from parent participants.

The objective of the analysis was to examine questionnaire answers to detect and compare significant differences between the open-bay and single family room NICUs. More specifically, the following hypotheses were tested:

1. Staff members and parents of patients are more satisfied with the environment of the SFR unit than the open-bay unit.
2. Staff members and parents of patients perceive the physical environment in the SFR unit to be better than that of the open-bay unit.
3. Staff members and parents of patients report less stress in the SFR unit than the open-bay unit.
4. Staff members have higher ratings of job satisfaction in the SFR unit than the open-bay unit.

Results

Plan reviews

The allocation of space within the NICUs participating in this study provides clues to trends regarding the need to accommodate parents and extended families, the participation of families and how much access they will have to their child and to healthcare, and the ability to meet the functional needs of the space and to provide adequate support for the unit staff. Allocated square feet imply a specific use or user. While it may be useful for an institution to compare its facility against the configuration averages, due to the variety of solutions for the NICUs within the configurations, the results are not generalizable.

Unit Space Allocations by Configuration

The review of plans shows that regardless of design configuration, there is a lot of variety in the organization of space. This study identified space allocated to infants; families; unit staff; building and medical systems; and the public, if applicable (see Appendix A). Generally, it appears that the design of the units may be driven by the

philosophy and nursing model of the NICU unit, the pragmatic needs of the staff, and the limitations of the building. For instance, the only facility that clearly integrates the family space (outside of the infant area for that family) within the infant care areas is Single Family Room Unit A. All other facilities, regardless of design configuration, relegate the family space to an adjacent area or, at best, to the very edge of the patient care areas. The relationship of unit staff space to the infant care areas is consistent through all configurations. Staff and support spaces are integral to the patient care areas, including the single family room unit configuration.

This study found that the mean space allocation within the unit for infants, families, and NICU staff combined was 59% of the unit design, regardless of configuration. For the SFR configuration, the mean was 51%; the mean for the open-bay configuration was 58%; the combination configuration mean was 68%; and the double occupancy configuration mean was 57%.

The double occupancy configuration allocated the most space to the patient. Space allocated to the infant is defined as the infant station, whether it is a room, a pinwheel, an open area, or a shared space. The least amount of space allocated to a patient was 23% of the open-bay unit. Space allocated to the family away from the infant station was similar in SFR, combination, and double occupancy configurations; however, the open-bay configuration had the most space allocated to the family, with a mean allocation of 10%. The mean allocation of space for staff work and support functions was lowest for double occupancy (17%) and SFR (19%). The unit configuration with the highest allocation of space for staff and support functions was the combination configuration, with a mean of 38% (Figure 1).

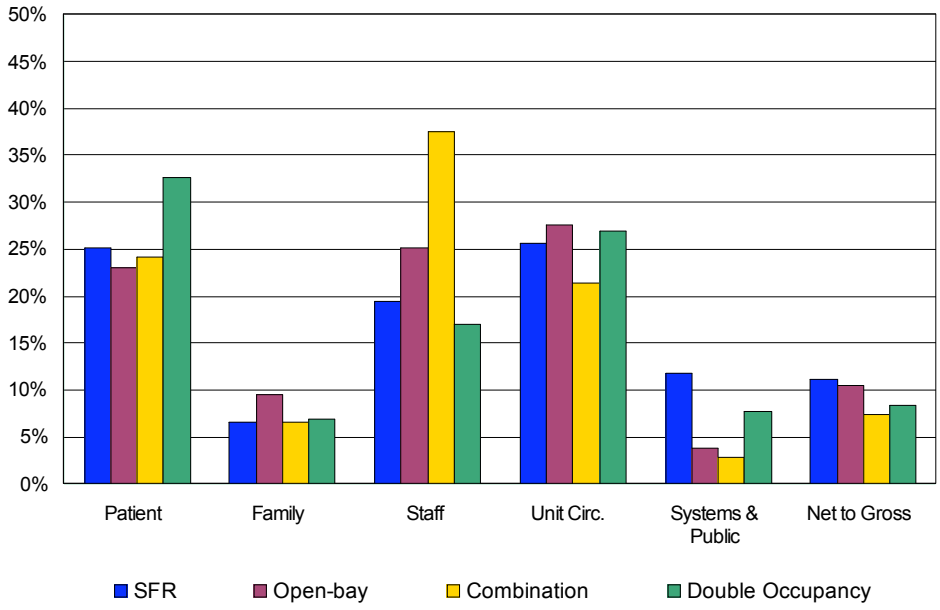

Figure 1. **Percentage of space allocation by use category comparing configuration types.**

The mean usable space allocated to circulation for all 4 configurations was 26%. The mean usable space allocated to circulation by configuration varied from 21% to 28%, from combination to open-bay, respectively. The SFR configuration's average allocation of space for circulation was closest to the overall average at 26%. The net-to-gross variance for all 4 unit configurations had a mean of 10%. The unit configuration with the lowest net-to-gross factor was the combination unit (7%), while the SFR and open-bay configurations shared the highest (11%).

Allocation of Space for Infant Station Area by Configuration

At the infant station or infant room, the average clear floor space for all infant station configurations was 73%, with all configurations within +/- 6%. The unit designs with the highest amount of space allocated to the infant were the open-bay configuration (24%) and combination configuration (19%); SFR allocated 12% to the infant. However, the space allocated to families was highest in the SFR unit, with 50%. The lowest amount of space allocated to the family at bedside was in the open-bay unit (39%). For staff and support space, the overall mean was 38%, with all configurations within +/-3% (Figure 2).

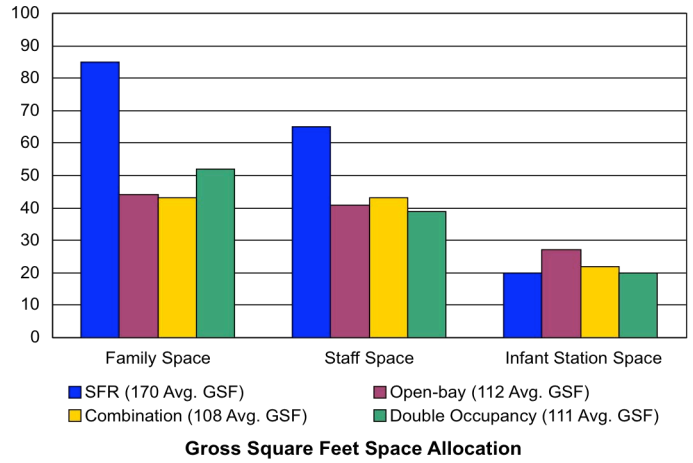

Figure 2. **Allocation of space within the infant station or infant room by unit configuration.**

Site visits and Post-occupancy Evaluations (POE)

SFR Unit

The SFR had 22 licensed infant stations in rooms ranging in size from 162 SF to 172 SF. Privacy is supported by design through the use of enclosed rooms with two privacy curtains – one at the door and one between the family zone and patient area. Nursing staff encourage families to close the door and curtains; acoustical privacy is still a concern voiced by the families. When parents are not in the SFR, the doors are open and nurses can view monitors. Of the 22 SFRs, 16 are visible from the desks in the pod central work areas. To combat the potential feeling of isolation, nurses bring babies from one pod to another for feeding so that they can congregate with other nursing staff.

There are four pods of patient rooms with staff stations in each, which are used for charting, communication, medicine preparation, discussions with parents and staff interaction. The hospital's patient satisfaction surveys indicate that the noise levels from these work areas are too high.

Open-bay Unit #1

Open-bay Unit #1 also has 22 licensed infant stations with 2 sets of 4 stations in pinwheel configurations and the rest along the perimeter of the unit. This unit has 2 isolation rooms and 2 bays for Extracorporeal Membrane Oxygenation (ECMO). The infant station care areas range in size from 102 SF to 110 SF. The isolation rooms are 130 SF and the ECMO bays are each 168 SF. For visual privacy, parents use privacy screens to separate their infant area from the rest of the unit. The ECMO bays have cubicle curtains covering glass partitions between the two areas while the isolation rooms have sliding glass doors, which afford acoustical privacy, but still requires the use of screens for visual privacy.

The nursing staff are all located in the same work area with the clerk located at the entrance to the unit. Additionally, there are two nurse chart areas within the nursery and a small work area adjacent to each infant station.

Open-bay Unit #2

Open-bay Unit #2 has 45 licensed infant stations with zones designated for Level III and Level II nurseries. There are six pinwheel islands, each with 3 infant stations; infant stations along the perimeter of the unit; one isolation room and two rooms that have 4 infant stations each. The space allocated for patient care stations range from 124 SF (pinwheel) to 130 SF (perimeter) with the two rooms holding for infant stations each at 293 SF and 282 SF. There are no provisions within the nurseries for auditory or visual privacy. The unit does have two breast feeding rooms.

There is one primary nursing station with a nurse work area located at the end of each patient care station. A small island work area is located in the center of the Level III nursery and a nurse/doctor work area is located in the Level II nursery.

Open-bay Unit #3

Open-bay Unit #3 has 30 licensed infant stations, split between Level III and Level II. Most of the infant stations are located around the perimeter, though 4 in the Level III area are in the center of the nursery. Two of the Level II beds are together in an isolation room. The infant stations size range from 88 SF (Level II) to 132 SF (Level III). According to comments from the staff, privacy is an important issue, though no provisions have been made to accommodate the need for visual or auditory privacy within the nurseries. However, the unit is supplied with two breast feeding rooms.

The Level II area has one centralized nurse station while the Level III area has two small nurse stations. Charting is accomplished at bedside.

Summary

Common to all facilities participating in the site visits and POE was the materials and finishes, which were typical for healthcare facilities. Each NICU provided a full complement of lighting fixtures to meet the needs of general lighting, exam and procedures, and controls at the infant station. Specific to the open-bay units, was the limits of visual and auditory privacy and, even though nurses could see infant stations across the open unit, visual access to the infant was limited by the use of isolette covers.

Post-occupancy Evaluation

Common to all units in this study was an agreement among staff that their new unit, regardless of configuration, was far superior to their old unit. Staff identified reduced crowding as a key feature. Other positive aspects were adequate room at bedside for at least two parent chairs, staff dedication and attention to infants, and the expression of concern for HIPAA compliance. Factors that may influence behavior were identified as parental presence polices, parental presence in practice, staff's accessibility to infants for monitoring, infant visibility, the nature and location of staff work space, controllable privacy and light at bedside, sound control features, distance to clean storage from bedside, acuity level of infants during visit, parental bedside features, parental sleep accommodations, methods for locating staff, amount of traffic within the unit, nursing assignment concerns, and methods for complying with HIPAA privacy. Security was a feature that involved the "buzzing in" of parents in the open-bay designs. The SFR did not have a locked door, but parents and visitors walked by a staffed desk between the elevator and the unit doors. There were also security cameras that covered all public spaces and could show any patient care room. The in-room cameras were used mainly when the mother was medically at risk or in cases when there was a history of domestic violence.

Privacy

The rooms in the SFR unit had both glass doors and curtains separating the infant care space from the public areas. These rooms also offered an additional level of parental privacy by providing a ceiling-mounted curtain between the designated parent space and the infant care and staff space. The isolation room at Open-bay #1 had glass doors with three opaque walls, and the two private bays had a combination of opaque and glass walls with no doors on the front of the bays. Screens were placed at the entrance to the bays to provide visual, but not auditory, privacy. Screens were also used in front of the glass side wall to increase privacy.

When SFRs are designed with privacy features that can be adjusted, how are these features ultimately used? At the SFR unit, families were the main controllers of the privacy features. Parents were present for long periods of time and appeared to choose privacy as soon as they arrived in the unit. When parents were present in the rooms, the sliding doors were closed more than halfway during 100% of the observations, and curtains were closed more than halfway for 87% of the observations. When parents are not present, staff members control the door and curtain; the door was closed at least halfway for 88% of the observations, and the curtain was closed for 82% of the observations. A common configuration for patient rooms when parents are not present is to have the curtain open wide enough to see the monitor while using an incubator cover to shield the infant from traffic. The door leading to empty rooms was open at least halfway for 70% of the observations, and the curtain was open for 54% of the observations. Temperature was another factor affecting door closure in the SFR unit. Although the original plan called for individual HVAC control for each room, the number was reduced to one control for every two rooms during the "value engineering" process. This leads to uneven temperature among the rooms, so the staff help parents modulate the temperature by opening or closing doors. The open-bay #1 "private" rooms/bays were closed off by a door or a screen for 100% of the observations; door closure was

controlled mainly by staff. Accessory equipment and staff protocols were used to provide privacy and confidentiality to open-bay units. Portable screens are commonly used to provide visual, but not auditory, privacy.

Traffic

The grand means of all observations of traffic counts is graphed in Figure 3. The SFR unit had notably lower traffic incidences than all the open-bay units. The open-bay units were not notably different from each other. The increase in traffic for open bays is attributable to increased staff entry to patient space and increased passerby traffic (looking and gaze averting). The relative ratios of traffic sources across units are shown in Figure 4. Parental presence was highest in the SFR. Parental presence in Open-bay #2 was concentrated between 4 to 6 p.m. and 8 to 9 p.m.

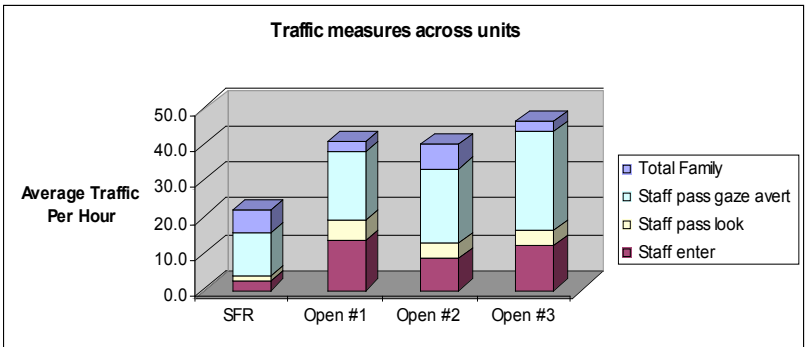

***Figure 3*. Traffic measures per hour across all 4 units.**

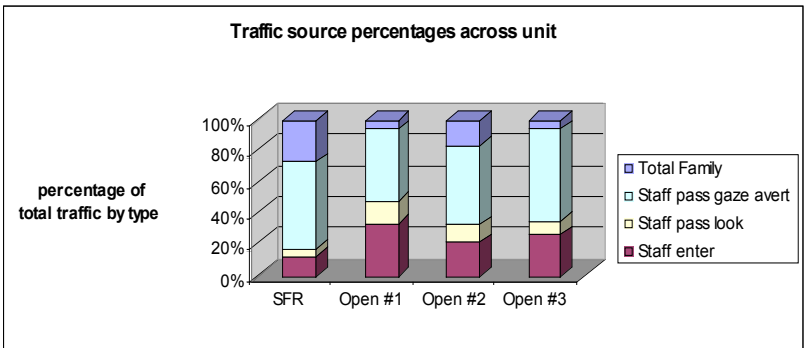

***Figure 4*. Percentage view of traffic sources across all 4 units.**

Individual Control of Space

Environmental dimensions that may be controlled in the unit are temperature, artificial light, daylight, noise, décor, traffic within the infant care area. In the SFR unit, each of these, with the exception of temperature, was individually controlled. The single-unit bays in Open-bay #1 were dimly lit for the high-acuity infants in the ECMO bays and well lit for larger, more stable infants in the isolation room, in accordance with each infant's response to stimulation. Staff controlled light levels, although one parent in the single bay requested a light change from staff, and researchers observed that one parent controlled noise around her infant by requesting lowered voices. In the open-bay units light, noise, temperature, and traffic were mainly under staff control. In Open-bay #2 a parent sitting between two infants who required minimal stimulation played a music

video at a low sound level; the nurse assisted with providing this stimulation, which was appropriate to the one family.

Controllable Privacy

One method of controlling privacy is shown in the traffic data over all conditions. The staff avert their gaze as they pass a bed space rather than look into the space. Parents and families showed a preference for gaze aversion as they passed a bed space as well.

The SFR unit had the highest use of controllable privacy. When they were present, parents were the main controllers of privacy measures. When parents were not present staff members controlled the privacy devices. The most striking finding was that all parents closed the glass sliding doors at least halfway when they were present.

Privacy in the Open-bay units was accomplished by providing movable screens and by facing families away from traffic. Screens were used 100% of the time for the private open-front bays in Open-bay #1. The door for the occupied isolation room was also closed during the entire visit. For the open portion of Open-bay #1 (excluding the private bays and isolation rooms) unit screens were used to increase privacy for 14% of the parents observed. No screens were in use in Open-bay #2 or Open-bay #3. Open-bay #3 reported frequent use of screens at other times.

Partition wall and partial-wall design affected privacy as well. Open-bay #1 also increased privacy by providing partial walls, which separated the beds around the perimeter into partially divided 2-bed bays. Center pinwheel walls were angled to traffic to provide increased privacy, especially for the side away from main traffic paths. This arrangement allowed sufficient privacy; for instance, when a code was occurring across the unit, parents on the other side of the pinwheels and partial walls were unaware of it. Open-bay #3 was designed with partial walls and pinwheels as well. The partial walls separated the beds around the perimeter into 2-bed bays, but the pinwheels were not angled in order to maximize the visibility of infants to staff. Planned 2-bed rooms at Open-bay #2 were designed to use glass walls and a door to increase privacy and reduce stimulation. These rooms were converted to 4-bed mini-pods with no division between the beds. Open-bay #3 had few walls separating the visual field, but the unit was designed with the long side of the patient care area along the perimeter wall. This orientation increased space between beds and allowed for more auditory privacy.

Parental Presence and Policies

Polices on parental presence were varied among units visited. As mentioned in the privacy section, 2 units had 24-hour parental presence policies (the SFR unit and Open-bay #3). Open-bay #1 was closed for one hour for each shift change. Open-bay #2 was closed to parents for two hours at each shift change (6–8 a.m. and 6–8 p.m.), during quiet time (1–3 p.m.), and during admissions. Each family who wished to enter Open-bay #2 had to be approved by the infant's nurse via a call from the unit clerk before they could enter. Open-bay unit staff might also ask parents to leave if an infant was coding or if there was a minor surgery occurring on the unit. Open-bay #1 staff asked parents who were near a code to leave, but the pinwheel and partial wall allowed parents on the other side of the room to be relatively unaware of two codes occurring simultaneously; these parents were allowed to stay. The all-SFR unit did not ask parents to leave during

admissions, codes, or procedures, since a parent inside one closed room is not generally aware of an admission, death, or procedure inside an adjacent room.

Units also had varied policies concerning the number of people at the bedside. Following advice from staff about noise and how to monitor infant response, the family was allowed to control traffic in the SFR unit. The desk clerk would phone parents when visitors arrived and would allow them to decide whether to visit in the lounge area or to bring the visitor back to the infant care space. Open-bays #1 and #2 enforced or encouraged a limit of two family members/visitors at the bedside; Open-bay #3 encouraged only two visitors in addition to parents.

Parent-to-Parent Contact

Parent-to-parent contact at the SFR unit was not very common. The unit was working to improve this situation and was considering options such as hiring a paid parent coordinator. Parents might see each other in hallways and briefly greet each other, but they did not interact in the lounge, in the rooms, or in the hallways during the observation period.

In the open-bay units, when parents were near their infants there was very little interaction between parents. When units were closed to parents for periods of time during the day, parent interaction occurred in the family lounge or hallways while parents waited for the unit to reopen.

Staff Monitoring of Infants

The SFR unit had the most sophisticated monitoring arrangement of the units observed. This unit had a staff locator system, which allowed the unit clerk to know where a staff member was at any time and allowed staff to see if a nurse was inside a room that was closed..

The other 3 units had individual monitors at bedsides, with auditory and/or flashing-light alarms that could be linked for assignments. They all required line of sight to at least one infant's monitor. This system kept nurses close to the infants' bedsides, even when charting. Line of sight was important in nursing assignments and care practices.

Staff Workspace Configuration

Staff workspaces varied across units. Each unit had some work space near the bedside. The SFR unit had a central workroom at the front of the unit and four "pod" substations in addition to bedside counter space. Shared equipment was stored in these areas. These pod substations are used for charting and conferring with colleagues. If a nurse had a "cross pod" assignment, she would generally chart at the pod where another nurse was sitting rather than have a pod to herself for an extended period. For quick tasks, nurses used all the pod spaces, sitting desks, and standing counters.

Open-bay #1 had a mix of substation desk areas (two) and distributed computers for charting. Open-bay #2 had more nurse activity in or near the patient care space, with little use of the two-sided central desk.

Pedometer Readings

Pedometer readings were used to test the supposition that SFR configurations would increase the amount of walking required by nurses during a shift. The lowest average steps per hour were found with the SFR unit, but the ANOVA shows no significant difference between the units.

Construction cost

The cost analysis based on the average cost per square foot suggests that the Combination configuration was the most cost effective, with an average of $204/SF (Figure 33). A $9 difference was found when comparing the average cost per square foot between SFR and Open-bay configurations ($294/SF and $285/SF, respectively). The Double Occupancy configuration had the highest average cost per square foot, with a dollar value of $331/SF. Interestingly, there was no suggestion of efficiency based on the average size of a unit and the cost per square foot. The cost differential between all four unit configurations was 24%. When comparing SFR and open-bay unit design, there was only a 3% increase in cost per square foot for the SFR. The combination unit design was the most cost effective, with a cost per square foot difference of 28% compared to open-bay and a 31% compared to SFR.

Patient Medical Outcomes

Hospital records for participating hospitals were collected to provide indicators of change in patient outcomes dependent on the move from an old NICU to a new NICU. The move to a new unit included moving from (1) open-bay to SFR, (2) open-bay to combination, and (3) open-bay to open-bay. The collection of data included average daily census (ADC), average length of stay (ALOS), average admissions and discharges, and average numbers of reported nosocomial infections (bloodstream and pneumonia).

The ADC increased for all three configuration types. The ADC increase for SFR units was 5%; the increase for open-bay units was 11%; and the combination units increased ADC by 6%. This increase generally correlates with the increase of the average number of infant stations for all configurations. The ALOS decreased in open-bay and combination units (2% and 9%, respectively). The ALOS for SFR units increased by 3%.

Average discharges were reported in three categories: (1) discharged home, (2) discharged transfer, and (3) discharged death. Average discharges increased in SFR units (4%) and combination units (20%). Open-bay units decreased by 9%. Alternately, SFR and combination units showed a decrease in patient transfers (15% and 13%, respectively). Open-bay units increased average number of transfers by 9%, the same percentage as the decrease in discharges to home. Open-bay and combination units showed a decrease in infant deaths. Open-bay decreased discharges due to death by 35%, while combination units decreased such discharges by 16%. SFR units averaged an increase of 15% for discharge of infants due to death, which correlates with the increased percentage of average number of infant stations. It is important to note that, in reporting these particular findings, the complex nature of variables influencing outcomes is not fully explored or explained within the context of this study.

Nosocomial infection rates were reported for bloodstream infections and pneumonia. Average rates of nosocomial bloodstream infections decreased in both SFR units (38%) and open-bay units (40%). Combination units showed an increase of 4% for

average rate of reported nosocomial bloodstream infections. The average rates for nosocomial infections for pneumonia decreased in open-bay units (88%) and combination units (22%). However, SFR units showed an increase of 55%. With only five hospitals providing nosocomial infection rates, the data set was very small, and no clear trends were evident.

Healthcare Staff Survey

A total of 75 staff questionnaire responses were received: 21 from Group 1 (Hospital 1, single family room), 27 from Group 2 (hospital 2, open bay), and 27 from Group 3 (Hospital 2, single family room). Among these groups, there were no significant differences in demographic characteristics, such as age, gender, and job title. The population surveyed was predominantly middle-aged Caucasian females. The average number of years working in NICUs was 13.38. Approximately 84% were nursing staff. The hypothesis that staff members in single rooms are more satisfied with the physical environment than the staff members in the open-bay configuration and perceive the former to be a better environment, are generally supported.

Staff members in Hospital 1 (SFR) are more satisfied with the physical environment than those in Hospital 2 (combination). The 2 groups (open and SFR) in Hospital 2 have similar satisfaction levels, although the data trends suggest that staff in the SFR are slightly more satisfied regarding all factors except waiting and resting space for families outside the NICU, and corridors and signage for Wayfinding (Figure 5).

In the staff's view, single rooms are superior compared to open bays in terms of providing privacy to families and infants (Figure 6). This is most strongly articulated in Hospital 1, which is limited to SFRs. However, in spite of the fact that some infants were housed in SFRs and some in open units in Hospital 2, very little difference was found in response to "the environment supports the family's presence and participation."

Single rooms are viewed by staff members to be less stressful for both family and staff members, although the SFR-only NICU is perceived as less stressful than the SFR portion of the combined unit (Figure 7). The SFR-only unit (Hospital 1) was perceived as less than half as stressful for family members (1.6) as the open-bay portion of the combined unit (3.5). A similar pattern was demonstrated with regard to the depression level communicated by the environment.

Both groups with single rooms seem to have lower stress levels and higher job satisfaction levels than the group with the open bay. Consistent with their high ratings of the physical environment, nursing staff members in Hospital 1 report less stress and more satisfaction with their job than their counterparts in Hospital 2. Within this context, the most problematic areas in all three unit types were workload, inadequate preparation, death and dying, and conflicts with physicians, all factors that are typically independent of the physical environment.

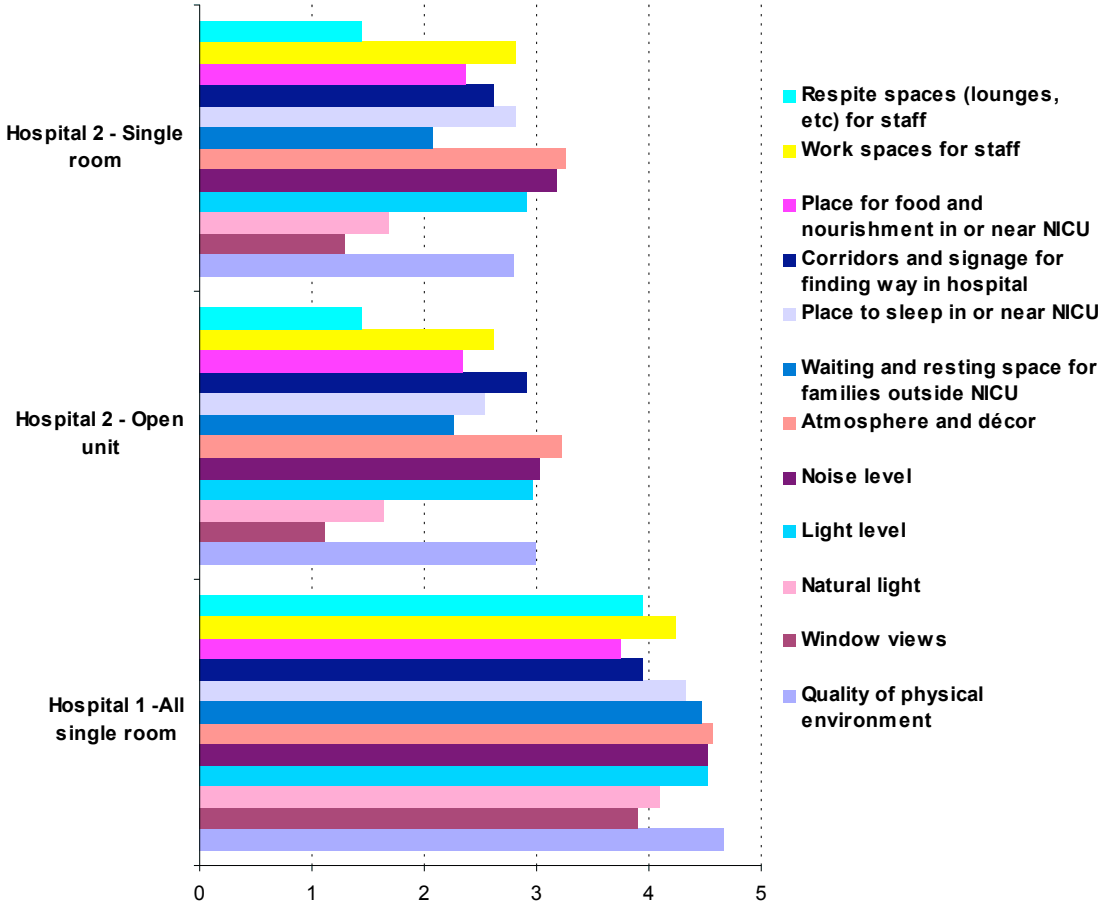

Figure 5. **Staff's degree of satisfaction with the physical environment.**

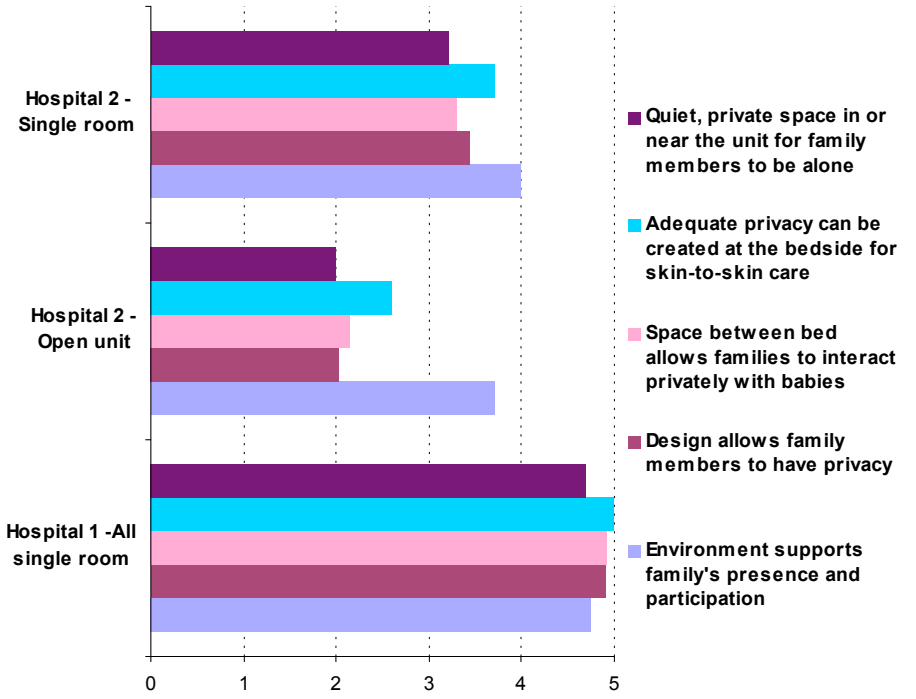

Figure 6. **Staff's levels of agreement regarding the physical environment.**

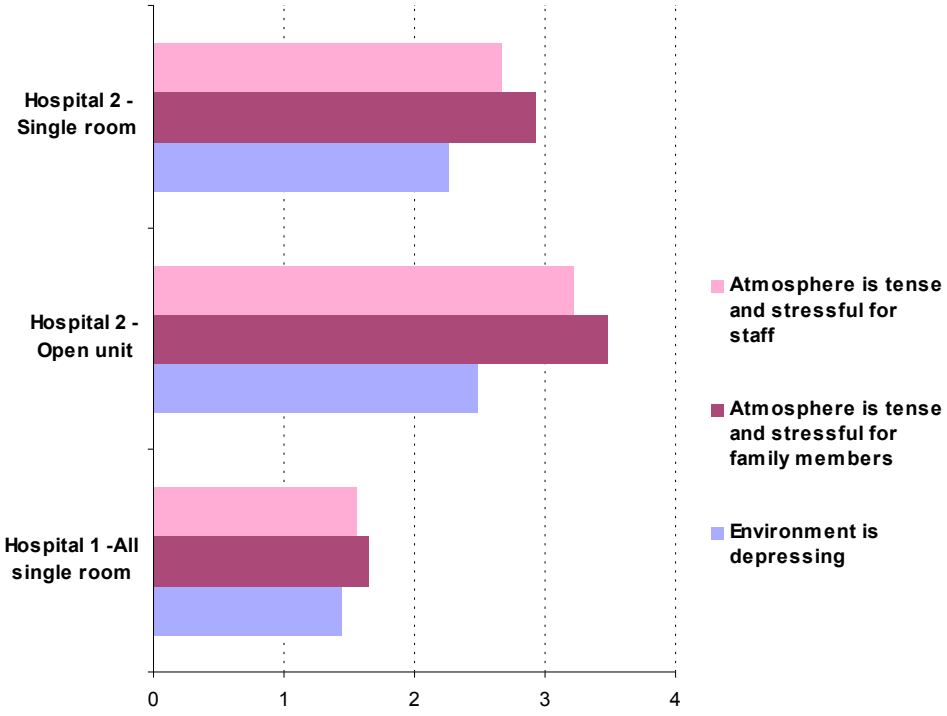

Figure 7. **Staff's levels of agreement regarding stress in the physical environment.**

Parent Survey

Twenty-one sets of parent survey responses were received: 16 from parents in single rooms and 5 from parents in open bays. Most were 21 to 40 years of age and Caucasian, and all were mothers. Two-thirds spent more than 8 hours per day in the NICU, and it was the first NICU experience for 86% of them. Similar to staff members, parents in single rooms seem to be more satisfied with the physical environment (Figure 8). The most significant difference was with regard to window view and place to sleep near infant. Wayfinding support was also perceived as being more effective, although this may be the result of changes outside the unit. Parents view single rooms as less stressful and less depressing than open bays, which is consistent with the staff members' views.

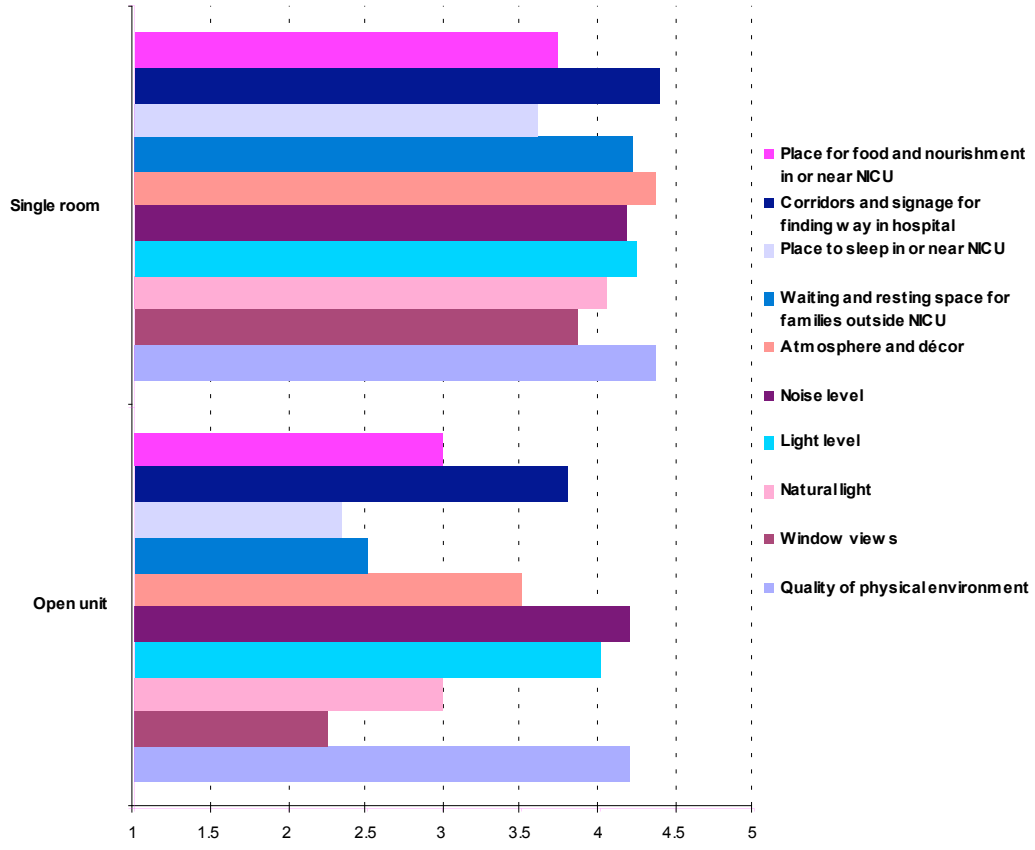

Figure 8. **Parents' degree of satisfaction with the physical environment.**

Discussion

Plan Reviews

Unit Configurations and Space Allocation

The plan reviews indicated that 59% of NICU units is allocated to patient, family, and staff programmatic requirements. The remaining area is allocated primarily to unit circulation, systems, and the net-to-gross factor (wall partitions). SFR unit configurations allocated 51% of usable area to patients, families, and staff; open-bay units allocated

58%; double occupancy unit configurations allocated 57%; and combination unit configurations allocated 69%.

The SFR configuration was equal to the aggregate mean of the 4 configurations for unit circulation (26%). Open-bay and double occupancy configurations exceeded the mean, and the combination configuration was below the mean. Developing design strategies for minimizing circulation to allocate valuable space to families and staff is recommended.

The SFR and open-bay configurations both had a net-to-gross factor of 11%. The means for combination and double occupancy unit configurations were below the average of 10% (they were 7% and 9%, respectively).

A higher number of infant stations indicates a trend toward spatial efficiency. However, this is not specific to the configuration of the unit.

Infant Space Configurations

The infant station or infant room is defined as clear floor space allocated to the patient, family, and staff. Within this area, the SFR had the most space allocated to family (85 SF=50%), while the open-bay and combination configurations had the least (44 SF=39%, 43 SF=40%, respectively). Space allocated to staff had a mean of 38%, with all configurations within +/- 3%. Square feet of configurations for staff space were (1) SFR, 65 SF; (2) open-bay, 41 SF; (3) combination, 43 SF; and (4) double occupancy, 39 SF.

Site Visits

Four NICUs were documented through site visits: 1 SFR and 3 open-bay units. Regarding the materials palette, there were no distinguishable differences in materials and finishes used within the units.

The achievement of privacy was most successful in the SFR unit. Private rooms allow privacy for parent-infant interactions such as kangaroo care, allow private consultation with the physicians, and shield the families from the activity and environmental noise from the unit at large. The open-bay units addressed privacy concerns in a variety of ways, including the deployment of mobile privacy screens and other objects. These alternatives were less successful in creating visual barriers.

Nurse supervision in the SFR was affected by the parents' ability to close doors and blinds to the single family room. Clearly, the families were exercising their right to privacy. Generally, when family members were not in the SFR, the nurses would partially open the doors and blinds for better visual access. The open units generally had a clear view across the unit, but staff had limited visible access to infants, as the infant stations were covered to shield the infant from light and noise.

The SFR units had decentralized nurse stations in their pod design. Patient satisfaction surveys indicated that noise levels were too high in these areas and that the source was the nursing stations. The open-bay units had centralized nursing stations with a charting area at the bedside. To successfully mitigate noise concerns, one open-bay unit utilized a meter with a flashing-light warning system. Noise continues to be a major concern for all NICUs.

The SFR unit had hand-washing sinks located at the entry to each pod of patient rooms and within each SFR. The open-bay units met minimum standards by providing an

adequate number of sinks within 20 feet of the infant stations. It is recommended that providing access to hand-washing sinks, utilizing newly approved portable hand cleaners, and providing continual education for patient safety be strategies for meeting expectations for infection control.

The SFR design supported individualized control of lighting. Also, as the private rooms are enclosed, the lighting is contained within that space and does not intrude on adjacent patients. In rooms with direct access to daylighting, nurses kept the blinds closed for the VLBW infants and opened for infants closer to transitioning. Staff had limited access to natural light. The open-bay units maintained a low level of light throughout the unit. Electric light at the bedside had separate controls, but access to controls varied among the units. The amount of daylight varied in the open-bay units, but adequate levels were provided throughout the space.

Post-occupancy Evaluations

Privacy

Ensuring privacy is a multi-component operation in the NICU. According to HIPAA guidelines, NICU staff must keep infant medical records private and available only to staff involved in care, staff-in-training, and parents of the infant. Parental privacy is also important. Having a child in the NICU is an emotional and sometimes overwhelming experience. Grief behaviors such as crying are common and personal. Being with one's infant is also an intimate experience, and many behaviors (skin-to-skin holding, singing, baby talk, and the like) are private in nature, especially for introverted parents.

Parental Space and Amenities at Bedside and Nearby

The SFR unit had the highest number of parent amenities. The bedside amenities included a small desk with a light, a built-in sofa, a storage area, a kangaroo recliner, and a rocking chair. Nearby were restrooms and a parent lounge that included a large-screen television, kitchen, shower, and laundry. The parent kitchen, shower, and laundry were used during the observation period, but the parent television was not. Parents who stayed the night had a choice between sleeping in a queen-sized bed in a parent sleep room down the hall from their infant or staying on a couch or recliner in the SFR. Parents who stayed overnight overwhelmingly chose the option of sleeping in the room with their infant and were observed pulling the curtain closed between the infant space and their space while they slept. During the observation period, just over one third of the infants had at least one parent stay with them overnight.

The other units had adequate space at the bedside for two parent chairs but had few other amenities for parents. These units did not have options for parents to stay in the unit, except for a sleep room where they could practice staying with the infant before discharge. Open-style units also varied in where parents were allowed at the bedside, with some having a defined staff side and a defined parent side. At Open-bay #1, staff preferred to place parents with their backs to traffic when possible, but that was also the side most likely to be used by staff when conducting an intervention with the infant, so sometimes parents would be facing traffic and would move over when the nurse was finished. Open-bay #2 had mainly office-type chairs for the parents, but rockers were also present. Open-bay #2 had the largest space for parents at bedside. Open-bay #3 had a variety of seating options that were pulled into the patient space for parent use. The staff

in Open-bay #3 expressed that a lack of a space for parents to keep drinking water at the bed space affected how long parents could stay. Two staff people reported that kangaroo care often had to end when the parents had to get something to drink; water was readily available in the unit but not at the bedside.

Walking During Shifts

The question of what effect having individual rooms would have on the amount of walking nurses would have to do during a shift has often been raised in discussions at conferences about SFR design. The hypothesis that SFRs will increase the amount of walking per shift was rejected by this study. The SFR unit had the lowest average number of steps per hour (322) compared to the three open-bay units, but due to the high within-group variability this difference was not significant.

Factors that did appear to influence the number of steps taken per hour included the distance from the bedside to the clean storage, the amount of lockable storage near the bedside, the need to search for shared equipment, and the number of times nurses went to each bedside.

Traffic

The amount of traffic going into or by patient spaces varied by bed space and unit practice. The SFR design was least sensitive to traffic noise and visual distraction, as when parents were present doors and curtains to the room were usually closed. Traffic is a much more important issue in the open-bay units, since the infant is exposed to the high traffic counts.

"Desirable Beds"

Staff in all units had opinions on which bed spaces were more desirable than others. The SFR patient rooms were relatively immune to generic noise and traffic; however, three rooms on each side did not have windows to allow direct access to daylight. These rooms were considered less desirable.

Staff in all open-bay units were concerned about noise and traffic, particularly at those beds that were excessively exposed. Traffic counts during site visits supported some of these concerns, but other beds were often found to have more traffic.

Construction Cost Analysis

Construction costs were analyzed based on cost per square foot and cost per infant station. Unit size, regardless of configuration type, did not prove to be an indicator of efficiency. The difference in cost per square foot between the SFR configuration and the open-bay configuration was about 3% per square foot. This difference is negligible considering the inherent variation of factors that determines the final design of any one unit. The units with a higher number of infant stations had a lower cost per infant station, with the exception of the double occupancy configuration.

Patient Medical Outcomes

The ADC increased for all configurations along with the increase in number of infant stations for the units. The ALOS showed mixed results, but data was not collected to indicate acuity levels that may be stable in some units but increased in others after

infants occupy their new NICU. There were no clear trends for reported nosocomial infections. With only 5 hospitals participating in providing this information, the data set was too small to provide clear indications of change.

Staff and Parent Surveys

The objective of the staff and parent surveys was to compare and detect significant differences between single rooms and open bays. More specifically, the following hypotheses were tested.

1a. Staff members in single rooms are more satisfied with the physical environment than the staff members in the open-bay configuration.

2a. Staff members in single rooms perceive the physical environment to be better than the staff members in open-bay units.

3a. Staff members in single rooms report less stress than the staff members in open-bay units.

4. Staff members in single rooms have higher ratings of job satisfaction than the staff members in the open-bay configuration.

1b. Parents of patients in single rooms are more satisfied with the physical environment than the parents in the open-bay configuration.

2b. Parents of patients in single rooms perceive the physical environment to be better than the parents in open-bay units.

3b. Parents of patients in single rooms report less stress than the parents in open-bay units.

Staff members in Hospital 1 (SFR) are more satisfied with the physical environment than those in Hospital 2 (combination). The two groups in Hospital 2 (open-bay and SFR) have similar satisfaction levels, although the data trends suggest that the staff in the SFR are slightly more satisfied regarding all factors except the provision of waiting and resting space for families outside the NICU, and corridors and signage for wayfinding. As these two environmental factors are identical for Hospital 2, we can assume that the data are inconsequential.

According to staff, single rooms are superior compared to open bays in terms of providing privacy to families and infants. This is most strongly articulated in Hospital 1, which is limited to SFRs. However, in spite of the fact that some infants were housed in SFRs and some in open-bay units in Hospital 2, very little difference was found in response to the question “the environment supports the family’s presence and participation.” The SFR-only NICU is perceived as less stressful than the SFR portion of the combined unit.

Similar to staff members, parents in single rooms seem to be more satisfied with the physical environment. The most significant difference was with regard to a window view and a place to sleep near one’s infant, the former of which is not necessarily related to SFR versus open-bay arrangements. Previous studies have indicated that window views have a powerful impact on satisfaction and on some measures of healing (e.g., Ulrich, 1984). Parents agree with staff members on the single room’s support for privacy and family’s presence. There are no noticeable differences between single rooms and open bays in terms of ease of supervision. Parents view single rooms as less stressful and less

depressing than the open bay, which is consistent with staff members' views.

Consistent with their high ratings of the physical environment, members of the nursing staff in Hospital 1 report less stress and more satisfaction with their job than their counterparts in Hospital 2. Within this context, the most problematic areas in all three locations were workload, inadequate preparation, death and dying, and conflicts with physicians, all factors that are typically independent of the physical environment.

The study confirmed that nurse job satisfaction can be considerably higher in the SFR configurations. This satisfaction is corroborated by other data indicating lower stress levels and perceptions of a higher quality experience for families. Interestingly, the results of the data supported all the hypotheses, except 3b, that parents of patients in single rooms report less stress than the parents in open-bay units. However, the number of subjects was extremely low, and this result needs to be studied with a larger population in a larger number of hospitals.

Design Guidelines

One of the primary shortcomings of design research is the difficulty associated with translating the data into a format that allows practitioners to apply the results to projects. The following is a distillation of information gathered through the various methodologies associated with this study, presented as design guidelines. For a complete list of guidelines for neonatal intensive care unit design, please consult the Recommended Standards for Newborn ICU Design by the Consensus Committee to Establish Recommended Standards for Newborn ICU Design (2002).

- General Guidelines for all NICUs
    - Increase the usable space for patients, families, and nursing staff; minimize circulation space, unless this space is necessary for the movement of equipment or to provide separation between babies to increase privacy.
    - Provide both centralized nursing stations and charting areas at or near bedside; these dual options support staff members by providing opportunities for collegial interaction and making independent work areas available at or near bedside.
    - Provide decentralized clean supply and support areas to minimize time and distance traveled by nursing staff.
    - Increase the number of hand-washing sinks throughout the patient area; for SFR units, provide hand-washing sinks in each SFR and additional easily accessible sinks within the unit. Meeting minimum requirements by providing hand-washing stations within 20 feet of all infant stations may not meet the need for easy access; provide waterless hand cleaners and soaps, and institute an ongoing campaign to direct attention to the importance of hand washing as a part of an effective infection-control strategy.
    - Provide natural light in family, patient, and staff areas; these light sources should be fitted with shading devices to control quantity of light.

  - Provide a comprehensive patient monitoring and security system that has the flexibility to incorporate technology as needed; current solutions may include a staff locating system, call system, and infant monitoring system.
  - Minimize exposure to noise (e.g., staff entry, pneumatic tube depository, equipment storage, door closures, and elevators) and traffic that are located in close proximity to nursing work areas.
  - Address visual and auditory privacy within the patient area of the unit; provide partitions or moveable screens for manipulation of unit layout.
  - Provide line of sight for nursing staff when possible; if possible, provide a remote camera system for patient observation.
  - Minimize parents' and families' visual exposure to medical equipment.

- Single Family Room Unit Design
  - The provision of single family room units should be seriously considered when creating an NICU; if this is not possible, a combination of both SFR and open-bay units is recommended.
  - Regardless of allocated space for family at bedside, design SFR units with family space within the unit for parent-to-parent socialization, education, dining, resting, and respite; additional amenities should include laundry and shower facilities.
  - Provide individualized control of environmental conditions, including temperature, artificial light, and daylight.
  - Provide enough space to accommodate families who want to stay with their infants by providing a work surface, sitting/sleeping furniture, storage for personal belongings, and additional seating solutions such as recliners and rockers.
  - Provide meeting space to support organized activities for parent-to-parent and parent-staff interaction.

Conclusions

The purpose of this study was to explore the implications of single family room design of neonatal intensive care units and compare to other design configurations currently in operation. The objective was to, through review of the research literature and new research and analysis provide practitioners with recommendations for the design of NICUs and present researchers with an agenda for future, more focused research studies.

Based on the results of this study, single family room NICU design provides solutions for increasing parent privacy and presence, supporting HIPAA compliance, minimizing the number of undesirable beds, increasing staff and parent satisfaction, and reducing nursing staff stress. Potential limitations of the SFR design are reduced parent-to-parent social contract and isolation of both parents and staff.

In the projects reviewed in this study, construction cost was not notable influenced by design configurations; there was a 3% increase in cost for single family room units compared to open-bay units. It is recommended to design for single family room units, when possible; if this is not possible, a combination of both SFR and open-bay units is recommended.

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THE IMPACT OF SINGLE FAMILY NICU ROOMS

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ABSTRACT

Purpose

A recent trend in the design of neonatal intensive care facilities has been to increase the number of private patient rooms for neonates and their families. Several factors have contributed to the popularity of single family rooms: (1) supportive data on infant outcomes when they are provided individualized care (Als, et al., 1994); (2) increased understanding of the value of breastfeeding and kangaroo care (Ferber & Makhoul, 2004); (3) the hospital-wide trend toward private rooms; and (4) the success of innovative prototypes. The implementation of the Health Insurance Portability and Accountability Act (HIPAA) has also influenced the design of NICUs due to the need to provide patient privacy (Mathur, 2004). The purpose of this study is to explore the implications of single family rooms (SFRs) relative to open-bay arrangements in neonatal intensive care units (NICUs).

Context

Recent technological advancements have resulted in an increase in the NICU population. Children who might have died five years ago are today surviving and are having extended stays in NICUs (Shepley, 2002). Because of the increased use of NICUs, many hospitals are expanding or adding neonatal services, resulting in new construction, remodeling of facilities, and experimentation with innovative nursing models and facility design.

Literature Review

The literature review focuses on environmental impacts on neonates, parents, and medical staff. Since the research on single family room design is very limited, this review includes the history of pediatric health design research and recent studies in NICU research, which may not specifically address single family room care. Recent literature in NICU research focuses on demographics; family experience; visitation; nurse experience; and behavior and environmental conditions that incorporate noise, light, and infection control.

In addition to environmental impacts on patients, families, and medical staff, the literature review addresses cost factors. Current research on operational costs for NICUs focuses on factors affecting cost of care, fixed and variable costs, strategies for cost containment, and the impact of costs on personnel and families. Finally, a brief review of literature pertaining to construction costs for NICUs discusses factors influencing and strategies for controlling construction costs.

Methodology

The settings for this research include 11 single family room, open-bay, combination, and double occupancy Level III NICUs across the United States. The research design used several methods. Plan reviews, site visits, and postoccupancy evaluations assessed the physical environment and impacts on the users. Construction cost data were evaluated based on adjusted to 2005 values and normalized to the National City Average (Waier, 2005). Anonymous personal health information was collected to compare patient medical outcomes including average daily census, average length of stay, and nosocomial infection rates. Surveys for NICU medical staff and parents explored the preferences and experiences of those providing and receiving care in 2

of the participating facilities; 1 facility was an SFR NICU, and the other was a combination unit with open-bay infant stations and SFRs.

Summary of Results

Based on the results of this initial comprehensive study, single family room NICU design provides solutions for increasing parent privacy and presence, supporting HIPAA compliance, minimizing the number of undesirable beds, increasing staff and parent satisfaction, and reducing nursing staff stress. Potential limitations of the SFR design are reduced parent-to-parent social contact and isolation of both parents and staff. In the projects reviewed in this study, construction cost was not influenced by design configuration; therefore, the decision to provide SFR units should not be influenced by financial implications. The provision of single family room units should be seriously considered when creating an NICU; if this is not possible, a combination of both SFR and open-bay units is recommended.

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CHAPTER 1: INTRODUCTION

This research project explores the implications of single family room care in neonatal intensive care units (NICUs). After updating and synthesizing relevant literature, a multi-methodological approach was used to gather new data. The settings for this investigation included both private and open units and allowed for a comparison regarding (1) neonatal outcomes; (2) family needs and preferences; (3) staff behavior, needs, and preferences; and (4) construction and operational costs. The findings are translated into design guidelines. This study is an initial, comprehensive effort, the purpose of which is to spawn future, narrower, in-depth studies focused on neonatal intensive care unit design.

A recent trend in the design of neonatal intensive care facilities has been to increase the number of private patient rooms for neonates and their families. Traditional unit designs have varied from open rooms supporting 10–50 beds to smaller rooms with four- to six-station pods. Several factors have contributed to the recent popularity of single family rooms:[2] (1) supportive data on infant outcomes, (2) increased understanding of the value of breastfeeding and kangaroo care (more easily accomplished in a private room), (3) the hospital wide trend toward private rooms for other populations, and (4) the success of innovative prototypes. The implementation of the Health Insurance Portability and Accountability Act (HIPAA) has also influenced the design of NICUs due to the need to provide patient privacy (Mathur, 2004).

Initial studies (e.g., Oelrich, 2003) suggest that there may be developmental benefits to individualized rooms. In addition to acoustical and lighting control and family privacy (White, 2003), improved infection control may be a significant benefit (Mathur, 2004). Potential disadvantages of private room environments may be the isolation of families, reduced family-to-

[2] The term “single room” may be confused with the notion of one open room. For the remainder of this report, the term “single family room” (SFR) will be used.

family interaction, impediments to patient supervision, and increased operational and construction costs. Unfortunately there is limited data to validate these hypothesized advantages and disadvantages.

There is a wealth of data, however, relating to aspects of the physical environment in neonatal intensive care units, apart from unit configuration and room size. Previous research has focused on the impact of light, noise, and music on infant outcomes (Shepley, 2005). The impact of family presence and visiting policy is also commonly addressed (e.g., Newman & McSweeney, 1990).

More specific, evidence-based design guidelines are needed regarding the implications of SFRs. Research must address the physical and psychosocial benefits and costs to families, neonates, and medical staff; and the monetary and organizational implications regarding construction and hospital systems. These results, in turn, must be translated into design guidelines to make them accessible to practitioners.

What is the best design for NICUs? The question is complex because infants are affected both directly by their environment and indirectly by their caregivers, who are also influenced by the environment. A broad range of outcome measures must be incorporated, including patient outcomes, construction costs, and the impact on staff and families. Specific research questions, such as those that follow, are addressed in this report.

Infants

1. Are medical outcomes—such as average length of stay and nosocomial infection rates—different for infants in the two settings?
2. Are there differences in the number of resuscitation events that take place in each setting?

Families

1. Are there differences in parent-child interaction in the two settings (e.g., number of visits, time spent at bedside)?
2. Which type of unit is most preferred by families?
3. Will family-to-family social support decrease in the SFR setting?

Staff

1. Are there differences in staff behavior (e.g., medical errors, retention, nursing models) in the two settings?
2. Which type of unit is more preferred by staff?
3. How does the amount of work compare in the two settings?

Administration

1. Are there differences in construction and operational costs between the two types of units?
2. What are the trends in configuration in recent years? Are we moving toward units with only private rooms versus those with a mix of rooms, as well as the creation of more family-centered amenities?
3. Does the use of SFRs improve marketing strategies for maternal child health services?

Although it is impossible to answer all of these questions in the scope of this project, several of these issues are addressed, including medical outcomes for infants, family and staff preferences and perceptions, and construction and operational costs. *Our study hypothesis is that SFR care has compelling benefits for the patient, families, and healthcare staff.*

CHAPTER 2: LITERATURE REVIEW

Review of Current Research on Single Family Room Design

Research on single family room design is very limited. Because of this, a net must be cast broadly to obtain information related to this topic. The following literature review addresses the history of pediatric health design research and NICU research, and recent studies focusing on NICUs, which do not specifically address single room care. Literature on single room maternity care is summarized, as some issues may be similar to NICUs. The brief body of literature pertaining to single family rooms is also summarized, and suggestions are made regarding the future of NICU research.

In this chapter, a literature review of administrative, construction cost, and plan review research follows the discussion of single family room studies. A review of literature associated with methodology is included in the Methodology section of this report. So little research has been published on this subject, that we included works in progress, texts and conference proceedings to provide additional information to the reader.

History

It is useful to examine NICU studies in the context of research regarding pediatric health design. There are four types of articles that address related issues: descriptive articles, guidelines, literature reviews, and scientific papers (Shepley, Fournier, & McDougall, 1998). Descriptive articles describe a particular facility, concept, or application. Many of these type of articles highlight the positive attributes of a design and provide no empirical support for their conclusions. Guidelines are suggestions and observations provided by professionals and consultants. Typically, the guidelines are derived from the author's personal or professional

experience. Few are based on systematic research findings. Literature reviews are articles in which the authors review literature and/or explain a theoretical approach. Scientific papers summarize research conducted to evaluate the impact of physical, environmental, and social issues on children and families in healthcare environments. They typically entail objective evaluation, either quantitative or qualitative.

Pediatric health design research by mid-1987 included 257 articles focusing on general facilities, ambulatory care, emergency rooms, inpatient units, play spaces/lounges, and psychiatric facilities. Thirty-two of these articles addressed pediatric intensive care units (PICUs) and NICUs. In the subsequent decade, 190 studies were conducted focusing on similar topics; however, 72 of them addressed PICU/NICU settings. This represents a growth in the literature on PICUs and NICUs from 12.5% to 39%. The cause of this growth is uncertain, although several factors probably contribute to the high interest level. One is the perceived vulnerability of the population. Another might be the awareness that children who receive good medical care will have fewer problems in the future. A third reason might be the specificity of the architectural setting. Lastly, PICUs and NICUs are a relatively new space type and therefore generate significant interest.

Recent NICU Literature

Recent NICU literature tends to focus on the following topics: demographics, family experience, visitation, nurse experience and behavior, noise and light, and infection control.

Demographics

Studies on the demographics of NICUs are common. Tatad and Frayer (2003) conducted a study examining statistical developments in the NICU population. A typical example includes a study of 25,448 infants who were admitted to the NICU at Weill Cornell Medical Center since

1978. The average length of stay (ALOS) for infants 1000 to 2000 grams decreased, while the ALOS for other infants remained constant. With the exception of the very smallest infants (less than 600 grams), the percentage of surviving infants increased.

Family Experience

Family experience constitutes a significant segment of the literature. Bell (1997) studied the adolescent mothers of premature infants using the NICU Parental Stress Scale (Miles & Funk, 1998). They noted that alterations to the traditional parental role, which frequently take place in a NICU, were very stressful for the mother and that the infant's appearance and behavior created psychological challenges for her. Bialoskurski, Cox, and Wiggins (2002) used the Molter Critical Care Needs Inventory (Leske, 1991) to study the experience of mothers of premature infants. Accurate information regarding the baby's health status was the most important need. The second most important need was good communication with professionals. Cescutti-Butler and Galvin (2003) addressed parental perception of staff competency in a NICU via unstructured tape-recorded interviews. Parents perceived competence in terms of specific factors: integration in the care process, control, and communication. The researchers found that when parents were given a sense of control, they felt less like "guests." Conner and Nelson (1999) were also concerned with parental satisfaction with the NICU. In a literature review focusing on the factors of assurance, caring, communication, consistent information, education, environment, follow-up care, pain management, participation, proximity, and support, they found that having a place to rest and access to food were highly desirable. A waiting area and overnight accommodations were determined to be essential. The researchers noted that parents tended to protect their infants from unnecessary stimulation such as bright lights and loud noises.

Fournier (1999) studied parental satisfaction in an open-bay NICU that was employing a family-centered (Planetree) approach in a Midwestern hospital. In this case study, three types of

interactions were categorized: interactions between parents and infants, interactions between families and caregivers, and interactions between caregivers and infants. Fournier found that the feeling of separation from their child (88% or *n*=22) and the feeling of helplessness regarding their child's pain (80% or *n*=20) were extremely stressful to parents. With regard to the specific design, most parents 48% (*n*=12) were satisfied with the space allocated to them by the bedside in terms of opportunities for privacy and intimacy. Most parents (76% or *n*=19) reported that the NICU environment supported the family's presence and participation, and 88% (*n*=22) of the respondents were extremely satisfied with the overall quality of the physical environment (i.e., the atmosphere, décor, and the size of family rooms). Eighty percent (*n*=20) of the respondents reported extreme satisfaction with the location of family rooms and showed a high level of satisfaction regarding information and support provided by the staff.

In another study on family-centered care, Harrison (1993) interviewed parents whose babies were in a NICU. One parent noted that open communication between families and staff was essential. This "information must be complete, specific, detailed, and meaningful" (p. 644). Respondents indicated that families must work with professionals to develop appropriate environments regarding light, noise, infant handling and positioning, and sleep disruptions.

Saunders, Abraham, Crosby, Thomas, and Edwards (2003) also focused on the impact of family-centered care by studying the effect of improved practices in 11 hospitals. These practices were identified using internal process analysis, examination of the evidence, collaborative learning, and visits to centers of excellence in family-centered care. Each center individually selected which practices to implement. No differences in length of hospital stay and feeding protocols were found between children who were in the unit prior to the protocol changes and children who were in the unit after the protocol changes during the period from 1998 to 2000. The impact of the intervention is questionable. In spite of the fact that some of these units described themselves as providing family-centered care, only 2 centers perceived families to be integral

members of the care team. Site visits demonstrated that the level of participation of families depended on the attitudes of the care providers and the relationships developed between the care providers and the families.

Jacano, Hicks, Antonioni, O'Brien, and Rasi (1990) compared the differences between families and caregivers in terms of their perceptions of the needs of families. Important differences in perceived needs of families of critically ill patients were identified in two areas: (1) the need to be perceived as an integral part of the care team and (2) the need for clear, honest information. Ward (2001) used the NICU Family Needs Inventory (a version of Molter's Critical Care Family Needs inventory) and found that parents ranked assurance and information to be the most important needs. Mothers reported higher overall need levels than fathers. Nystrom and Axelsson (2002) interviewed mothers regarding their experience related to separation from their newborns in the NICU after delivery, which they noted caused emotional strain and anxiety. In spite of these differences in perception, the relationship with the caregiver is critical. Riper (2001) examined maternal perceptions of family-provider relationships using the Family-Provider Relationships Instrument NICU (FAMPRO-NICU), a measure of psychological well-being and a general scale of family assessment. Mothers who expressed a positive relationship with their healthcare providers in the NICU reported more overall satisfaction.

Miles and Brunssen (2003) developed a tool that is useful in evaluating parent stress. This tool, the Parental Stressor Scale: Infant Hospitalization (PSS:IH) consists of 22 items involving parental role alteration, infant appearance and behavior, and sights and sounds. The PSS:IH, which is used in the study described in the ensuing document, has been proven to have adequate internal consistency, reliability, and construct validity (Miles & Brunssen, 2003). Another tool used to evaluate parent satisfaction in the NICU is the Neonatal Index of Parent Satisfaction (NIPS), which has also been determined to have good reliability and validity (Mitchell-Dicenso, Guyatt, et al., 1996).

The relationship between outcomes and developmental care is an important topic in NICU design. For a detailed discussion of the neurodevelopmental effectiveness of the individualized developmental care of neonates, see Als et al. (2004).

Other related literature includes Frayer's (1983) description of a NICU renovation at the New York Hospital-Cornell Medical Center, a qualitative study of the emotional world of the parents of premature infants (Sim, 2000), a literature review on facilitating infant adaptation in the nursery environment (Warren, 2002), and Raman's (1997) overview on the status of NICUs.

Visitation

Visitation is one of the most thoroughly examined research topics in intensive care environments. In a parallel literature review, Shepley and Hamilton (2006, in progress) found more than 60 recent articles on this topic and noted several trends. First, in the United States, families and patients desire visitation in ICUs; however, patients, particularly older patients, may wish to have a say in the frequency of visits. Most staff also support opportunities for visitation, and while many originally believed it would be an impediment to the care process, the majority now see the family as a potential team member in this effort.

Regarding NICUs, Giacoia, Rutledge, and West (1985) identified factors affecting visitation of sick newborns for infants born in the hospital (inborn) and infants born out of the hospital (outborn). As might be expected, outborn parents visited less frequently and made fewer phone calls than did parents of inborn babies. Low income was also found to inhibit visitation. The following factors were identified as limiting visitation: care of siblings, travel expenses, absence of transportation, distance to hospital, and demands of work.

Visitation by siblings has been a topic of debate. While it was once commonly believed that siblings' presence in ICU environments would be psychologically detrimental to children, studies have indicated that children who are prepared for these visits have better outcomes than those who do not visit at all. Newman and McSweeney (1990) conducted a descriptive study of

sibling visitation in NICUs via interviews in exemplary units. According to interviews with key experts in neonatology, factors inhibiting sibling involvement were identified as: (1) requirements for special staffing and organization to accommodate visiting children, (2) restrictive visitation policies, (3) recognition of older siblings' needs, (4) lack of information on sibling visitation, and (5) the possibility of infection from visiting children. NICU nursing staff found that sibling involvement is related to (1) a liberal visiting policy; (2) support from nursing, medical, and ancillary services; (3) staff awareness of the implications of sibling involvement; (4) endorsement of family-centered care; (5) the physical configuration and space allocation in the unit; (6) logistics; (7) control of noise levels; (8) protocols for infection control; and (9) parental anxiety. Jones (1982) noted that parent-infant contact was inhibited by distance between home and hospital and that staff perception of parental visitation was linked to the staff's sense of the parent, based on initial telephone calls and personal contacts. Other factors affecting parenting in the intensive care nursery were examined by Walker (1998) in a national survey. The survey noted that equipment (e.g., ventilators, oxygen devices) and fear and anxiety inhibited parent involvement.

Nurse Experience and Behavior

Very little has been written on the topic of the nurse's experience in the NICU. In a rare study, Jones (1982) investigated this topic using the Infant Environmental Analysis (IEA) tool, which is composed of observation, mapping, case histories, interviews, and a psychological profile survey. Jones found that staff preferences are affected by family-infant and staff-family relations, sense of success, ethical issues, and accessibility to infant. Interestingly, staff were observed to contact infants approximately 6.1 hours per day. Building on information regarding staff needs, Shepley, Bryant, and Frohman (1995) conducted an analysis of staff preferences and behavior in a pre- and postoccupancy evaluation of a new NICU. The original floor plan was

compartmentalized, and the new plan was open bay. Utilizing interviews, questionnaires, and behavior mapping, the researchers found that staff spent less time on traveling in the open-bay plan and that interactions with families were increased.

Sound and Light

The literature on noise in NICUs is extensive. Several studies have documented noise levels, which vary depending on the location in the NICU. Guimaraes, et al. (1996) found noise levels range between 61 and 67 dB, with spikes over 100 dB. Kent, Tan, Clarke, and Bardell (2002) found that the mean noise levels inside the incubator can be significantly higher than the levels outside of the incubator, and the ambient noise levels were higher in the acute care room than rooms with less activity. Paralleling this finding, the noise levels in Level III NICUs (54 dB) have been found to be higher than the noise levels in Level II NICUs (49 dB) (Levy, Woolston, & Brown, 2003).

Chang, Lin, and Lin (2001) found that noise levels exceeded 59 dBA during approximately 70% of the observations. The researchers found that more noise was generated in the daytime during the week than at night or on the weekends. Most studies suggest that staff conversations are the major contributor to noise levels.

Philbin has studied and written extensively on noise in NICUs (see Gray & Philbin, 2004; Philbin, 2000, 2004; Philbin & Gray, 2002; Philbin & Klaas, 2000; Philbin, Robertson, & Hall, 1999). Gray and Philbin (2004) hypothesized that attention to sounds is important for normal development and is negatively impacted by background masking sounds. According to this theory the younger the infant and the more unpredictable the environment, the more easily the infant is distracted.

Philbin and Gray (2002) looked at the impact of noise in a NICU relative to no intervention, a staff behavior-modification program, and a facility renovation. The staff behavior

change consisted of maintained periods of quiet every hour. A renovation of the NICU was perceived by staff to be three to four times quieter than the original NICU. Robertson, Cooper-Peel, and Vos (1999) examined the contribution of mechanical systems and conversation to ambient sound levels and found that the reduction achieved by decreasing conversation was larger than that achieved by restricting the airflow of heating, ventilation, and air-conditioning systems.

Studies have been conducted on the impact of acoustical modifications to the physical environment. Berens and Weigle (1996) reviewed the impact of acoustic ceiling tile in a 20-bed NICU and found a slight decrease in the decibel level, although this decrease was not perceived by observers. Johnson (2003) documented the impact of modifications involving door closings, pulse oximetry alarms, portable x-ray equipment transfer, and staff and visitor traffic. Environmental noise levels decreased by 9 dB to a mean level of 55 dB after the modifications.

For an overview on the topic of NICU light and acoustical environments on developmental outcomes, Blackburn (1998) and Graven (2000) provide excellent summaries. Additionally, Bremmer, Byers, and Kiehl (2003) provide general suggestions regarding light and noise relative to medical outcomes, and Thomas and Martin (2000) discuss the acoustical environment and provide recommendations based on a literature review.

A broad discussion of the impact of light on NICU environments can be found in Charpak, Ruiz, and Calume (2000); Fielder and Moseley (2000); Graven (1997); and Lotas (1992). In a recent study on light and the NICU, Brandon, Holditch-Davis, and Belyea (2002) found that infants of a gestational age of 31 weeks or less had improved growth in environments with cycled lighting than in environments that were continuously dark. While Rivkees (2004) argues that premature infants in low-intensity cycled-lighting environments are quicker to develop sleep patterns that are synchronized with the diurnal cycle than are other infants, Mimiran and colleagues (Mirmiran & Ariagno, 2000; Mirmiran, Baldwin, & Ariagno, 2003;

Mirmiran, Maas, Ariagno, 2003) have taken a different stance. Although it is commonly believed that environmental light will impact the circadian rhythms in neonates, these authors suggest that sleep organization may be endogenous (internal/biological) in infants.

Several studies involve the combined impact of light, sound, and other NICU activities. Slevin, Farrington, Duffy, Daly, and Murphy (2000) examined the impact of light level, sound level, alarm occurrences, staff conversation activity, and infant handling on 10 preterm infants on assisted ventilation. During the quiet period involving reductions of all these variables, infant blood pressure and movement were decreased. Walsh-Sukys, Reitenbach, Hudson-Barr, and DePompei (2001) reduced light and sound levels and measured environmental levels, safety, and staff satisfaction. Light and sound levels were reduced using moderate modifications. The reduced light and sound levels did not negatively impact patient safety, and staff members were satisfied with the reductions in noise levels.

A literature review on the sensory environment of neonates, families, and staff can be found in Volume 31 (2) of *Clinics in Perinatology* (Brown, 2004; Graven, 2004; Gray & Philbin, 2004; Johnson, Abraham, & Parrish, 2004; Philbin, 2004; Rea, 2004; Rivkees, 2004; Schaal, Hummel, & Soussignan, 2004; Shepley, 2004; Smith, Bajo, & Hager, 2004; White, 2004a, 2004b, 2004c).

Infection Control

A nosocomial infection is defined by the U.S. Centers for Disease Control and Prevention as an infection, not present or incubating at the time of admission, during hospitalization (Clark et al., 2004a). In a recent report on the role of the physical environment in the hospital (Ulrich & Zimring, 2004), the authors identified more than 120 studies linking the built environment to infection in the hospital. The studies focused on sources of airborne infections, primarily air quality and natural and forced ventilation (Oren, Haddad, Finkelstein, & Rowe, 2001), as well as

on the control and prevention of airborne infections using HEPA filters (Dharan & Pittet, 2002). According to Ulrich and Zimring (2004) the vehicles for transmission are patient to patient and patient to healthcare worker to patient. Current literature addresses the need for increased hand washing and suggests effective education, accessible hand-washing stations and alcohol-based cleansers, and single patient rooms as strategies that may reduce the rate of infections in patient units (Adams-Chapman & Stoll, 2002; Cohen, Saiman, Cimiotti, & Larson, 2003; Gelber & Ratner, 2002; Saiman, 2002; Ulrich & Zimring, 2004).

Nosocomial infection rates are up to three times higher in adult and pediatric intensive care units than in medical and surgical patient units (Weinstein, 1998) and are responsible for increased morbidity and mortality and prolonged length of stay among neonates (Adams-Chapman & Stoll, 2002; Clark, et al., 2004a). Specific to neonatal infection is early onset (within the first three days of life) and late onset (after 72 hours of life) (Clark, et al., 2004a). The nosocomial infection rate for neonates who weigh less than 1500g is at least 50%, with rates between 9.3% and 25.6% for the general NICU population (Mussi-Pinhata & Nascimento, 2001). Premature and very low birth weight (VLBW) infants, with their underdeveloped immune systems, appear to be vulnerable to nosocomial sepsis (Clark, et al., 2004a).

Studies related to infection in NICUs focus on hand washing, contaminated medical equipment, and crowding or baby placement (Cohen, Saiman, Cimiotti, & Larson, 2003; Gupta, et al., 1991; Kilbride, et al., 2003; Mussi-Pinhata & Nascimento, 2001). Other studies present strategies for infection control that include continuous monitoring and surveillance of infection rates, nursery design, and staffing (Adams-Chapman & Stoll, 2002). In their principles for the prevention of nosocomial infection in the NICU, Adams-Chapman and Stoll (2002) recommend and discuss strategies for improving hand-washing compliance through education and accessibility to hand-washing sinks and alcohol-based products. In addition, they recommend that

the nurse-to-patient ratio be appropriately maintained and that NICUs should avoid overcrowding.

Contamination of the physical environment may facilitate patient-to-healthcare worker-to-patient transmission of pathogens known to cause infection (Boyce, Potter-Bynoe, Chenevert, & King, 1997). Factors that may influence incidence of nosocomial infection are (1) overcrowding, (2) inappropriate design decisions regarding sinks and soap containers, (3) inconvenient location of supplies, (4) improper maintenance of surface-covering materials (e.g., carpet), and (5) poorly designed mechanical air systems (Clark et al., 2004b). Reservoirs for transmission are numerous, from laundry and toiletries to toys, medical equipment, water faucets, and medical supplies (Clark et al., 2004b). Clark et al. (2004b) go on to say that 85% of all NICU surfaces will grow nosocomial pathogens.

The design guidelines (AIA, 2001) for NICUs recommend that each bed be located within 20 linear feet of a hands-free hand-washing station. The AIA (2001) goes on to recommend 120 square feet (SF) of clear floor space per bassinet, excluding sinks and circulation. Clark et al. (2004b) expands on those recommendations by suggesting separate areas for gowning and storage of clean and soiled materials located directly outside or just inside the entry to the infant station area.

Single Room Maternity Care

While little information is available on single family room care in NICUs, it may be useful to look at the research on single room maternity care. Although adult or pediatric intensive care unit research might also be relevant, single room maternity care facilities are frequently a part of the same design projects that involve NICUs. While major goals of SFRs in NICUs are to provide privacy and light/noise control for patients and their families, Labor/Delivery/ Recovery (LDR) and Labor/Delivery/Recovery/Postpartum (LDRP) models also seek to

consolidate birthing activities into a single space. Still, LDRs and LDRPs result in improvements in privacy and environmental control. Ladfors, Eriksson, Mattsson, Kyleback, Magnusson, and Milsom (2001) found that 85% of the women in their study preferred having a single room or sharing a room with only one other woman in the postnatal ward.

When significant physical changes are made to environments, there are operational implications. Ecenrod and Zwelling (2000) describe the process of remodeling a family-centered maternity care unit. This information may be useful to NICUs transitioning from open-bay to SFR environments.

Janssen, Harris, Soolsma, Klein, and Seymour (2001) examined nurse satisfaction in a new facility that had a single maternity room with a large sofa for sleeping, contemporary fabrics, maple furniture, and showers/tubs versus a delivery suite with no windows, one chair, and a shower. Nurses in the single room unit were more satisfied with the physical environment, their ability to address patient needs, inter-staff collaboration, and perceived competence. In general, the single room maternity nurses were more satisfied than traditional-room delivery nurses. In a related study, Janssen, Klein, Harris, Soolsma, and Seymour (2000) compared women who had experienced traditional care to those who had experienced single room care. The women in the single room group were more satisfied along various dimensions: information and support, the presence of families, privacy, the character of the physical environment, the ability of staff to deliver care, patient education, and patient discharge preparation. Other studies have confirmed staff and patient satisfaction. Olson and Smith (1992) found that both mothers and nurses were satisfied with the private room. Interestingly, mothers' satisfaction with care provided during labor and delivery was higher than that of nurses. Specific components of the operational program thought to promote satisfaction were visiting hours, quiet time, and meals.

Stolte, Myers, and Owen (1994) evaluated nurse perceptions of maternity care via a questionnaire. The most frequently reported changes associated with the SFR model were the

introduction of new technology, changes in the legal climate, reductions in length of patient stay, reductions in costs, increased family participation, recognition of the need for interspecialty training, and increased market demand. In a postoccupancy evaluation of one of the first freestanding single room maternity care facilities, researchers conducted medical staff behavioral observations and interviews (Shepley, Bryant, & Frohman, 1995). The facility was generally well received; however, suggestions were made with regard to the location of supplies in the patient room and the size and location of nursing stations.

Single Family Room NICU Care

The majority of the literature on single family room care is descriptive. Brown and Taquino (2001) described the experience in the IICU at Children's Hospital and Regional Medical Center in Seattle and observed that the design positively impacts lighting, acoustics, privacy, and comfort. Guidelines identified to support staff include low, angled walls with glass doors and windows; bedside and central monitoring locator badges to enhance communication among staff; and decentralized supplies at each bedside. Bowie, Hall, Falkner, and Anderson (2003) observed the impact of single family room care on a Level II NICU at Providence Seattle Medical Center. The authors suggest that SFRs will increase privacy for parents and that the individualized acoustical and lighting systems will increase families' sense of control over their environment. The authors note that windows between baby stations and the use of pagers increase the flexibility of the working environment for staff. The need for privacy has also been identified by Pector (2004) in a study involving views of multiple-birth parents on life support decisions, the dying process, and discussions surrounding death.

White (2003) states that the primary advantages of SFRs are appropriate lighting, sound, and activity levels for the developmental state of the infant. Other benefits are family privacy and an enhanced sense of belonging to NICU activities. The disadvantages are enumerated as separation of staff, loss of the sense of constant observation, isolation of families, and potentially

high construction costs. Mathur (2004) also cites improved infection control, clinical outcomes, environmental control, and client satisfaction. Mathur suggests that the size of the unit does not have to increase and that staffing efficiency can be maintained.

To our knowledge, only Oelrich (2003) and Rosenblum (2005) have conducted studies on single family room NICUs. Oelrich (2003) studied the impact of single family room NICUs at Providence and Blank hospitals in Alaska and Iowa, respectively. The variables studied were outcomes, average length of stay, communication, and infection. Oelrich found that caregivers perceived improvements in both outcomes and communication and that staffing ratios held constant. In spite of the single rooms, nosocomial infections were found to increase at Blank. According to the author, this might be attributed to an increase in central line usage and low birth weight of infants, or the presence of families or carpeting. Rosenblum (2005) found improvements in SFR infants across a variety of indicators, including weight gain. The need for ventilator use in SFRs dropped from 10.8 days to 9.7 days in all patients less than or equal to 32 weeks estimated gestational age (EGA) at birth. Hospital-acquired infections for patients less than or equal to 32 weeks EGA who developed a documented bacterial or fungal bloodstream infection after 7 days of age fell from 17.7% to 5.9%. When parents were queried, they indicated that the environment appeared to have lower noise levels, more privacy, more attention from staff, more information provided to families, and more courteous nurses.

Review of Current Research on Operational Costs for NICUs

A comprehensive investigation of NICU design implications would not be complete without examining the impact of NICU design on operational factors and the cost of care. With decreased mortality and morbidity rates, the cost of care has increased. The literature focusing on operational costs of NICU care includes factors affecting the cost of care, fixed and variable costs, strategies for cost containment, and the impact on families and healthcare staff.

Accompanying the change of configuration to single family room design is the change in daily operations, a potential shift in personnel requirements, and issues related to staff satisfaction and retention. Aside from enduring the stress of having a new infant in the NICU, parents face a real financial burden, which influences job retention, childcare for siblings, transportation costs, and the amount of time that families spend with their new family member.

The Cost of Care

While neonatal care is effective and has dramatically decreased infant mortality and morbidity over the last three decades, the provision of medical care to infants in the NICU is costly (Budetti, McManus, Barrand, & Heinen, 1981; Office of Technology Assessment, 1987). Estimates of the cost of neonatal care in the first year of life exceed $2–$4 billion per year in the United States, accounting for 35% of all healthcare costs in the first year of life (Gaynes, et al., 1991; Lewitt, Baker, Corman, & Shiono, 1995).

Approximately 11%–12% of infants are born prematurely, and 1.4% weigh less than 1500 grams (Martin, 2002). As many as 7%–8% of infants born in the United States require admission to the NICU (Schulman, 2003). While some of these admissions may be relatively brief, lasting only several hours or days, other admissions may require intensive care for several months, resulting in extremely high expenses.

Experts anticipate that the cost of neonatal care will continue to rise at a relatively rapid rate. With decreased mortality and morbidity rates, the overall cost of care has increased due to longer stays for very low birth weight infants who prior to the advent of NICU care would have died in the first few days of life. Although the birthrate in the United States remains relatively stable, the number of preterm infants and infants born weighing less than 1500 grams is rising (OECD Health Data, 2001). Between 1991 and 1997, the incidence of live births of infants weighing less than 1500 grams rose from 1.3% to 1.5% (CDC, 1997).

Factors Affecting Cost of Care

Infants born preterm accounted for most of the $10 billion spent on neonatal care in 2003 (Cuevas, 2005). This expense is related to the requirement of highly qualified personnel to provide care to these infants, the need for expensive technology and pharmacology, and the extended time period these neonates often remain in the hospital (LaPine, Jackson, & Bennett, 1995; Merritt, Pillers, & Prows, 2003; O'Shea, Klinepeter, Goldstein, Jackson, & Dillard, 1997; Rogowski, 2003; Roth, et al., 1995).

The cost of neonatal care is based on intensity of treatment and length of stay (Doyle, Murton, & Kitchen, 1989; Powell, Powell, Hollis, & Robinson, 1992). Both of these factors are inversely related to gestational age and birth weight. The smaller, sicker infants need the most intensive care and require an extended stay in the NICU. Cost of care is also directly proportional to survival. Since the survival rate of critically ill infants has increased and this trend is expected to continue, the cost of neonatal care is also expected to increase (Walker, Vohr, & Oh, 1985).

Factors that further increase both the intensity of treatment and length of stay include respiratory distress syndrome, chronic lung disease, necrotizing enterocolitis (inflammation of the small intestine and the colon), surgical procedures, mechanical ventilation, and infection (Payne, et al., 2004). Hospital-acquired infections are common, occur in approximately 20% of VLBW infants, and are associated with a significant increase in hospital costs (Gaynes, et al., 1996; Sohn, et al., 2001; Stoll, et al., 2002). Much of the cost is related to an increased length of hospital stay, with 70% of costs related to accommodations (Leroyer, et al., 1997; Mahieu, Buitenweg, Beutels, & De Dooy,2001; Moris de la Tassa, Fernandez, Autuna, Gutierrez, de la Fuente, & Sanchez,1998). Length of stay has been shown to increase by up to 24 days in the presence of hospital-acquired infections, with an increased cost of up to 20% per patient (Gaynes, et al., 1996; Leroyer, et al., 1997; Mahieu, Buitenweg, Beutels, & De Dooy, 2001).

A number of studies have attempted to ascertain the exact hospital cost that a low birth weight (LBW) infant accumulates during his or her hospital stay. Rogowski (2003) estimated that infants weighing between 501 and 750 grams had a median length of stay of 87 days, costing an average of $1,650 per day for a total of $103,600. Infants between 751 and 1000 grams had a median length of stay of 66 days, costing an average of $1,330 per day for a total of $79,400. Infants between 1251 and 1500 grams had a median length of stay of 32 days, costing an average of $1,050 per day for a total of $31,200. Although infants less than 500 grams had a high level of intensity of care costing an average of $1,780 per day, they rarely survived more than a few days, and therefore their total cost was only an average of $9,400; but there is recent evidence that survival in this group in increasing, with a concomitant increase in cost. The Office of Technology Assessment (1987) estimated that infants weighing between 1000 and 1499 grams cost an average of $86,284, and infants between 500 and 999 grams cost an average of 118,418. The average LBW infant in1988 cost hospitals an average of between $14,000 and $30,000 (Office of Technology Assessment, 1988). Chollet, Newman, Jr., and Sumner (1996) estimated that infants less than 1000 grams accrued average hospital costs of $70,239, which was 7 times that for a full-term normal infant.

Fixed and Variable Costs

Costs in the NICU can be broken down into fixed costs and variable costs. Fixed costs are those that are constant and do not change depending on the number of patients in the NICU. These include costs association with such things as overhead, NICU space, hospital facilities, and equipment. Variable costs are those costs that change as the patient census varies. These include medications, radiology and lab services, and disposable supplies. Costs can also be categorized as either direct costs, which are related to the care of a specific patient, or indirect costs, which are overhead costs accrued by all the patients in the unit. All direct and indirect costs have a variable

and fixed component. In general, NICUs have high fixed costs with lower variable costs. Therefore, strategies that lower fixed costs can have a significant impact on the actual costs associated with an individual unit.

The cost of NICU care can be broken down into three general categories: personnel, overhead and equipment costs, and the cost of ancillary services and supplies. Nursing services are by far the highest expenditure for personnel cost. Nursing accounts for between 40% and 70% of the personnel costs in the NICU and is estimated to cost $855 per day per infant (Richardson, 2001; Rogowski, 1998, 1999; Zupancic, Richardson, Lee, & McCormick, 2000). This cost is relatively high due to the NICU patient's acute level of health, which requires very labor-intensive nursing. Although high, this expenditure is considered cost-effective, since patient-to-nurse ratios have been closely related to mortality rates. Increasing this ratio may thus decrease competency and compromise performance. Expenditures on nursing care are based on nurse-to-patient ratio; noncontact nursing hours, including in-services, orientation, and vacations; and differences in salary within an individual unit due to differential pay for off-hour shifts, education, and seniority (Richardson, 2001). Expenditures on other personnel, including resident physicians and/or neonatal nurse practitioners who function in most of the larger NICUs, are usually incorporated into the per-day hospital costs.

Ancillary personnel include social workers, respiratory therapists, pharmacists, nutritional and lactation consultants, and occupational and physical therapists. Twenty-nine hospitals that participated in the Neonatal Intensive Care Quality Improvement Collaborative Year 2000 provided information on 6,797 VLBW infants with admission dates between 1997 and 1998. The median cost for these ancillary services was $14,328 per patient. This cost varied considerably based on both birth weight and gestational age. Those infants with the lowest birth weight and gestational age had the greatest need for ancillary services. For infants between 501 and 750 grams the median ancillary service cost was $34,386 per patient, while the median cost

for those infants weighing 1251–1500 grams was only $6,032. The median cost for infants between 751 and 1000 grams was $23,939; infants between 1001 and 1250 grams cost $12,437; and infants between 1251 and 1500 grams cost $6,032. Pharmacy services also varied according to birth weight, with those infants weighing 501–750 grams accruing $5,591 in pharmacy charges; infants weighing 751–1000 grams accrued $4,416; and those between 1251–1500 grams accrued $1,321 (Rogowski, 2003).

The per-diem cost of an infant admitted to the NICU is also based on the accommodation cost of the NICU care, which includes the cost of the hospital space plus operating expenses for nonpatient care services such as accounting, security and housekeeping services, equipment needed to successfully care for the infants, and disposable supplies. Expensive technologies are a significant source of increased healthcare costs. The NICU has more high-technology equipment than perhaps any unit in the hospital, and the cost of this equipment can be very high (Richardson, 2001). In spite of the high cost, the care of pregnant women and infants is a benefit for all of society, improving health status and cost efficiency. In the Oregon Medicaid Priority-Setting Project, Golenski and Blum (1989) rated maternal and infant care as the most ethical and cost effective.

Strategies for Cost Containment

Clinicians caring for critically ill infants in the NICU are sometimes placed in the difficult position of meeting the numerous demands of the premature infant with few resources (Kuzma-O'Reilly, et al., 2000). Although decreases in healthcare spending have been associated with an increased infant mortality, clinicians must continue to seek ways to decrease medical costs without compromising quality of care (Cremeux, Oulett, & Pilon, 1999).

In the NICU there may be several potential areas where hospital costs can be contained without increasing either the mortality or morbidity of the neonatal patient. One such avenue that

is currently being explored is the provision of developmental care. Developmental care focuses on coordination of activities to increase the amount of uninterrupted sleep, positioning to prevent disorganization and to promote self-regulation, and decreasing both light and noise in the NICU environment (Als, 1992; Als, et al., 1986, 1994). Developmental care has been shown to decrease the length of stay and the total hospital costs by $4,340–$25,670 per infant (Als, 1996; Fleisher, et al., 1995; Petryshen, Stevens, Hawkins, & Stewart, 1997).Developmental care has also been shown to decrease the risk of severe lung disease, decrease the rate of intraventricular hemorrhage, increase weight gain, and decrease the need for more intensive nursing care, all of which increase both hospital costs and length of stay (Als, 1996; Fleisher, et al., 1995; Petryshen, Stevens, Hawkins, & Stewart, 1997).

Another potential way to decrease the cost of healthcare in the NICU is by implementing early discharge programs. Aggressive discharge planning, extensive parental education, and home healthcare have been shown to significantly decrease hospital costs in the NICU by decreasing the average length of stay by 12–30 days, resulting in a significant cost savings of up to 27% (Brooten, et al., 1986; Kotagal, et al., 1995; Merritt, Pillers, & Prows, 2003).

Formal quality improvement plans can result in decreased hospital costs in the NICU (Rogowski, 2003; Rogowski, et al., 2001). Practice styles of clinicians caring for infants in the NICU can also be an important determinant of costs and outcomes in the NICU. Perlstein, et al. (1997) found significant variation among physicians in the provision of ancillary care of VLBW infants, including expenditures ranging from $210 to $644 per day in the first few weeks of life. Physician practice style may be particularly important when studying differences in treatment using more expensive treatment modalities such as surfactant therapy, nitric oxide therapy, blood transfusions, and mechanical ventilation.

Hospital administrators are under enormous pressure to provide cost containment strategies to reduce hospital costs in the NICU (Bowen, 1995). In state-funded units and managed

care settings, high NICU costs may necessitate decreased funding for other perinatal or pediatric budgets to compensate for the high cost of neonatal care. Insurers and varying forms of managed care are also placing pressure on hospital administrators to decrease spending in the NICU. These organizations are understandably concerned, since neonatal cases often fall into the catastrophic category of insurance claims (those costing over $100,000/year) (Schulman, 2003). Although neonatology has been largely ignored by insurers and managed care organizations, rising neonatal healthcare costs and increasing restraints on those costs will likely result in greater efforts at cost containment in this specialty (Schulman, 2003).

Hospital administrators and managers of NICUs must therefore concentrate efforts on significant cost containment strategies in their NICUs. One avenue that has been investigated to trim neonatal healthcare costs is reduction of nursing staff. A design configuration for the NICU that increases the need for more nurses could impact the operational cost for the unit. Nursing care accounts for 40% of hospital charges, and significant cost savings would be expected if this expense were reduced. This strategy must be undertaken with extreme care, however, since higher patient mortality and morbidity have been attributed to an increased nurse-to-infant ratio (Goldfrad & Rowan, 2000; Tarnow-Mordi, Hau, Waraden, Shearer, 2000; Tucker & UK Neonatal Staffing Study Group, 2002).

Administrators have utilized measures to decrease the cost of nursing care without actually decreasing the amount of time a nurse spends providing direct patient care. These strategies include reducing redundant or unnecessary testing and treatments and decreasing the number of activities performed away from the bedside, including charting, parent education, nursing education, staff meetings, and reporting. While these strategies may reduce nursing costs, they may also decrease staff satisfaction, which could potentially increase unit costs through high staff turnover. Delegation of nursing duties to other less highly paid personnel such as nurse

extenders and unit clerks may also be an effective strategy for cost reduction (Richardson, Zupancic, Escobar, Ogino, Pursely, & Mugford, 2001).

Another mechanism for decreasing nursing-related costs is variation in the number of available nurses as the unit census varies. Several approaches have been shown to be effective, such as developing better workload predictors using patient characteristics in order to anticipate the number of nurses required in the unit at a specific time and using simulation models of patient flow in NICUs (Zupancic, Shah, & Richardson, 1999).

Impact on Personnel and Families

Cost containment can significantly affect the job satisfaction of personnel working in the NICU. While reducing the amount of money spent in the short term, a reduction in personnel has the potential to actually increase the overall personnel cost in the NICU. A decrease in number of staff tends to increase the workload of the remaining staff, which may decrease job satisfaction, resulting in an increased turnover rate. Costs related to both the exiting of one employee and the hiring and orientation of another can be enormous in both loss of revenue and loss of production. The cost of replacing a worker has visible costs, also called adjustment costs, which include termination, advertising and recruitment, candidate travel, selection and hiring, orientation, and relocation (Abbasi & Hollman, 2000). In addition, there are many "hidden" costs and consequences, such as the costs incurred during the vacancy of the position and the loss of production while the new hire acclimates to the job requirements before achieving maximum efficiency (Abbasi & Hollman, 2000). Professionals estimate that a new staff member produces at only 25%–50% of the level of an experienced employee during the first three months and that it takes a year until a new employee is fully productive (Gustafson, 2001).

The high cost of neonatal intensive care coupled with strategies used to decrease spending may also affect the satisfaction level of parents of infants in the NICU. In the current

healthcare climate, patient satisfaction is considered to be extremely important. The potential increase in parent satisfaction in the SFR unit may have cost implications. This is especially true as healthcare providers compete for patients and for subsequent reimbursement from third-party payers and public funding; such cost implications may even be included in an institution's outcome reports (Draper, Cohen, & Buchan, 2001; Ireson, Ford, Hower, & Schwartz, 2002; Uzan, 2001; Woodbury, Tracy, & McKnight, 1998). Other financial losses, including lost wages and the cost of transportation and childcare for other children, can place a significant financial burden on families and may greatly increase their level of stress (Rawlings & Scott, 1996; Richardson, 2001).

As previously discussed, early discharge may be an effective mechanism for cost containment in the NICU. In addition, parents' satisfaction increases with early discharge as evidenced by improved parent-infant relationships (Jeffcoate, Humphrey, & Lloyd, 1979), fewer incidents of child abuse and abandonment, and less grieving (Affonso, et al., 1992; Hunter, Kilston, Kraybill, & Lodon, 1978). However, early discharge places a large burden of responsibility on the parents (Rawlings & Scott, 1996).

Review of Current Research on Construction Costs for NICUs

Factors Influencing Costs

Studies reporting construction costs related to NICU environments were not found. In an expanded search on construction costs for acute-care facilities, empirical studies focusing on hospital construction costs were not found. However, a discussion of the rising cost of constructing healthcare facilities indicates that design elements and strategies for patient-friendly healthcare environments are often the first items cut from projects during value engineering (Moon, 2005). Moon states that price increases from commodities such as oil, steel, and other construction materials, coupled with larger space requirements and changing technology help to fuel the rising costs. Moon cites an increase of 10%–15% for many healthcare facility projects currently under construction compared to the previous year.

By contrast, an article on single-room maternity care indicated that initial comparisons of NICUs from hospitals of differing sizes demonstrated that changing from an open-bay to private rooms for labor, delivery, recovery, and postpartum (LDRP) care increased patient volume and reduced operational costs (Nathanson, 1985). The primary reason cited for lower operational costs was a decrease in the number of full-time employees (FTE). LDRP suites have become standard in many hospitals across the nation, suggesting that in spite of the expected increases in costs for private room design, the provision of LDRP suites is a facility strategy that is continuing to infiltrate other types of patient units, including NICUs.

Controlling Costs

Controlling costs is essential for hospital administrators in today's tough economic environment. The costs to the healthcare system are many and complex and include up-front costs associated with the construction of the facility. Construction costs can vary depending upon a number of factors, such as policies of regulatory agencies; type of contract; season of the year;

construction management issues; weather; building codes; availability of adequate energy, skilled labor, and building materials; owners' special requirements/restrictions; safety requirements; size of project; and location (Waier, 2005).

Healthcare construction costs vary by region, with a premium for construction in seismically active areas (Bobrow & Thomas, 2000). When making cost comparisons of hospital units from city to city and region to region, the Means City Cost Index (CCI) provide average construction cost indexes for 719 U.S. and Canadian cities covering over 930 three-digit zip code locations and is updated yearly. The publication is aimed primarily at commercial and industrial projects costing upwards of $1 million.

CHAPTER 3: METHODOLOGY

Introduction

The use of multiple research methods allows researchers to gather sufficient data about different aspects of a subject. The complexity of healthcare environments and users requires multiple techniques to understand the interaction between participants and environment (Zeisel, 1984). According to Maxwell (1998), the objective of the multimethod research design is to reduce the risk of systematic distortions inherent in the use of one methodology alone.

Using multiple research methods and triangulation to study neonatal intensive care unit design configurations may increase reliability and decrease the chance of falsely constant results (Harris, 2000). This research study employed methodological triangulation, the use of two or more methods of data collection procedures within a single study (Leedy, 1993). The appropriate combination of methods—evaluation of the physical environment, surveys of user groups, examining aggregate hospital data, and analyzing cost analysis data— enables the greatest level of control over data collection and analysis and the incorporation of the findings in developing design guidelines for the design and construction of NICUs. This study utilized plan reviews with aggregate data for construction costs, hospital records, and surveys of healthcare staff and parents of infants who were treated in the Level III NICU.

Environmental Sampling and Analysis

Eleven hospitals participated in this study. Each provided construction documents, specifications, construction costs, and access for site visits. Construction documents provided data for plan reviews and program analysis. Site visits verified the accuracy of the plans and the

relationship of support areas to the building and medical systems. Postoccupancy evaluations (POEs) documented how the unit operated and identified best practices. Construction cost data supplied by the hospital system was limited to initial costs and provided key data for the planning of NICUs.

Plan Reviews, Site Visits, and Postoccupancy Evaluations

Floor plan analysis provided relevant information about the participating NICU departments and supported the aggregate data supplied by each hospital. The physical environment was documented through architectural plans, specifications, and program. Through plan analysis, the program was extracted and compared to facilities of the same configuration and to other configuration types. In addition, the floor plan analysis provided a defined context in concert with other data to generate a POE of a given site.

Archival data collection and POE analysis offered opportunities to present lessons learned for the design and construction of future facilities (Wang, 2002). Preiser, Rabinowitz, and White (1988) divide POEs into three levels: indicative POE, investigative POE, and diagnostic POE. An indicative POE analyzes as-built drawings and divides them into categories while interviews are conducted with building occupants to better understand the performance of the building. An investigative POE is one that compares an existing situation with comparable facilities and summarizes current literature regarding the topic. A diagnostic POE involves a multimethodological approach (surveys, observations, physical measurements, etc.) conducted in comparison to other facilities.

One part of the POE is the plan review. The method of floor plan analysis for this endeavor incorporates three types of analysis: the review of as-built drawings, comparison with comparable facilities, and analysis of measured categories (Preiser, Rabinowitz, & White, 1988).

According to Moon (2005), providing private rooms may result in higher construction costs due to more square footage. However, according to Mathur (2004), the increased area for a single room is offset by the elimination of parent sleep rooms within or adjacent to the unit. Unfortunately, there is little evidence to support either suggestion.

This study analyzed each participating facility, examining allocations of space for the staff, patients, and families; those for circulation; and net-to-gross ratios. First, the plan was reviewed and a program generated by placing every room into one of six general categories: patient, family, staff, public, systems, and unit circulation. The total area in square feet of every space was measured and listed in a Microsoft Excel spreadsheet. The defined infant station areas were measured and documented. Space allocations at the infant station were defined as patient, family, and staff; additionally, clear floor space was measured and documented.

After the floor plans were assessed and measured, three sets of diagrams were prepared: (1) circulation diagram, (2) allocation of space diagram, and (3) infant area diagram. The diagrams visually defined the circulation patterns and user zones for each setting.

The plan assessment was followed by calculating the average square feet for (1) infant space, (2) family space, (3) staff space, (4) circulation, (5) staff space at bedside, and (6) family space at bedside. Space allocated to public space and vertical circulation was excluded from the overall square feet of each unit. Once all of the plans were measured and the areas determined, the net-to-gross factor for each facility was calculated based on the non-usable square feet (wall partitions).

Based on the plan analysis and participating unit configurations, site visits and POEs were completed at a select group of NICUs.

There are several issues that have been raised in relation to room design that can be observed through site visits and POEs, such as parent and staff behavior in relation to the space. To examine parent behavior, the researchers looked at interaction with infants, staff, and other

parents, as well as controllable features of the infant care space. Regarding staff behavior, the researchers looked at interaction with infants, families, and other staff; amount of travel per hour; and controllable features of the space. The researchers sought to address issues regarding the distance nurses travel per shift, visual and acoustical privacy versus isolation for families, staff isolation, and nurses' ability to adequately monitor the condition of the infant.

The researchers visited one SFR and three open-bay units. This was a sample of convenience based on access and availability for hospitals to participate. The researchers had expected Open-bay #1 to be all open architecture, but the unit had four private rooms/bays, three of which were in use during the site visit; these spaces were treated differently by staff and by families. Open-bay #2 and Open-bay #3 were completely open-bay designs. Open-bay #2 had three semiprivate bays planned and built, but unit practice and exterior lighting levels did not support the initial design; one of the semiprivate rooms was turned into an office, and two were converted to quad rooms/pods. These converted rooms did not meet space guidelines found in the Recommended Standards (Consensus Committee, 2002). This, in effect, converted Open-bay #2 to a completely open design.

The POE team consisted of two research team members and one research intern. Data sheets were designed before visits to measure traffic, infant visibility from nursing stations, pedometer results, and controllable privacy methods used.

The first task at each unit was to have a guided tour by a staff person (an neonatal nurse practitioner [NNP] or unit manager), who explained how the space was used and the level of satisfaction with the unit design for these tasks. Photographs of features relating to infant space, parent space, public space, and staff space were taken by the research team architect with experience in POE. The POE team paid attention to infant-monitoring and security features and how they were used. Parental presence policies and visitor policies were also recorded. Researchers noted any features that affected the function of the unit, such as thermostat function,

which affected door closure to the SFRs. Open-ended interviews were used to collect comments from nurses, therapists, management staff, unit clerks, nurse practitioners, and physicians. Early visits were three days in length, but as the team gained experience it became clear that a single day was sufficient to collect the necessary data.

Visual privacy was measured by observing the use of privacy controls such as screens, curtains, doors, chair positions (away from or facing traffic), opaque walls, full or partial walls, infant bed covers, and window coverings. The use of these controls was measured in the morning, in the afternoon, in the evening, and at night for all units except Open-bay #3, where data collection was interrupted, preventing morning measures. The researchers accepted this limitation since the other units had shown less familial presence and a lower use of visual privacy measures in the morning in Open-bay units. Measures were made at least twice during each time frame by conducting a walk through across the entire unit. Traffic exposure was noted to see how susceptible each space was to possible intrusions of visual or acoustical privacy. Any changes to privacy measures were also noted during the extended traffic study observations. Any behaviors that supported or violated privacy that were observed during traffic measures were also noted.

Traffic measures were performed by researchers who sat or stood in a location in a unit where multiple infant care spaces or their entrances could be observed. The observation site was selected based on the layout of the space and visual access to multiple baby stations or rooms, not a random selection. Anyone coming into the visual field was scored as staff, parent, or other family/visitor on a data collection sheet. The assignments of parent or other family/visitor were made by observation and by confirming with the nurse responsible for that particular infant. Each person was also scored as entering the infant space, passing by and looking into the infant space, or passing by and averting their gaze. All traffic creates noise (visual and auditory), but gaze averting adds a layer of privacy. Two locations in each unit were observed. The SFR unit had 8 one-hour observations. At Open-bay #1 the traffic was more than double that of the SFR unit, and

the data sheet was filled within a half hour. Times of observation for the Open-bay units were shortened to 30 minutes to preserve accuracy of the counts. Open-bay #1 had 8 half-hour observations, Open-bay #2 had 4 half-hour observations, and Open-bay #3 had 3 half-hour observations. Means, standard deviation, and minimum and maximum counts were calculated for each occupied bed. Unoccupied beds were excluded from the results calculations since there was little activity in these spaces.

Individual control of space was determined mainly by direct observation during walk throughs and traffic measures and by interviews with staff. Items noted were decoration of space, temperature control, light control, noise control, privacy control, and number of visitors.

Parental presence and visitation policies were obtained through interviews with upper-level staff on the initial walk through. These were confirmed by direct observation during walk throughs and traffic observations. Staff comments about these policies were recorded in the notes.

Parental amenities at bedside and beyond were noted on the initial tour; they were photographed at empty bedsides as well as when the amenities were not in use.

Parent-to-parent contact was directly recorded on walk-throughs and during traffic observations. Staff members were also interviewed about parental interaction and the activity of formal parent support groups.

The method of infant monitoring was reported by the staff while on the initial tour, it was directly observed during traffic measures, and it was collected through staff comments.

Staff workspace configuration was noted from the plans. Use of the space was observed on walk-throughs and during traffic observations.

Staff interaction with families was noted during traffic observations.

Walking during the shift was recorded by at least 4 nurses at the SFR and at Open-bay #1 (5 nurses) and #2; these nurses wore a pedometer for periods ranging from 1 hour to 12 hours. Three nurses participated at Open-bay #3. To gather data on this concern, we calibrated 4 Omron

HJ-105 pedometers until they reliably read 100 steps with +/- 2%. We asked nurses to wear these pedometers and then divided the steps by the number of hours. The total hours recorded at each site were 40 hours for the SFR unit, 12.3 hours for Open-bay #1, and 12 hours each for Open-bay #2 and #3. Pedometers were worn at the convenience of volunteer staff nurses. The hourly average was calculated and an ANOVA was run using an EXCEL statistics package to test for significant difference. The desirable beds were described by traffic counts, use in the unit, and staff interviews.

An assessment of the selected NICUs will provide meaningful data about particular units in areas including the physical environment, the nursing model, and operational procedures; it will also identify best practices across the boundaries of unit configurations.

Construction Cost Analysis

All of the 11 participating hospitals provided this study with construction cost data. Since the units are located throughout the United States and were built between 1995 and 2005, it was necessary to adjust the costs for comparison. Construction costs were compared after adjusting to the year 2005 and normalizing to the national average cost. The Means Historical Cost Index was used to adjust the archival cost data from each participant to what the approximate construction cost for each facility would be in the year 2005 (Waier, 2005). After the costs were adjusted to 2005, the Means City Cost Indexes (Waier, 2005) were used to compare cost from city to city, with the end result normalized to the National City Cost Average. The cost analysis was based on the dollar value of the unit, which may in some cases have been extracted from larger projects or, in the case of expansions, extracted from the cost associated with addition to the building envelope. After the analysis, the costs were expressed in cost per infant station and cost per squire foot.

Participants Sampling and Analysis

Patient Medical Outcomes

Of the 11 hospital participants, only 5 were able to provide the requested hospital records data for two years prior to occupying the new unit and two years post-occupancy. The data was supplied by two SFR units and three open-bay units. The data collected focused on patient and staff data that was generally available through the healthcare systems database and was supplied to the research team by a hospital employee. Data points included

1. staff turnover
2. staffing FTEs
3. patient-to-staff ratios
4. patient transfers (acute and convalescent)
5. admissions and discharges per year (inborn and transfers)
6. average daily census (ADC)
7. average length of stay (ALOS)
8. nosocomial infections reported
9. mortality percentage

This data provided a snapshot of the complex environment and its impact on patients and staff, focusing on patient outcomes and operational issues within the unit.

Surveys for NICU Staff and Parents

Surveys of NICU staff and parents of infants who had been treated in the NICUs explored the preferences and experiences of those who were providing and receiving care in open-bay units compared to single family room units and combination units. The staff surveys were distributed to two facilities: one unit had changed from open-plan to single family room; the other unit had changed from open-bay to a combination unit. One hundred sixty staff surveys

were sent out, with a return rate of 47%. The parent survey was sent in two batches. The first batch was a randomized selection of 596 families. Of the 596 total surveys, 40% were returned to sender, suggesting that, at best, 357 surveys were delivered to potential participants. As only 14 completed surveys were returned, a second batch was sent to a subset of individuals who had received the first request. Assuming that one of the factors that inhibited a good response rate was the fact that, for some subjects, up to 6 years had passed since the NICU experience, the second wave of surveys was limited to those individuals whose experience was most recent. Two hundred surveys were resent. A total of 21 responses were received from parent participants.

The following literature review describes the surveys from which our research was developed, defines the research questions and goals of the surveys, and discusses the procedure employed for analysis.

Expanded Nurse Stress Scale

This study utilized 48 questions from the 59 items in the Expanded Nurse Stress Scale (ENSS) by French, Lenton, Walters, and Eyles (2000). The original Nurse Stress Scale (NSS), developed by Gray-Toft and Anderson (1981), has 34 items in 7 subscales, while the expanded one has 59 items in 9 subscales. NSS has been widely used; the use of ENSS is limited.

The scoring of the NSS is the summation of scores of items in one subscale or scale (Huengsberg, Vedhara, Nott, & Bradbeer, 1998; Parker, Barnes, McKee, Morgan, Torrington, & Tregenza, 2004). According to Gray-Toft and Anderson (1981), each item is scored as 0: never experienced" to 3: frequently experienced." In ENSS, one choice of "not applicable" is added. In accordance with the scoring of the Parental Stress Scale: Neonatal Intensive Care Unit (described below), the "not applicable" choice will be also rated as 1, which is the same as "never stressful."

Only one article described the use of 1 subscale of ENSS with the other 7 subscales of NSS (AbuAlRub, 2004). All other articles described the use of NSS with some adaptations (adding or removing some items).

Depending on the focus of studies, two methods were used in data analysis. If the study compared 2 groups, parametric tests—such as *t* test, analysis of variance (ANOVA), and analysis of covariance (ANCOVA, e.g., Huengsberg, Vedhara, Nott, & Bradbeer, 1998)—and nonparametric tests (e.g., Escot, Artero, Gandubert, Boulenger, & Ritchie, 2001) were used. If the study focused on the correlation of two or more variables in 1 group, multiple regression analysis and correlation analysis were used (e.g., Bowman & Stern, 1995; Lambert, Lambert, & Ito, 2004).

Due to the difference in samples, French, Lenton, Walters, and Eyles (2000) suggested this scale should be further tested when used in new samples.

Job Satisfaction Scale

The Job Satisfaction Scale (JSS) was originally a 5-item subscale in the Nurse Stress Index developed in England by Harris, Hingley, and Cooper (1988). This scale is less frequently used than other standard scales (Cooper & Mitchell, 1990). Most articles describing the use of this scale are from England or Australia.

The scoring of this scale is the summation of all items (e.g., Healy & McKay, 1999). Analysis methods include descriptive statistics comparison (e.g., Happell, Martin, & Pinikahana, 2003; Pinikahana & Happell, 2004), *t* test (e.g., Healy & McKay, 1999),ANOVA on 2 groups(Cushway, Tyler, & Nolan, 1996), and regression/correlation analysis (e.g., Healy & McKay, 2000).

Parental Stress Scale: Neonatal Intensive Care Unit

The Parental Stress Scale: Neonatal Intensive Care Unit (PSS:NICU) was developed by Miles, Funk, and Kasper (1991) and Miles, Funk, and Carlson (1993). It includes 46 items in 4 subscales: sights and sounds, baby appearance, parent role, and staff relationship and communication.

The testing of the scale showed a low frequency of answers in the subscale "staff relationship and communication," so this subscale has been dropped in the recent revision (Miles & Funk, 1998; Miles, Funk, & Kasper, 1991). The reason might be, as noted by Miles, Funk, and Kasper (1991), that parents cannot "critically assess" nurses when their infants are still in the NICU. Three subscales from the PSS:NICU were selected for this study: sights and sounds; parent role; and staff behaviors and communication. Because the survey is mailed to parents after the discharge of their child, parents are more likely to express concerns about nursing staff (Reid & Brammell, 2003).

Miles and Funk (1998) described three methods in scoring the scale: Metric 1: Occurrence of stress ("not applicable" as missing); Metric 2: Overall stress level ("not applicable" as "1, Not at all stressful"); and Metric 3: Frequency stress as "1"; "not applicable" as "0"). The score of a subscale or a scale is simply the average of scores of the included items.

Analysis methods appearing in the literature include nonparametric test (Preyde & Ardal, 2003); ANCOVA (Meyer, Coll, Lester, Boukydis, McDonough, & Oh, 1994); *t* test and ANOVA (Dudek-Shriber, 2004; Miles, Funk, & Kasper, 1992); and regression/correlation analysis (Meyer, Garcia Coll, Seifer, Ramos, Kilis, & Oh, 1995; Shields-Poe & Pinelli, 1997; Spear, Leef, Epps, & Locke, 2002).

Previous research identified several factors influencing the PSS:NICU scores, including age, gender, marital status, and length of stay (Dudek-Shriber, 2004).

Satisfaction and Perception of Physical Environment

The questions used in the sections of "satisfaction with physical environment" and "level of agreement regarding the physical environment" are adapted from the survey questionnaire given to family members in the NICU that was developed by Fournier (1999) in her dissertation study. Fournier (1999) used descriptive statistics and charts to summarize several themes, which were generated from the survey responses.

In the study undertaken here, which compares two different NICUs, the descriptive statistics and charts of two NICUs are listed side by side to visually show the differences between the two. This method has been used on the JSS, as described in Happell, Martin, and Pinikahana (2003) and Pinikahana and Happell (2004).

Aims

The objective of the statistical analysis was to examine questionnaire answers to detect and compare significant differences between two NICUs. More specifically, the following hypotheses were tested:

1. Staff members and parents of patients are more satisfied with the environment of the SFR unit than the open-bay unit.
2. Staff members and parents of patients perceive the physical environment in the SFR unit to be better than that of the open-bay unit.
3. Staff members and parents of patients report less stress in the SFR unit than the open-bay unit.
4. Staff members have higher ratings of job satisfaction in the SFR unit than the open-bay unit.

Procedure

The statistical analysis included the following procedures:

1. Data input and manipulation

The raw data sets on paper were first transferred to electronic files using spreadsheet software such as Microsoft Excel. Then the input was double-checked by two independent researchers to make sure there was consistency between electronic files and the original data.

Some of the items in "perception of physical environment" are negative (e.g., depressing) while other items are positive (e.g., supporting family presence). The ratings on these negative items were reversed; thus, for all items higher scores indicate better environment.

Because our study focused on the overall stress level of parents, the Metric 2 method suggested by Miles and Funk (1998) was used to recode the PSS:NICU data. The response "not applicable" was recoded as "1," while other responses didn't change. The score of the subscale is the average score of all items in this subscale; the score of the scale is the average score of all items in the scale.

For ENSS, the score for one subscale is the summation of the items in that subscale; the overall score is the summation of the items in the scale. Each item was scored as being from 0 to 4. For JSS, the score of the scale is the average score of the answered items. At the end of this step, data files were transferred to a statistical analysis package, Statistical Package for Social Sciences (SPSS).

2. Preliminary analysis

Descriptive statistics—e.g., means, medians, variances—along with plots—e.g., scatter plots, histograms, normality plots of all variables-were produced to check the nature of the data. Certain tests, such as the normality test in SPSS, the Breusch-Pagan and Koenker test, were used to determine whether the data are normally distributed with equal variances. If not, the data set

was transformed, according to the results of procedures such as Box-Cox, to meet the assumptions of parametric tests.

Then, to ensure similarity between samples, *t* tests or nonparametric tests were performed to detect differences in demographic characteristics, such as age and length of stay, between the respondents from the two NICUs. If any significant difference was found in one variable, this variable was entered as a covariate in the subsequent analyses. This may help to more confidently contribute to the physical environment the difference in dependent variables.

3. Hypothesis testing

Based on the results of step 2 and using the data from ENSS, PSS: NICU, and JSS, several procedures were used to test the hypotheses.

If the assumptions of the parametric test were met, the data was analyzed using the *t* test (if no difference was found in group characteristics) or ANCOVA. If these assumptions were not met, nonparametric tests, such as the Mann-Whitney *U* test, were used. In addition to calculating the overall score for each of these scales, scores on subscales were tested individually. The confidence level for this study is 95% (α=0.05).

For the data related to satisfaction with and perception of physical environment, tables and charts of descriptive statistics were used to compare aspects of the environment of the two NICU settings.

CHAPTER 4: RESULTS

Introduction

This study utilized multiple methodologies to investigate the typical design configurations for neonatal intensive care units including single family room, open-bay, combination, and double occupancy designs. The hypothesis states that single family room NICUs have compelling benefits for the patient, families, and healthcare staff. This chapter begins with the research findings from evaluations of the physical environment and its interface with users, then focuses on the construction cost analysis, and finally discusses patient outcomes and surveys of the healthcare staff and parents of neonates.

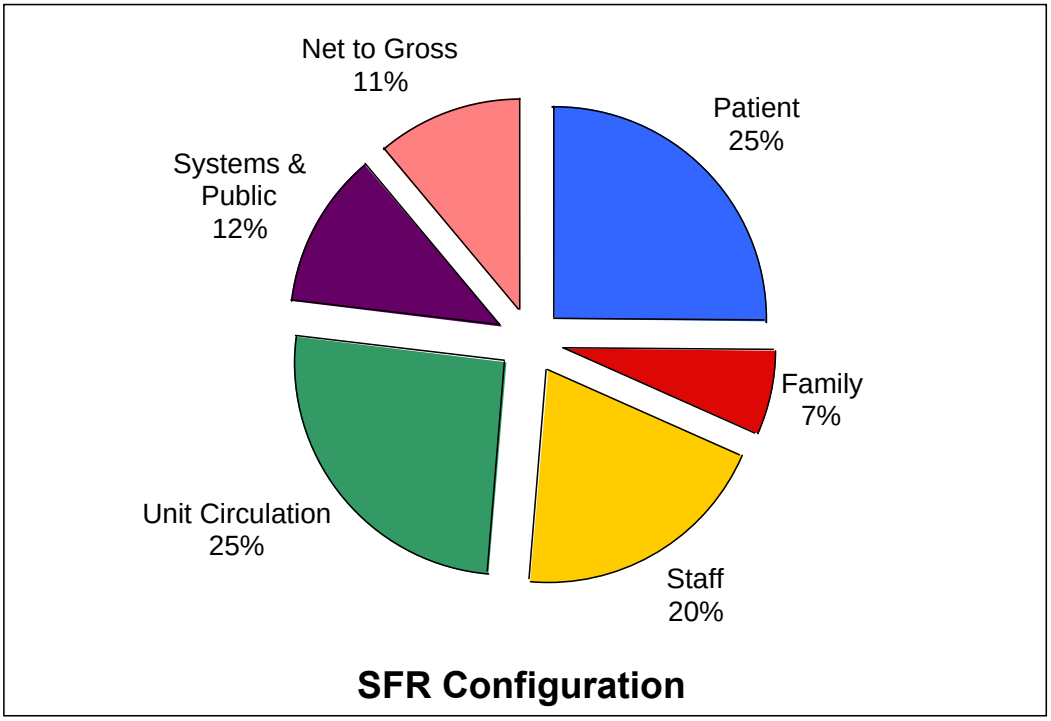
Plan reviews

The allocation of space within the NICUs participating in this study provides clues to trends regarding the need to accommodate parents and extended families, the participation of families and how much access they will have to their child and to healthcare, and the ability to meet the functional needs of the space and to provide adequate support for the unit staff. Allocated square feet imply a specific use or user. In addition, the circulation within the unit; the net-to-gross factor; and allocated space not specific to the infant, family, or NICU staff are part of the equation of determining the amount of space in the unit and how it is used. While it may be useful for an institution to compare its facility against the configuration averages, due to the variety of solutions for the NICUs within the configurations, the results are not generalizable.

Unit Space Allocations by Configuration

The review of plans shows that regardless of design configuration, there is a lot of variety in the organization of space (refer to the explanation of methods for plan review on p. 32 for

additional information). This study identified space allocated to infants; families; unit staff; building and medical systems; and the public, if applicable (see Appendix A). Generally, it appears that the design of the units may be driven by the philosophy and nursing model of the NICU unit, the pragmatic needs of the staff, and the limitations of the building. For instance, the only facility that clearly integrates the family space (outside of the infant area for that family) within the infant care areas is Single Family Room Unit A. All other facilities, regardless of design configuration, relegate the family space to an adjacent area or, at best, to the very edge of the patient care areas. The relationship of unit staff space to the infant care areas is consistent through all configurations. Staff and support spaces are integral to the patient care areas, including the single family room unit configuration (Figures 1 & 2).



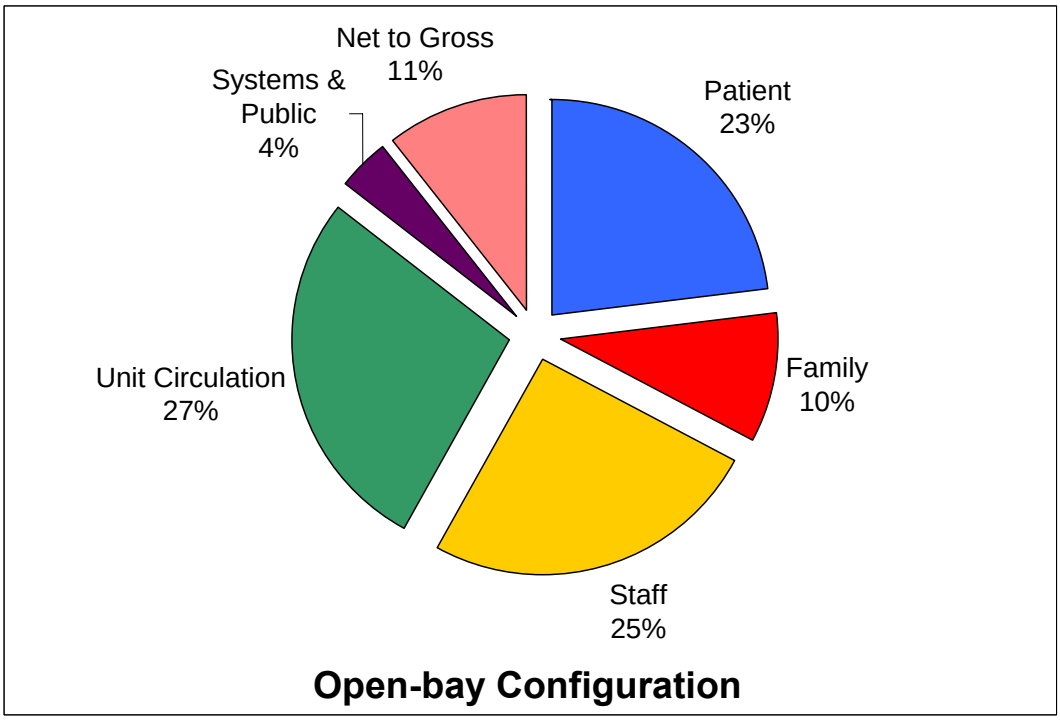


***Figure 1*. Mean space allocations by NICU configuration (SFR and Open-bay).**

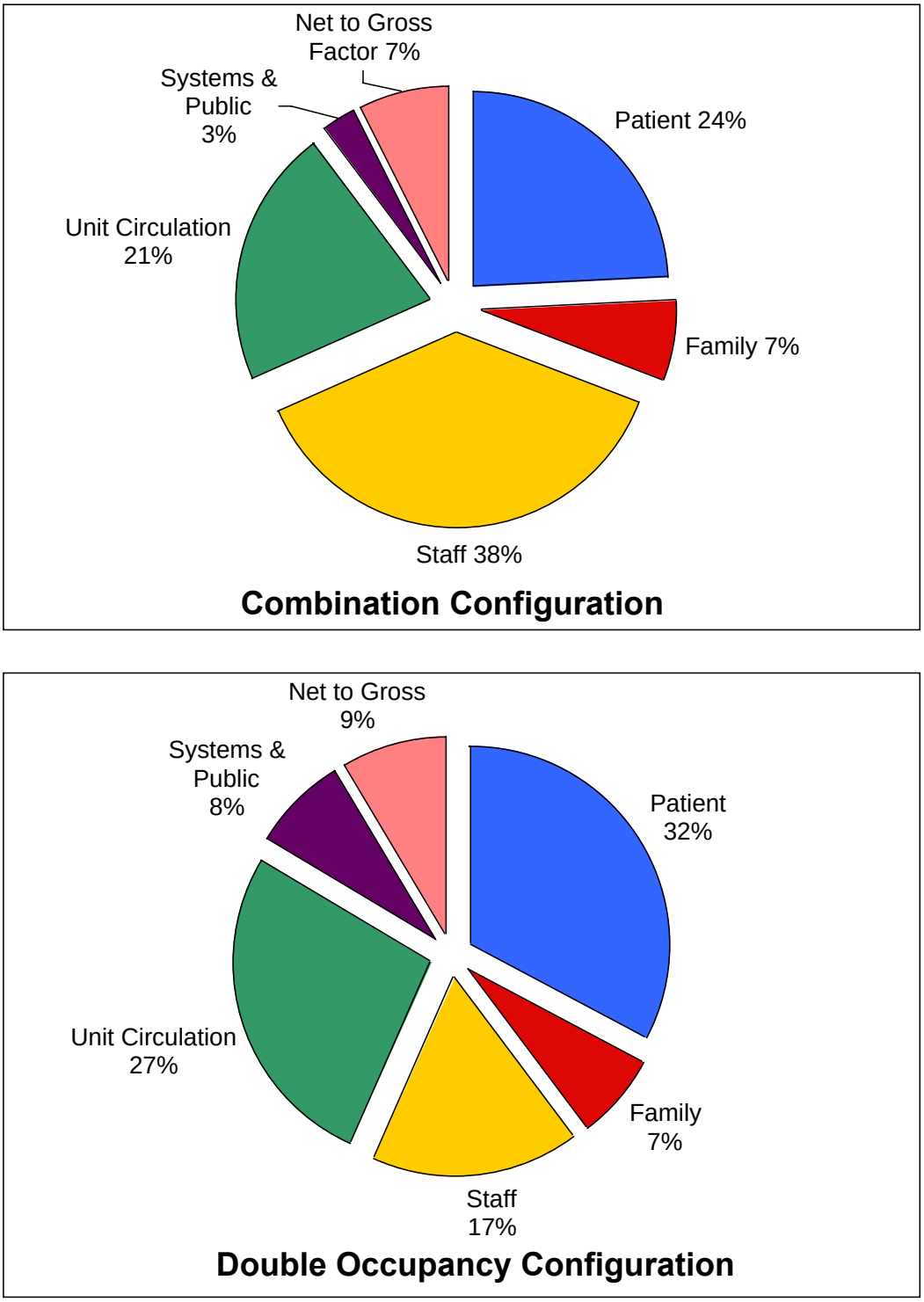


***Figure 2*. Mean space allocations by NICU configuration (Combination and Double Occupancy).**

Circulation paths are driven by the building plan. A “race track” design is used most consistently; however, in some instances, a radial design is used as a primary or secondary circulation path. The open-bay configuration had the highest percentage of circulation allocated to the configuration average, with a mean of 28% (Table 1). When reviewing the plans the researchers found that more area for circulation is located around the “pinwheel” infant stations, suggesting a difference in space efficiency compared to other configurations, including open-bay units with infant stations located around the perimeter.

This study found that the mean space allocation within the unit for infants, families, and NICU staff combined was 59% of the unit design, regardless of configuration. For the SFR configuration, the mean was 51%; the mean for the open-bay configuration was 58%; the combination configuration mean was 68%; and the double occupancy configuration mean was 57%.

The double occupancy configuration allocated the most space to the patient. Space allocated to the infant is defined as the infant station, whether it is a room, a pinwheel, an open area, or a shared space. The least amount of space allocated to a patient was 23% of the open-bay unit (Figure 1, Table 1). Space allocated to the family away from the infant station was similar in SFR, combination, and double occupancy configurations; however, the open-bay configuration had the most space allocated to the family, with a mean allocation of 10%. The mean allocation of space for staff work and support functions was lowest for double occupancy (17%) and SFR (19%). The unit configuration with the highest allocation of space for staff and support functions was the combination configuration, with a mean of 38% (Figure 3).

Table 1. **Allocation of space within the NICU unit organized by configuration.**

	Patient	Family	Staff	Unit Circ.	Systems & Public	Net to Gross
SFR	25%	7%	19%	26%	12%	11%
Open-bay	23%	10%	25%	28%	4%	11%
Combination	24%	7%	38%	21%	3%	7%
Double Occupancy	33%	7%	17%	27%	8%	9%

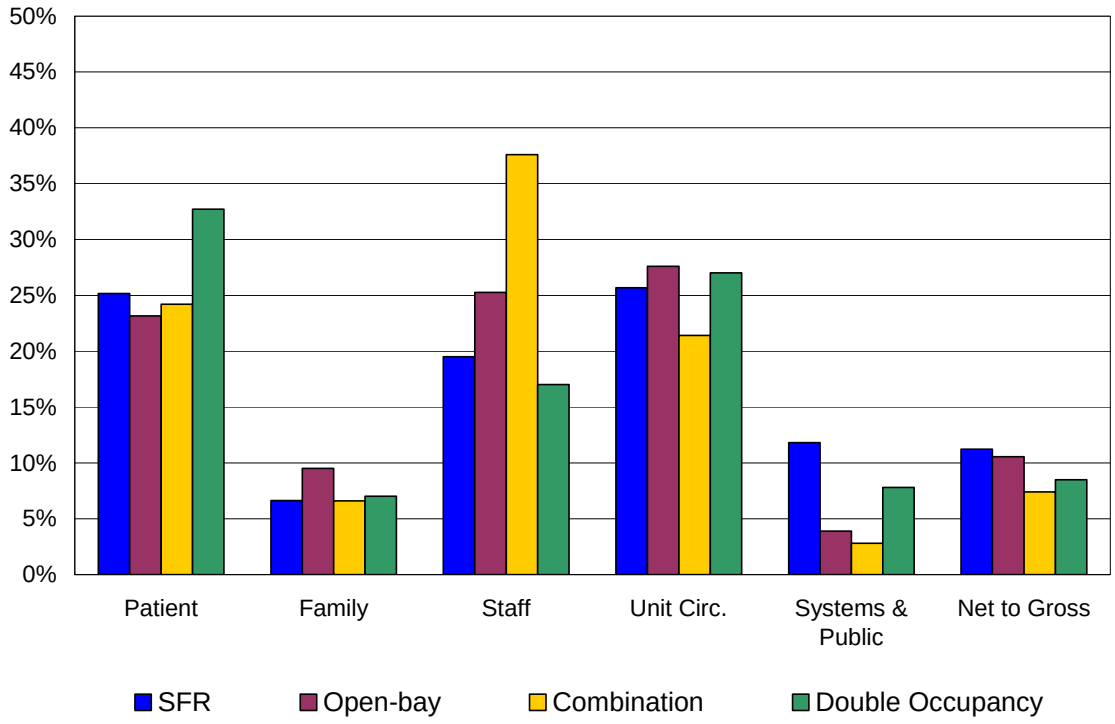


Figure 3. **Percentage of space allocation by use category comparing configuration types.**

The mean usable space allocated to circulation for all 4 configurations was 26%. The mean usable space allocated to circulation by configuration varied from 21% to 28%, from combination to open-bay, respectively. The SFR configuration's average allocation of space for circulation was closest to the overall average at 26%. The net-to-gross variance for all 4 unit

configurations had a mean of 10%. The unit configuration with the lowest net-to-gross factor was the combination unit (7%), while the SFR and open-bay configurations shared the highest (11%).

The remaining percentage of the unit configurations contained programmed space for building and medical systems, public space, and vertical circulation. Building and medical systems were consistent regardless of design configuration. Areas used for public space and vertical circulation, including general waiting areas, elevators not specific to the NICU, and fire stairs, were tracked in this study to account for square feet not attributed to the NICU. However, their role in this study is negligible; the amount of square feet for these areas was excluded from the total gross square feet (GSF) from each participating facility and will not be discussed. Finally, the relationship between the unit configuration total SF and the number of infant stations indicated a trend toward efficiency based on a higher number of infant stations. The SFR configuration averaged the highest GSF per infant station (675 SF for 28 infant stations), and the double occupancy configuration ranked the lowest for GSF per infant station (340 SF for 48 infant stations) (Figure 4).

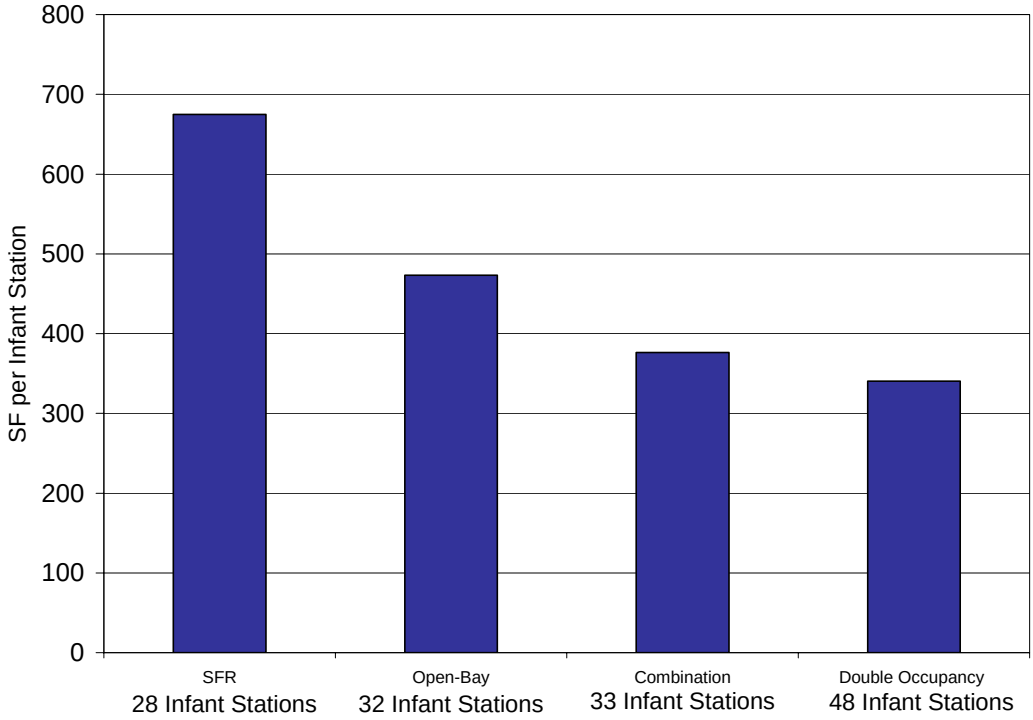
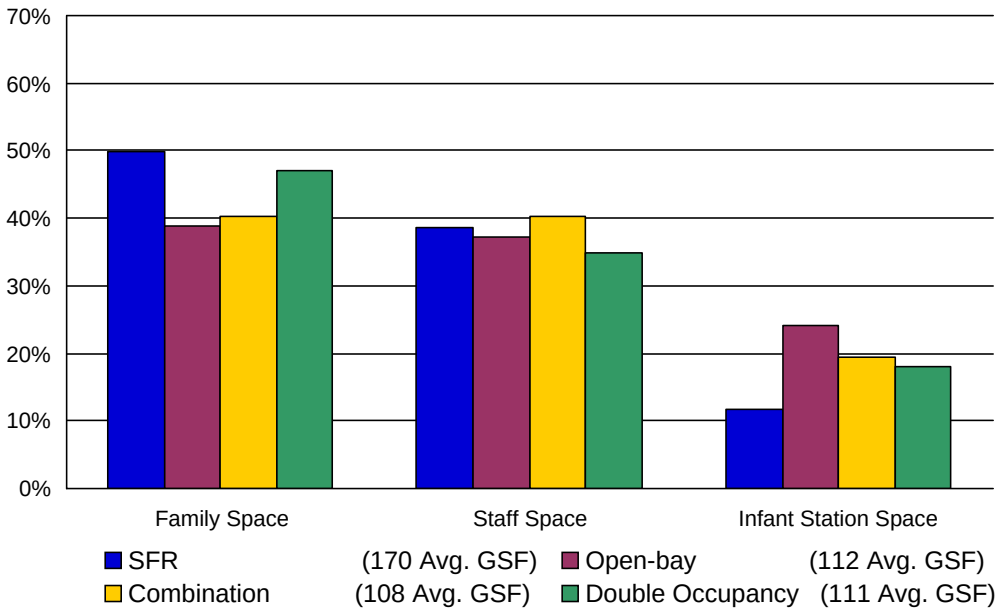


Figure 4. **Unit square feet per infant station organized by configuration**.

Allocation of Space for Infant Station Area by Configuration

At the infant station or infant room, the average clear floor space for all infant station configurations was 73%, with all configurations within +/- 6%. The unit designs with the highest amount of space allocated to the infant were the open-bay configuration (24%) and combination configuration (19%); SFR allocated 12% to the infant. However, the space allocated to families was highest in the SFR unit, with 50%. The double occupancy unit was second highest with 47%. The lowest amount of space allocated to the family at bedside was in the open-bay unit (39%). For staff and support space, the overall mean was 38%, with all configurations within +/-3% (Figure 5).



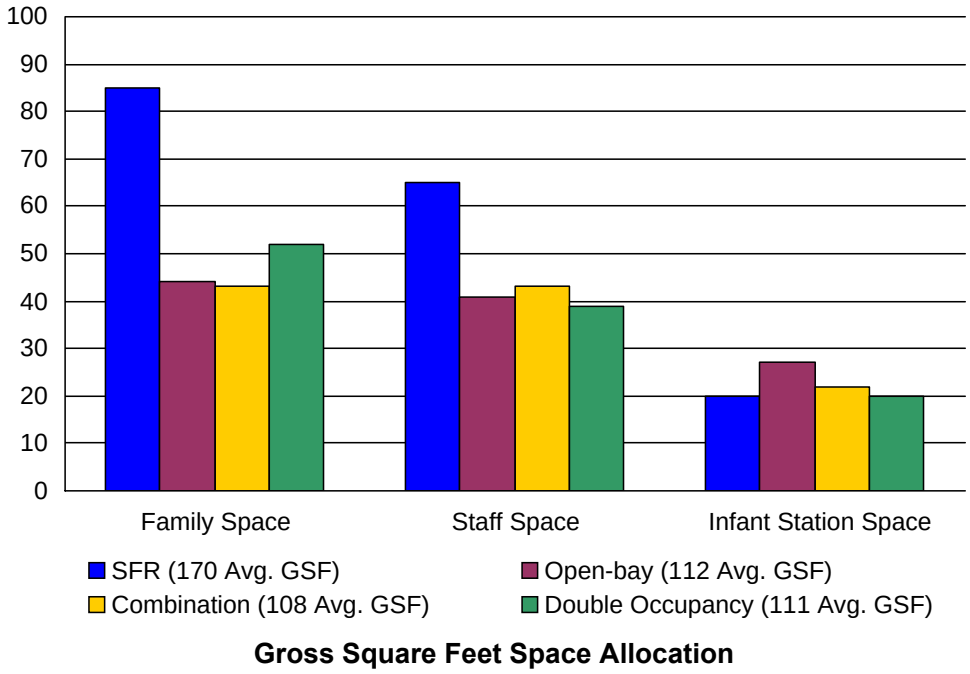


Figure 5. **Allocation of space within the infant station or infant room by unit configuration.**

Site Visits

Single Family Room Neonatal Intensive Care Unit

Introduction

This SFR unit is located in the Midwestern United States and has 22 licensed patient stations. The rooms range in size from 162 SF to 172 SF; the architecture plans provided by the participant were verified, indicating that the plan represents the site accurately and the unit operates as intended (Figure 6).

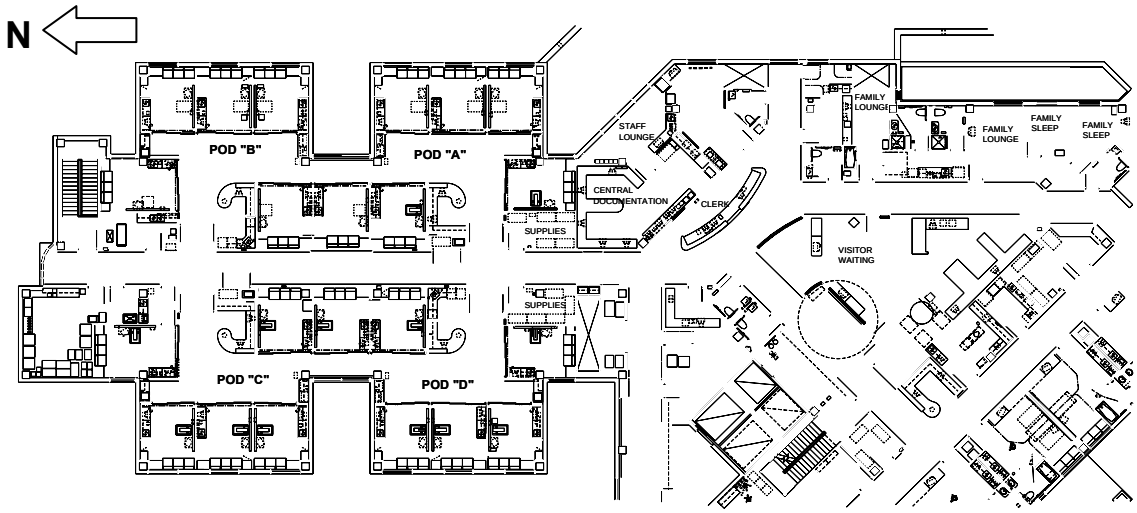


Figure 6. **Single family room (SFR) neonatal intensive care unit floor plan (not to scale).**

The line of sight is limited within the pods of patient rooms. The staff minimizes the feeling of isolation by using staff locators. Anecdotal comments from the staff, which focused on design improvements, include (1) the anteroom adjacent to the isolation room would be better used if it was a toilet; (2) pods without medication prep stations should have hand-wash sinks; (3) the formula prep areas should have sinks; and (4) the clerk station would be better placed opposite from the elevators so that it would be the first thing a visitor noticed.

Materials and finishes

The interior materials and finishes are within the range of standard finishes for a NICU. The flooring is carpet throughout the facility; the walls are painted drywall; the ceiling is 24" x 24" suspended acoustical tile with a minimum NRC rating of .80; and the casework is finished with plastic laminate with a wood grain pattern and PVC-edged plastic laminate countertops with stainless steel sinks (Figure 7).

Figure 7. **Patient room.**

Privacy

Privacy is a concern of particular importance. Each SFR has two curtains within the patient room, one at the door and one between the family zone and the patient care area. When parents are in the single family patient room, the doors and the cubicle curtains are closed. This is encouraged by the nursing staff. If a mother is breastfeeding and/or pumping, it is done in the patient room. Parents complained of too much noise on this unit. The source of their irritation is the physicians clustering in the pod work areas to have meetings.

Nursing supervision

Questions have been raised about whether nurse supervision is compromised in the SFR configuration. When parents are not in the SFR, doors and cubicle curtains are partially open so that the nurses can see the monitors. Of the 22 SFRs, 16 are visible from the desks in the pod central work areas.

Figure 8. **Glass doors to patient rooms.**

However, as previously noted, the cubicle curtains are generally pulled nearly closed in occupied rooms (Figure 8). The nursing staff may feel isolated from one another due to the pod design. Nurses will bring babies from one pod to another for feeding so they can congregate and socialize. Generally, the nursing staff has contact with parents outside of the SFR. When the room doors are left slightly open, the nurses can see and hear the monitors on the patient headwall.

Staff and functional work areas

There are four pods of patient rooms, with staff stations in each. These staff stations are used for record keeping, communication, medicine preparation, and staff interaction (Figure 9). The staff clusters around the work areas within the pods for the informal exchange of information and for socialization. They migrate from one pod to another to participate in these activities. Additionally, the staff communicates and interacts with parents at these stations. However, in the hospital's patient satisfaction surveys, patient commented that the sound levels are too high and that the source was primarily staff conversations at pod workstations.

Figure 9. **Staff station.**

Figure 10. **Patient room storage.**

This unit utilizes a centralized storage system between the pods for most supplies. Casework in each patient room contains a minimal amount of basic supplies (Figure 10). For each patient care pod, scrub sinks are located at the entry and within each patient room.

Family space and social interaction

Figure 11. **Family lounge.**

This unit provides family lounges, sleep rooms, and a visitor waiting room, located between the NICU and the PICU, as places for parents to go when leaving the patient room (Figure 11). The staff reported that the PICU parents utilized these spaces more than the NICU parents. The nurses also reported that there was very little interaction between parental groups.

The unit accommodates large and extended families, both spatially and philosophically. Within the local community, there are cultures represented that tend to come to the hospital in large groups. For example, the Laotian community brings the family and extended family and neighbors to the hospital, as it is customary for the community to wish the newborn well at the time of birth. The medical and nursing staff makes them feel welcome.

Lighting

Each SFR has a variety of lighting types to accommodate both healthcare services delivered to the patient at bedside and general lighting needs throughout the day and night. The SFR configuration allows for control of lighting, and no infant station is exposed to lighting from another infant station. Each room has individualized lighting controls. Generally, the lighting levels are low within the patient room and in the corridor immediately outside the patient room.

Six of the 22 rooms are not on an exterior wall but have access to indirect daylight through the glass door entry to the room. Two of the 6 rooms are directly opposite an exterior window, while the other 4 have a diagonal relationship to the exterior window. The remaining 16 rooms are on exterior walls and have direct access to daylight. In these rooms, the blinds are

generally closed for very small infants and are more likely to be open for those infants closer to full gestational age.

The nursing staff has very limited access to natural light in the pod work areas. Access to daylight is through the patient rooms, which, as mentioned before, often have curtains drawn and doors closed for privacy. Also, the clerk station and central documentation areas do not have access to natural light and views. However, the staff lounge is located on an exterior wall with a window.

Heating, ventilation, and air conditioning (HVAC)

HVAC controls were altered during the construction period to have one thermostat for every two SFR patient rooms. The outcome of this decision is extremely unbalanced temperatures between the room with the control and the room without the control. The staff attempts to achieve comfortable room temperatures by keeping doors to rooms that share the thermostat in the same state of closure; therefore, when one room has a door open 20%, the other door is also opened 20%.

Security system

The original design for security was to have proximity devices worn by all persons entering the patient pods. This system was not installed, so the current strategy is to use tracking devices attached to each infant's arm. The clerk station has a computer that is dedicated to this system. This system was installed after occupancy along with the closed circuit television (CCTV) system for public corridors. The stairway doors are not alarmed.

Open-bay Unit #1

Introduction

Open-bay Unit #1 is located in the Southeastern United States and has 22 licensed infant stations (Figure 12). Eight beds are in a "pinwheel" configuration, which affords greater privacy in an open bay. Two beds are located in isolation rooms. There are two rooms for Extracorporeal Membrane Oxygenation (ECMO), which provides larger, individual spaces. This unit is a Level III ICU. There is an older unit nearby that is used as an intermediate or Level II unit.

The open-bay infant care stations range in size from 102 SF to 110 SF. The isolation rooms are 130 SF, and the ECMO bays are 168 SF. The plan furnished by the participating hospital verified that the unit was built as specified and is used as intended.

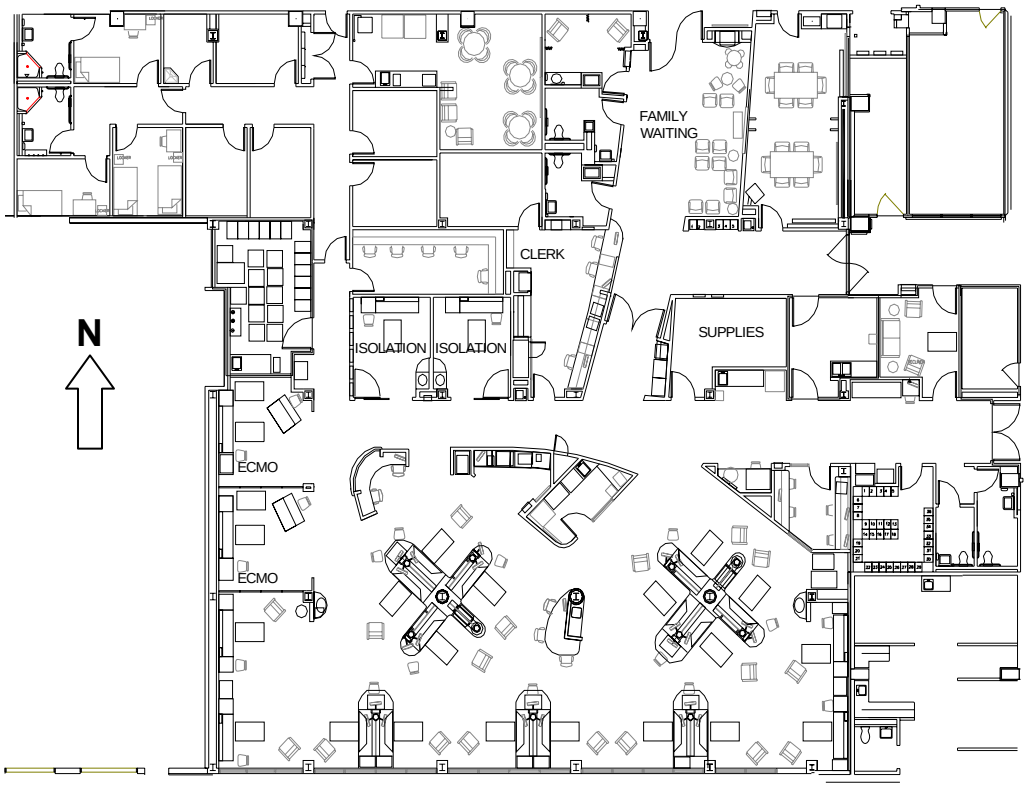


Figure 12. **Open-bay neonatal intensive care unit #1 floor plan (not to scale).**

Materials and finishes

The finish materials are fairly typical for this type of unit. The flooring material is sheet vinyl; the walls are painted drywall; and the ceiling is 24" x 24" suspended acoustical tile with a minimum NRC rating of .80 (Figure 13). The finish materials for casework in the patient care stations are plastic laminate and solid surface countertops with integrated sinks. The nurse workstations consist of wood grain panels with solid surface countertops (Figure 16).

Figure 13. **Open-bay unit #1.**

Anecdotal comments concerning improvements to the facility include (1) the "pinwheel" patient stations should be larger; (2) the monitors in the isolation rooms cannot be heard when the doors are closed; however, the problem could be resolved with an allied monitor located in the work area; (3) raising the level of privacy would benefit the parents and increase parent satisfaction (Figure 15); and (4) this unit does not have a transition room, and all teaching is done at the bedside. The staff would like to have at least one transition room and would prefer two.

Figure 14. **Staff communication.**

Privacy

Privacy is a challenge in the open-bay NICU environment. In this unit, parents use mobile privacy screens (Figure 15) to create a limited measure of privacy. This is accomplished by parents making a request for privacy and the nurses assisting in rolling the mobile screens into position.

Figure 15. **Mobile screen.**

The ECMO rooms have sliding glass panels between the two rooms but are open to the unit at the end of the room. Cubicle curtains are installed for visual privacy. The isolation rooms have sliding glass doors, which afford acoustical privacy, but there are no cubicle curtains, so visual privacy must be attained through the use of the mobile screens. Patient/family privacy is compromised, while nursing staff keep their voices low in an attempt to comply with HIPAA. Finally, one breastfeeding room is located off of the family waiting room.

Nursing supervision

The nurses have visual access to multiple patient care stations from nearly anywhere within the open-bay area. However, due to extensive use of isolette covers, most babies are not visible except at bedside.

Figure 16. **Nurse chart station.**

Staff and functional work areas

The nursing staff communicates with ease, since they are all located in the same work area (Figure 14). The clerk station is located at the entrance to the unit. There are two nurse chart areas within the nursery (Figure 16). Nurse work areas are located at the end of each patient station along the perimeter wall and at the end of each arm of the pinwheels. A small alcove exists near the staff entry to the unit, and the doctors work in this alcove.

Each patient care station has a limited amount of storage for supplies. There is one central supply room that the nurse must access frequently in order to get what is needed to support patient care. In addition to the scrub sinks at the entry to the unit, there are three hand-washing

sinks in the main nursery to serve 20 beds (including the ECMO rooms). Each isolation room has a sink.

Family space and social interaction

Other than the waiting room, the only place for parents to stay is within the patient care areas. The parents in this open environment have access to information about infants other than their own. Maintaining HIPAA compliance is a challenge for staff. Generally, parents spend about one hour at the patient's bedside, then they leave. Occasionally, some parents sleep in the waiting room. The hospital does have a Ronald McDonald House on campus. Given the limited space, accommodation of large and extended families is a difficult situation.

Noise

This unit has sound meters installed for the purpose of controlling noise within the unit. It is not known if this is effective.

Lighting

There are multiple types of lighting throughout the patient care area and over each patient care station. However, lighting is maintained at a very low level. Lighting over each patient care station is controlled at that station. During the day, daylighting creates a much greater ambient lighting level than what is achieved during the night. One entire wall of the patient care area has a ribbon window. This window faces south and has sunshades on the exterior and horizontal blinds on the interior for light control. The amount of daylight allowed in through this window is ample, and all portions of the patient care area can receive this daylight.

Security system

In the Level II NICU, infants have transponder wristbands, and entry/exit points are alarmed. The Level III NICU has coded locks on entry doors and does not rely on electronic devices attached to infants, as the entire unit is open and visible throughout. Parents and visitors call on a phone at the entry, and the clerk establishes identity and allows access to the unit.

Open-bay Unit #2

Introduction

This is a 45-bed, open-bay unit located in the Southeastern United States. There are six pinwheel islands, each with 3 beds. The original design called for two semiprivate rooms, one isolation room, and the remaining beds in open bays around the perimeter of the space. The space allocated for patient care stations ranges from 124 SF for the pinwheel stations to 130 SF for the perimeter stations. The enclosed rooms on the south side are 293 SF and 282 SF. The plan was verified, and it was noted that changes have been made to the physical configuration (Figure 17).

This unit has modified the workspace so that the intended use of the space has been altered. The small space behind the clerk station was originally intended to be the charge nurse office. The staff did not like that the office was enclosed with windows. The southwest corner room was originally a family rooming-in room. This has been converted to the charge nurse office.

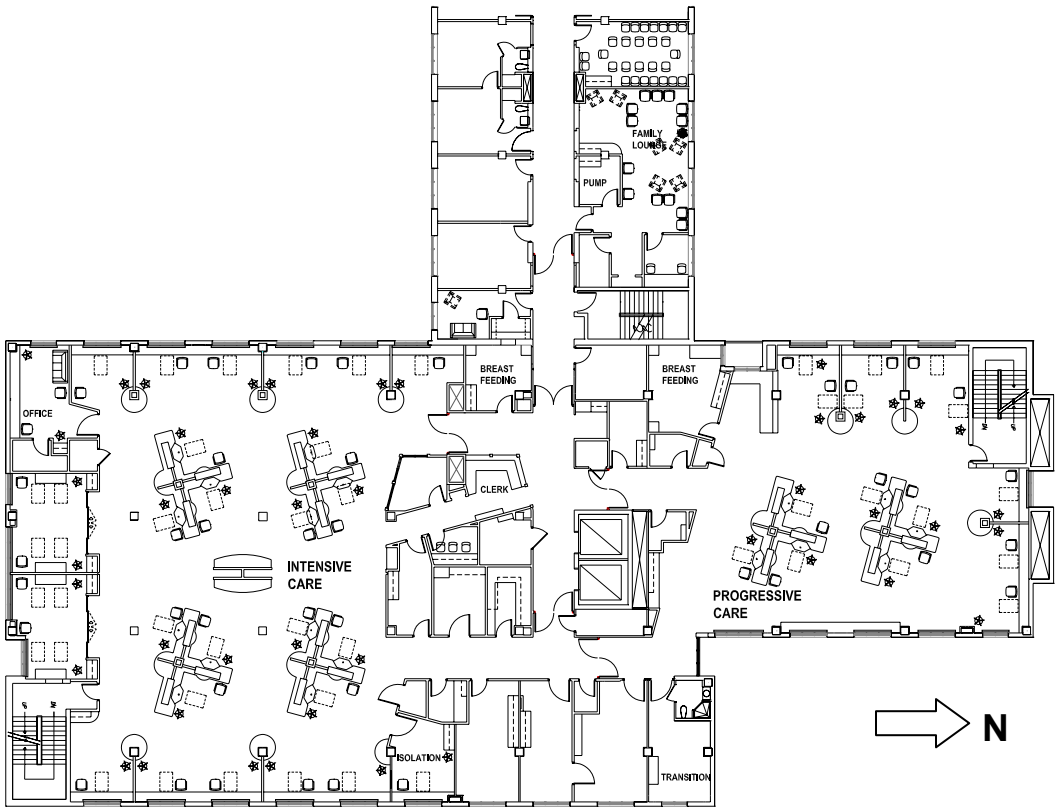


Figure 17. **Open-bay neonatal intensive care unit #2 floor plan (not to scale).**

The two rooms at the south end of the NICU were originally designed as semiprivate rooms. These rooms have been converted into four patient rooms and, as such, are below the recommended standards of space per infant.

Originally, the unit was designed to have an integration of Level II and Level III infants throughout. The notion was that each nurse would have a mix of acuities to lighten the load. Shortly after occupancy, the staff elected to have the south side of the unit allocated to Level III infants and the north side dedicated to the Level II infants. The change stemmed from a concern regarding the disruption of care for infants of different levels; for example, a nurse taking care of a Level II infant would often need to put down that infant when her assigned Level III infant

needed attention. The nurses felt that this model of care was disruptive to the care of the more stable child; hence the segregation of acuities.

Anecdotal comments from the staff focused on the limited size of the Level II unit. As the demand for patient space exceeds the 15 beds in this area, most patient stations accommodate two infants.

As an aside, the researchers observed an adult patient in a stretcher being transported through the NICU and onto one of the elevators located within the unit.

Materials and finishes

This unit has materials and finishes that are considered to be within the typical range of products for this type of facility (Figure 18). The flooring is sheet linoleum; the walls are painted drywall; and the ceiling is 24" x 24" suspended acoustic tile with a minimum NRC rating of .80. The casework is plastic laminate with a wood grain pattern and solid surface countertops with integrated sinks. In addition to the scrub sinks at the entry to the unit, there are multiple hand-washing sinks in the main nursery. Each individual room has a sink.

Figure 18. **Open-bay unit #2.**

Privacy

This unit does not provide privacy screens for the infant stations. There are no provisions within the nurseries for auditory or visual privacy. Two breastfeeding rooms are provided in the unit. One has two curtained cubicle areas to accommodate two mothers, and the other room is

private. A room adjacent to the family room is allocated for mothers to use as a breast pump room.

Nursing supervision

The nursing staff can see multiple patient care stations from nearly anywhere within the open-bay area. However, due to the use of isolette covers, most infants are not visible to staff unless the staff are at the bedside.

Staff and functional work areas

The unit staff easily communicate with one another, as they are essentially all together. Staff and parents interact readily in this open-bay configuration. The clerk station is located at the entrance to the unit.

A nurse work area is located at the end of each patient care station. A small island work area is located in the center of the Level III unit, and a nurse/doctor work area is located in the Level II unit.

Figure 19. **Patient care station.**

Each patient care station has accommodation for supplies (Figure 19). One side of each pinwheel is used for supplies and support. There is also one central supply room.

Family space and social interaction

Other than the waiting room, the only place for parents to stay is in the patient care areas. Parents in the open environment have access to information about other infants aside from their own. Maintaining HIPAA compliance is a challenge for staff.

The hospital restricts the times during which parents may be at the bedside with their infant. Given the limited space, accommodation of large families is difficult.

Noise

This unit does not employ sound meters as a control/warning system.

Lighting

There are multiple types of lighting throughout the patient care area and over each patient care station (Figure 20). Lighting over each patient care station is controlled at that station. The nurses exercise control over the lighting levels, and parents are not allowed access to the lighting controls. Daylight is available to all patient care stations; however, the ones on the interior of the pinwheels have a diminished effect from daylighting. The unit staff benefit from the widespread daylighting throughout the units. The exterior windows have roller shades for light control, but these are not "black out" shades and only diffuse the bright sun.

Figure 20. **Patient care station.**

Security system

The entrances to the unit are equipped with door access controls. Staff use key cards for entry. Parents and visitors are identified and provided access through the locked doors.

Open-bay Unit #3

Introduction

Open-bay Unit #3 is located in the Midwestern United States and has 30 licensed infant stations in the NICU. Fifteen infant stations are Level III critical care stations, and the remaining 15 are Level II, providing intermediate care. The patient care stations are arranged side-by-side around the perimeter of the space. Four beds in the critical care side are in the center of the large room, orientated toward each other in pairs. Two of the intermediate care beds are together in an isolation room. The Level II patient care stations are 88 SF, and the Level III patient care stations are 132 SF. The plan was verified, and no changes have been made to the physical configuration. This unit is being used as intended. The hospital is planning a new NICU, which will utilize single family room design.

Materials and finishes

Figure 21. **Open-bay unit #3.**

This unit has materials and finishes that are considered to be within the typical range of products for this type of facility (Figure 21). The flooring throughout the unit is sheet vinyl. The walls and soffits are painted drywall, and the ceiling is 24” x 24” suspended acoustical tile with a minimum NRC rating of .80. The casework is plastic laminate. Patient care stations have solid surface countertops. Nurse work areas have PVC-edged plastic laminate countertops with stainless steel sinks. In addition to the scrub sinks at the entry to the unit, there are hand-washing sinks at the staff work areas within the units. Also, the isolation room has a hand-washing sink.

Privacy

Documented anecdotal comments suggest that privacy is an important issue. At this time, there are no mobile privacy screens in use within this unit. No provisions have been made to accommodate the need for visual or auditory privacy within the nurseries. For mothers who are breastfeeding, the unit has supplied two breastfeeding rooms. One is located within the unit, and the other is located off the unit in the family waiting room.

Figure 22. **Patient care area.**

Nursing supervision

Nursing staff can see multiple patient care stations from nearly anywhere within the open-bay area (Figure 22). However, due to the use of isolette covers, most babies are not visible to staff unless the staff is at the bedside.

Staff and functional work areas

Communication among the staff is open and convenient, since they are essentially all together. Staff interact with one another readily and frequently. Staff and parents interact readily in this open-bay configuration. The clerk station is located at the entrance to the unit and functions as an information point for the unit. A centralized staff workstation is in the center of the Level II unit. Two small staff workstations are located in the Level III unit. Charting is accomplished at bedside.

A doctor's work area is located along the passageway between the two units. Each patient care station has limited space for supplies. There is one central supply room. A mobile cart is used in the Level II area to supplement the bedside storage.

Family space and social interaction

Other than the waiting room, the only place for parents to stay is in the patient care areas (Figure 23). Parents in the open environment have access to information about infants other than their own. Maintaining HIPAA compliance is a challenge for staff. The hospital has a 24/7 policy for parents to be with their infants, except during rounds and report meetings. A transition room is used by staff for education of parents prior to infants' discharge. The unit has only one room of this type. Given the limited space, accommodation of large families is difficult.

Figure 23. **Patient care area.**

Noise

The patient stations adjacent to the unit entrances are the last to be assigned do to the perception of those stations exposure to elevated noise levels. When not in use for patients, these infant stations are used to park moveable equipment. This unit does not employ sound meters as a warning system for noise levels.

Lighting

There are multiple types of lighting throughout the patient care area and over each patient care station. Lighting over each patient care station is controlled at that station. The lighting is

maintained at a very low level at all times. The perimeter of the nurseries has but a few windows on the exterior wall. Hence, daylight is not readily perceived in all parts of the unit. The few exterior windows have horizontal blinds for light control.

Security systems

The entrances to the unit are equipped with door access controls. The unit staff has key cards for entry. Parents and visitors are identified and allowed entry through the locked doors.

Post-occupancy Evaluations (POE)

Common to all units in this study was an agreement among staff that their new unit, regardless of configuration, was far superior to their old unit. Staff identified reduced crowding as a key feature. Other positive aspects were adequate room at bedside for at least two parent chairs, staff dedication and attention to infants, and the expression of concern for HIPAA compliance. Factors that may influence behavior were identified as parental presence polices, parental presence in practice, staff's accessibility to infants for monitoring, infant visibility, the nature and location of staff work space, controllable privacy and light at bedside, sound control features, distance to clean storage from bedside, acuity level of infants during visit, parental bedside features, parental sleep accommodations, methods for locating staff, amount of traffic within the unit, nursing assignment concerns, and methods for complying with HIPAA privacy. Security was a feature that involved the "buzzing in" of parents in the open-bay designs. The SFR did not have a locked door, but parents and visitors walked by a staffed desk between the elevator and the unit doors. There were also security cameras that covered all public spaces and could show any

patient care room. The in-room cameras were used mainly when the mother was medically at risk or in cases when there was a history of domestic violence.

Privacy

SFRs can easily provide auditory and visual privacy to preserve confidentiality and parental privacy. The rooms in the SFR unit had both glass doors and curtains separating the infant care space from the public areas. These rooms also offered an additional level of parental privacy by providing a ceiling-mounted curtain between the designated parent space and the infant care and staff space. The isolation room at Open-bay #1 had glass doors with three opaque walls, and the two private bays had a combination of opaque and glass walls with no doors on the front of the bays. Screens were placed at the entrance to the bays to provide visual, but not auditory, privacy. Screens were also used in front of the glass side wall to increase privacy.

When SFRs are designed with privacy features that can be adjusted, how are these features ultimately used? At the SFR unit, families were the main controllers of the privacy features. Parents were present for long periods of time and appeared to choose privacy as soon as they arrived in the unit. When parents were present in the rooms, the sliding doors were closed more than halfway during 100% of the observations, and curtains were closed more than halfway for 87% of the observations. When parents are not present, staff members control the door and curtain; the door was closed at least halfway for 88% of the observations, and the curtain was closed for 82% of the observations. A common configuration for patient rooms when parents are not present is to have the curtain open wide enough to see the monitor while using an incubator cover to shield the infant from traffic. The door leading to empty rooms was open at least halfway for 70% of the observations, and the curtain was open for 54% of the observations. Temperature was another factor affecting door closure in the SFR unit. Although the original plan called for

individual HVAC control for each room, the number was reduced to one control for every two rooms during the "value engineering" process. This leads to uneven temperature among the rooms, so the staff help parents modulate the temperature by opening or closing doors. The open-bay #1 "private" rooms/bays were closed off by a door or a screen for 100% of the observations; door closure was controlled mainly by staff.

Accessory equipment and staff protocols were used to provide privacy and confidentiality to open-bay units. Portable screens are commonly used to provide visual, but not auditory, privacy. They are normally used in special cases in which there is an increased need for privacy, such as skin-to-skin care, breastfeeding, parental discomfort, or when a bright light bank is being used at a neighboring bed. Though all the open-bay units had several screens, they were rarely used during the periods of observation. When they were employed, they were provided by staff, although there were reports from staff in Open-bay #3 that long-term parents deployed screens themselves. Using screens for privacy tends to be the exception rather than the rule in open-bay units, whereas doors and curtains are the most common mode of gaining privacy in SFRs. Voice modulation in open-bay units with widely spaced beds can keep patient information confidential and allow a parent to sing quietly without disturbing other patients or passersby. Most, though not all, staff used this method effectively in all three open-bay units. Parent seating usually faced away from traffic flow in Open-bay #1, in effect using the chair and the parent's back as a screen for privacy. Parents were likely to avert their gaze as they went by an infant care space. Visitors other than parents were split between gaze aversion and looking at infants around as they passed by infant care spaces.

Maintaining confidentiality during report meetings and rounds was handled differently by each of the units. Open-bay Units #1 and #2 maintained confidentiality by closing the unit to parents during that time. One unit was closed for an hour at each shift change, the other for two

hours during each change. The two-hour closures at Open-bay #2 occurred from 6 to 8 a.m. and from 6 to 8 p.m., the highest parent presence time at other units. Open-bay #3 held report meetings and rounds with parents present, but the unit was configured with the beds far enough apart to allow voice modulation to maintain patient confidentiality. Voice modulation in open-bay units was effective due to the increased space between beds in new units, but it was not universally observed by all staff. The SFR unit discussed rounds with parents present at bedside and with the door closed. Change-of-shift coordination occurred at nursing substations. Normal voices carried from substation to substation and allowed for incidental breaches of confidentiality through open doors or hallways where family and visitors were out of staff's line of sight. Since patient information is transmitted among staff at times other than during rounds, the SFR with the door closed was the most reliable means of reducing accidental breaches of confidentiality.

Traffic

Traffic counts constituted the largest data set of observations. The grand means of all observations is graphed in Figure 24. The SFR unit had significantly lower traffic than all the open-bay units. The open-bay units were not significantly different from each other. The increase in traffic for open bays is attributable to increased staff entry to patient space and increased passerby traffic (looking and gaze averting). The relative ratios of traffic sources across units are shown in Figure 25. Parental presence was highest in the SFR. Parental presence in Open-bay #2 was concentrated between 4 to 6 p.m. and 8 to 9 p.m.

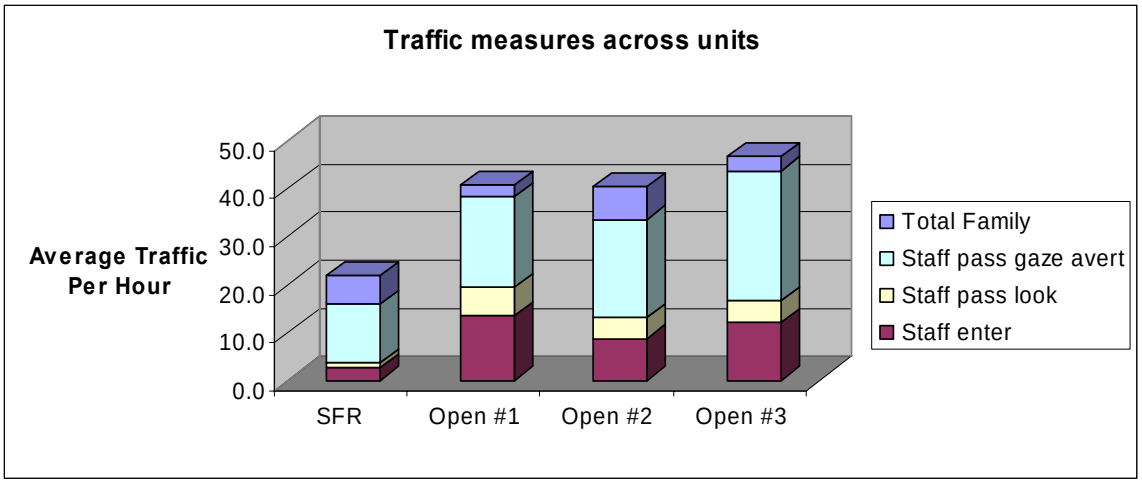


Figure 24. **Traffic measures per hour across all 4 units.**

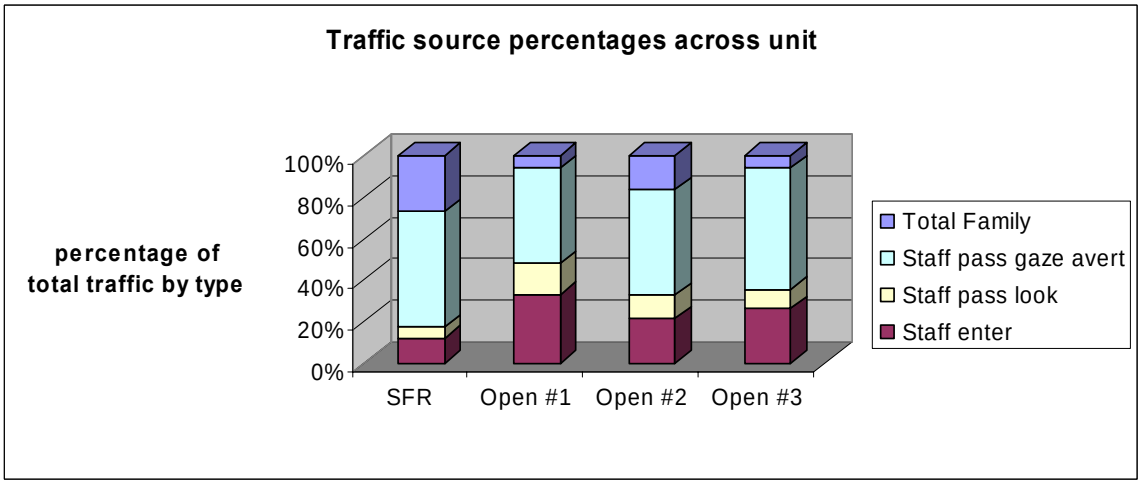


Figure 25. **Percentage view of traffic sources across all 4 units.**

Traffic SFR

Table 2 shows the average amount of traffic and types of traffic per hour per occupied bed at the SFR unit. This unit had the highest parental presence, with parents in the infants' room 48.3% of observations. The unit is open to parents 24 hours a day. The highest proportions were found in this unit, and the only time combined family traffic exceeded staff traffic for this unit was from 5 to 6 p.m. on Friday.

There was some difference in traffic from one bed space to the next due to the SFR's proximity to the entryway. The SFR unit had four entrances to the pods of SFRs that were located off the central entry hallway and that were shared by families and staff. Beds located near doors generally had greater exposure to walk-by traffic. Increased counts for passing by a room were affected by neighboring room admissions; the highest pass-by count was for a bed adjacent to a room where an admission was taking place. Maximum entry traffic was also influenced by admissions when frequent entries by multiple staff occurred. At the time of the observation the unit had 15 of 22 beds in use, and the infants were mainly lower acuity at the end of long stays. Each nurse had three to four infant assignments. With the exception of admissions, nurses spent longer amounts of time on each visit to the bedside but made fewer entries into the patient care space than into the open-bay units. Table 3 shows the grand mean, standard deviation, maximum, and minimum traffic per hour. Figures 26 and 27 show traffic means in the SFR unit for day 1 and day 2, respectively, and demonstrate the increased traffic levels on weekends.

Table 2. **Mean per-bed traffic total by type across observation periods at SFR unit.**

Day 1 Friday	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert	Total family/ visitor
2 p.m.	13.80	1.60	0.20	8.40	0.40	0.00	3.20	0.00	0.00	0.00	3.60
3 p.m.	15.33	2.33	1.00	7.00	1.67	0.00	3.33	0.00	0.00	0.00	5.00
5 p.m.	29.40	3.20	0.20	11.00	0.80	0.00	5.80	0.80	3.00	4.60	15.00
6 p.m.	11.33	3.00	0.00	6.00	0.67	0.00	1.67	0.00	0.00	0.00	2.33
Day 2 Saturday											
11 a.m.	24.57	1.29	1.29	13.86	0.71	0.00	2.00	1.14	0.00	4.29	8.14
12 p.m.	23.43	2.00	2.00	15.86	0.43	0.57	2.14	0.14	0.00	0.29	3.57
1 p.m.	24.38	4.63	1.88	14.50	0.38	0.63	1.88	0.13	0.13	0.25	3.38
2 p.m.	23.43	2.00	2.00	15.86	0.43	0.57	2.14	0.14	0.00	0.29	3.57

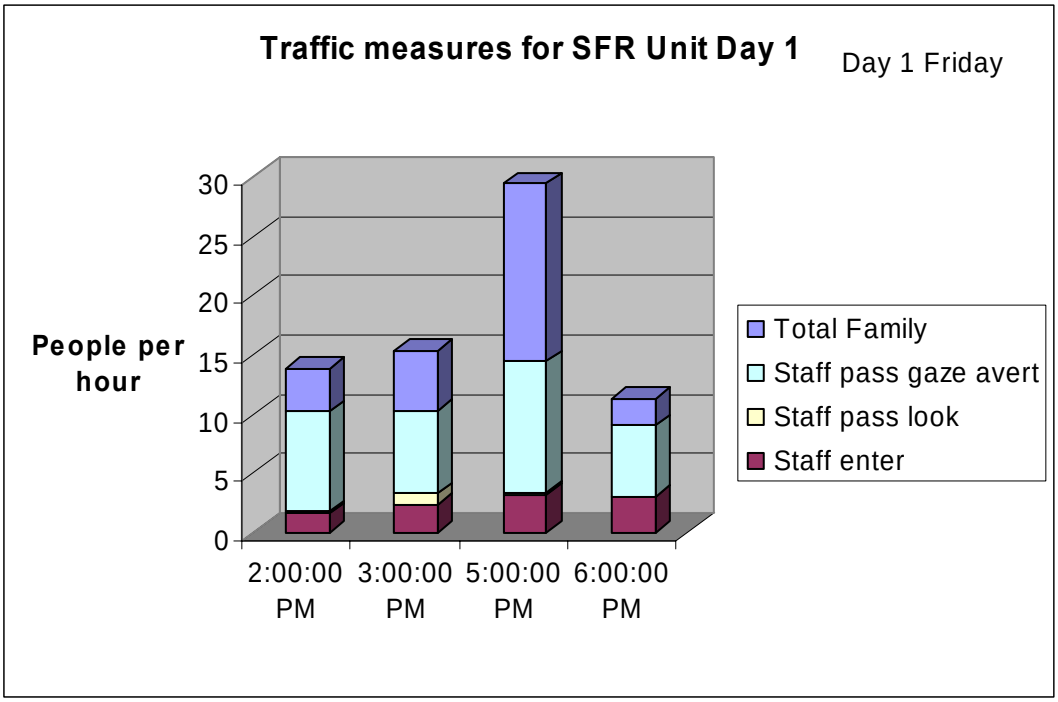


Figure 26. **Traffic means across observations for day 1 in the SFR unit.**

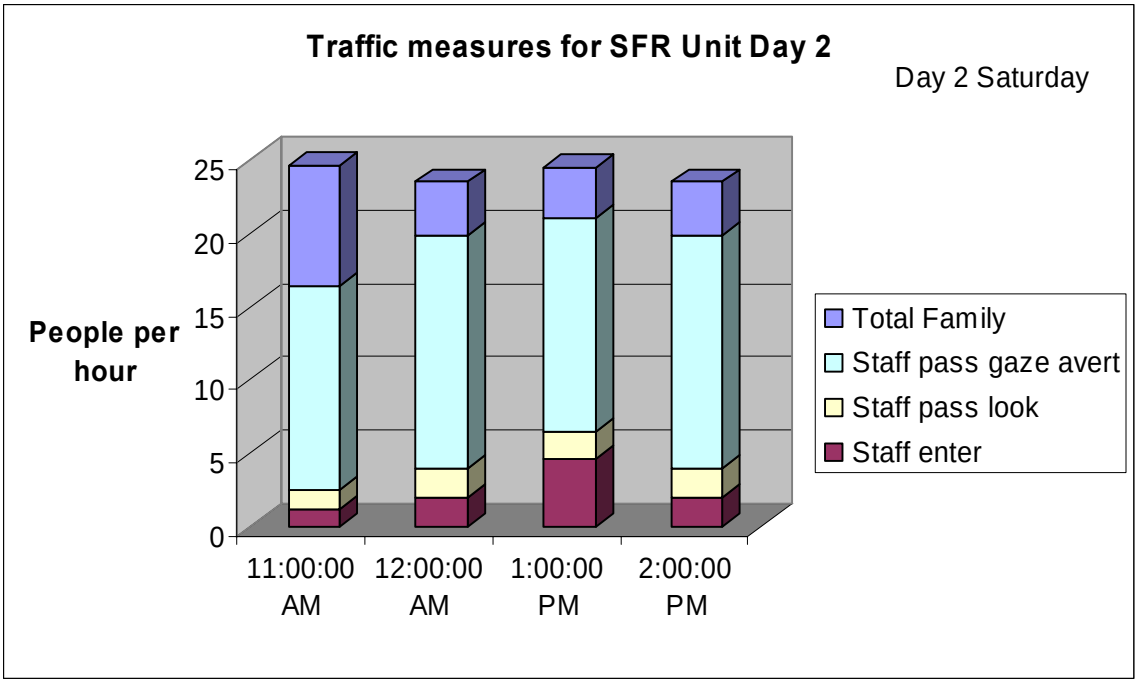


Figure 27. **Traffic means across observations for day 2 in the SFR unit.**

Table 3. **Mean, standard deviation, maximum, and minimum traffic per hour by type across all observations.**

	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert
Mean	21.8	2.6	1.1	12.1	0.6	0.2	2.7	0.4	0.4	1.5
Standard deviation	8.7	4.0	1.2	5.5	1.1	0.5	2.2	1.0	1.1	3.4
Maximum traffic count	37.0	23.0	4.0	24.0	5.0	2.0	6.0	4.0	4.0	13.0
Minimum traffic count	9.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0

Traffic Open-bay Units

Open-bay units exhibited higher staff traffic counts. Open-bay #1 had high-acuity infants and nursing assignments of 1:1 or 1:2. Low-acuity infants were transferred to an adjacent step-down unit. Open-bay #2 had mixed acuity, but very-low-acuity infants were moved to the

adjacent step-down unit. Open-bay #2 had been designed for mixed acuity, but one side became used for high- to moderate-acuity infants, and the other side became used for low-acuity infants and as feeder and grower space. All measures were taken in the high- to moderate-acuity side. Open-bay #3 was a mixed-acuity unit, with some nurses caring for only one infant and others covering multiple infants.

Table 4 shows the half-hour traffic counts across time for Open-bay #1. Figures 28 and 29 show half-hour counts across time for day 1 and day 2, respectively. Staff entry counts are higher in this unit than in the SFR; it was noted that staff made multiple short visits to the bedside during a given observation period. The first column shows a projected total for one hour computed by doubling the traffic in a half hour, due to interrupted data collection. Table 5 shows the mean, standard deviation, maximum, and minimum for the total number of observations. The highest traffic counts for walking by were for the 2 private bays and the 2 private isolation rooms. These rooms were located immediately inside the staff entrance to the unit. Rooms with high traffic were also found near the other entrance, which was used by families and by staff coming from the step-down unit. This area also had a sink, the clean supply cabinet, and the pharmacy delivery system. Staff activity accounts for the increased traffic. Parents represent a smaller percentage than in the SFR, with 25.6% of infants having at least one parent present across all observations. For infants in the private bays and the isolation room, parents were present for 53.3% of the observations. Notes on traffic showed that staff entered patient care space to look for shared equipment. Traffic was also generated by staff looking for other staff. A modest amount of collegiality occurred at distributed workstations at the edge of patient space, within patient space, and at the two desks.

Table 4. **Traffic counts across time by totals and type for Open-bay #1 (note: observation periods in this unit were 30 minutes).**

	People total/hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/ visit enter	Other fam/ visit pass look	Other pass gaze avert	Total family
Day 1												
2 p.m.	25.82	12.91	4.55	1.45	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 p.m.	49.11	24.56	10.11	5.00	8.44	0.44	0.11	0.22	0.22	0.00	0.00	1.00
5:15 p.m.	68.60	34.30	7.40	4.70	20.40	0.50	0.00	1.30	0.00	0.00	0.00	1.80
5:50 p.m.	41.25	20.63	5.63	2.50	8.88	0.75	0.13	2.13	0.13	0.00	0.50	3.63
Day 2												
7:50 a.m.	30.80	15.40	6.90	2.50	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1:30 p.m.	42.22	21.11	7.22	4.67	7.33	0.78	0.33	0.33	0.22	0.22	0.00	1.89
7:45 p.m.	34.91	17.45	4.55	1.91	10.27	0.27	0.09	0.36	0.00	0.00	0.00	0.73
8:25 p.m.	35.11	17.56	8.11	2.00	6.00	0.67	0.00	0.33	0.11	0.00	0.33	1.44

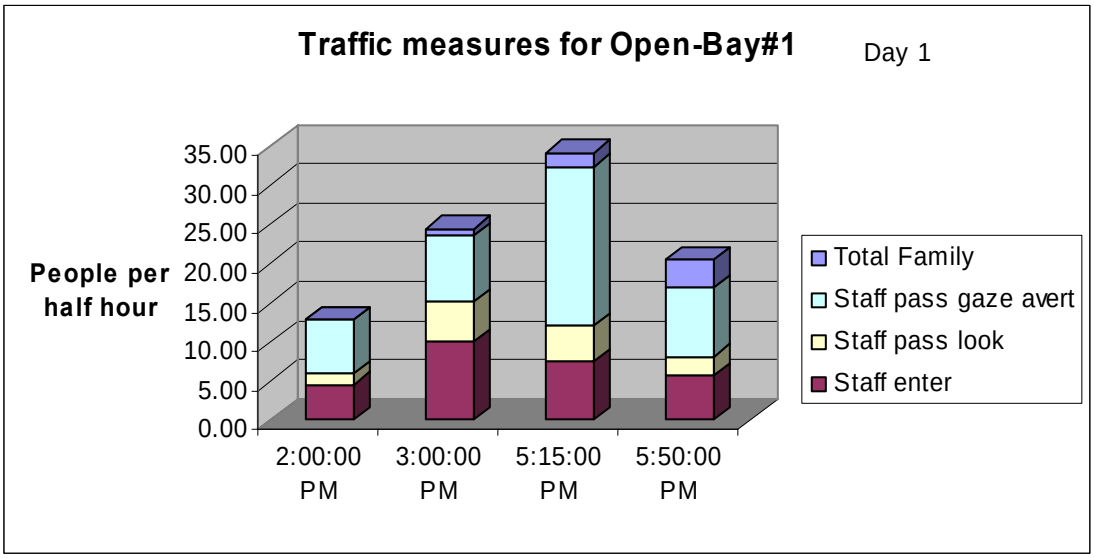


Figure 28. **Traffic means across time for half-hour observations showing relative ratios of traffic types.**

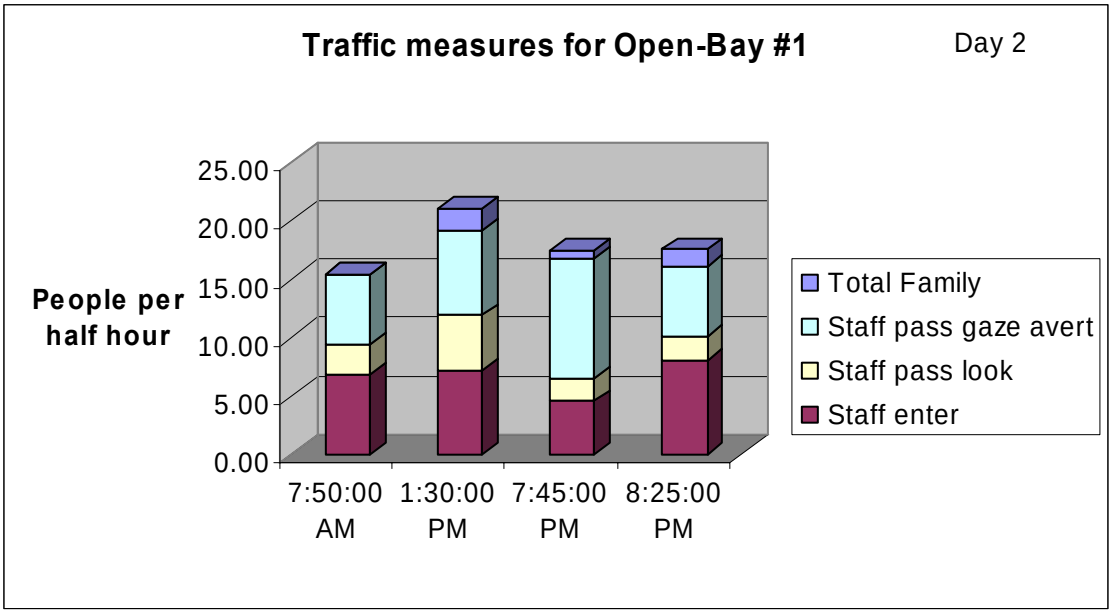


Figure 29. **Traffic means across time per half-hour observations showing relative ratios of traffic types.**

Table 5. **Mean, standard deviation, maximum value, and minimum value for all half-hour observations with calculated means and maximums per hour for Open-bay #1.**

	People total/ hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/ visit enter	Other fam/ visit pass look	Other pass gaze avert
Mean	40.6	20.3	6.7	3.0	9.4	0.4	0.1	0.5	0.1	0.0	0.1
Stand dev	23.8	11.9	6.5	2.6	8.0	0.7	0.3	1.2	0.3	0.2	0.3
Max	126.0	63.0	46.0	12.0	36.0	3.0	1.0	8.0	2.0	2.0	1.0
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean/ hour		40.6	13.4	6.1	18.7	0.8	0.2	1.1	0.2	0.1	0.2
Max/ hour		126.0	92.0	24.0	72.0	6.0	2.0	16.0	4.0	4.0	2.0

Open-bay #2 had the most restricted parental presence policy; due to these restrictions, we had only three half-hour observations when parents were present. One observation was done during the 1–3 p.m. “quiet time” when the unit is closed to parents and families. The census was

22 in the high- to moderate-acuity room. Traffic in this open-bay unit was also higher than for the SFR unit, though these infants were of a lower acuity than those in Open-bay #1. No nurses at the time of the observations were on a 1:1 assignment. Parents were present in the open hours for 31% of the infants. Parents were present in the largest numbers between the end of quiet time (3 p.m.) and the end of shift change (8 p.m.) at a rate of 36.4% (Table 6). Parental presence was concentrated into primarily 3 hours of the day, from 4 to 6 p.m. and from 8 to 9 p.m. Families were also limited to two people per bedside, despite the fact that this unit has the largest bedside space of any open-bay unit. Between 8 and 9 p.m. three families were observed having a shift change pattern, with both parents coming in, the father escorting the mother out and returning with one grandparent, the father taking out the grandparent and returning with another grandparent or a sibling, and finally the father bringing the mother back for the last part of the visit.

Total traffic was highest during the quiet time (Figure 30). The highest traffic counts were beds 14 and 15, located near the staff entrance and near the parent entrance into the unit, respectively. Some staff traffic was generated by staff looking for shared equipment, looking for other staff members, and looking for the source of audio alarms. Since workspace is mainly at the bedside, staff who left one patient's bed space generally entered another bed space to work. Monitors were yoked to other infants on the same assignment, but staff needed to stay within visual contact of at least one monitor on their assignment. Beverages for staff and families cannot be placed in patients' bed space. Without access to a central staff desk or a special parent desk on which to place these items, staff and families had to walk out of the main unit to get a drink. A modest amount of staff collegiality was observed and took place mainly within or at the edge of a patient's bed space.

Table 6. **Means across observation times by category, with the first column as a calculated hourly rate for total traffic in Open-bay #2.**

	People total/hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert	Total family
1:50 p.m.*	54.33	27.17	6.33	3.83	16.67	0.33	0.00	0.00	0.00	0.00	0.00	0.33
4:40 p.m.	42.67	21.33	4.17	1.33	8.67	1.00	0.67	4.50	0.17	0.17	0.67	7.17
5:10 p.m.	32.33	16.17	3.00	1.00	9.00	0.50	0.00	1.00	0.50	0.00	1.17	3.17
8:20 p.m.	42.67	21.33	5.67	3.17	7.33	1.33	0.50	2.17	0.67	0.17	0.33	5.17
9 p.m.	36.00	18.00	4.17	2.42	8.33	0.75	0.25	1.50	0.33	0.08	0.17	3.08

* Note: At 1:50 p.m. the unit is closed to parents for quiet time.

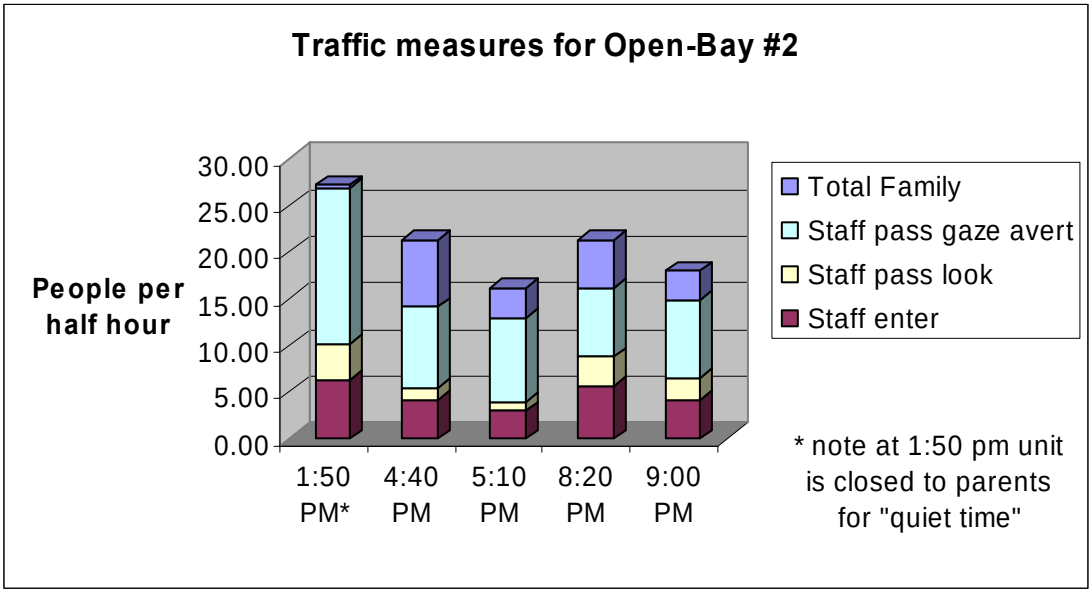


Figure 30. **Traffic counts for four half-hour observations at Open-bay #2, with ratios shown for staff and family traffic.**

Table 7. **Mean, maximum, and minimum traffic counts across all half-hour observations, with a calculated total hourly traffic rate for Open-bay #2.**

	People total/hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert
Mean	40.3	20.1	4.4	2.2	10.2	0.7	0.2	1.7	0.3	0.1	0.4
Standard deviation	16.3	8.2	3.7	1.9	6.0	1.2	0.8	2.4	0.7	0.3	1.1
Maximum	80.0	40.0	18.0	7.0	25.0	4.0	3.0	10.0	3.0	1.0	5.0
Minimum	12.0	6.0	1.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Calculated mean/hour		40.3	8.7	4.4	20.4	1.3	0.5	3.4	0.5	0.1	0.9
Calculated max/hour		80.0	36.0	14.0	50.0	8.0	6.0	20.0	6.0	2.0	10.0

Open-bay #3 had the most open configuration among the open-bay units, and most of the occupied beds could be seen from most of the observation points in the unit. High traffic was more evenly spread in this unit, since there was a high traffic inflow from the staff entrance and from the unit desk near the family entrance (Tables 8 and 9; Figure 31). Parents are only excluded from the unit if a surgical procedure is being performed within the unit, a situation that occurs once every 2–3 months. Two of the parents observed were present for all three observation periods. This unit had mixed-acuity infants during the visit. At least one parent was present for 20% of the infants during the observation periods. Notes from traffic studies showed that one staff member charting at the unit desk walked repeatedly across the unit to take readings and to ask questions; the staff member commented to the observer about the need for computers near the infants. Traffic was also generated by staff looking for other staff and family members. A modest amount of staff collegiality occurred at bedsides but more often occurred at one of the two desks in the unit.

Table 8. **Mean traffic counts by type across half-hour observations, with a calculated hourly rate for Open-bay #3.**

	People total/hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert	Total family
6 p.m.	36.00	18.00	8.25	1.88	7.75	0.13	0.00	0.00	0.00	0.00	0.00	0.13
6:48 p.m.	47.00	23.50	5.75	1.75	14.50	0.38	0.13	0.25	0.63	0.00	0.13	1.50
7:23 p.m.	60.33	30.17	3.67	3.17	20.17	0.67	0.17	0.17	0.67	0.00	1.50	3.17

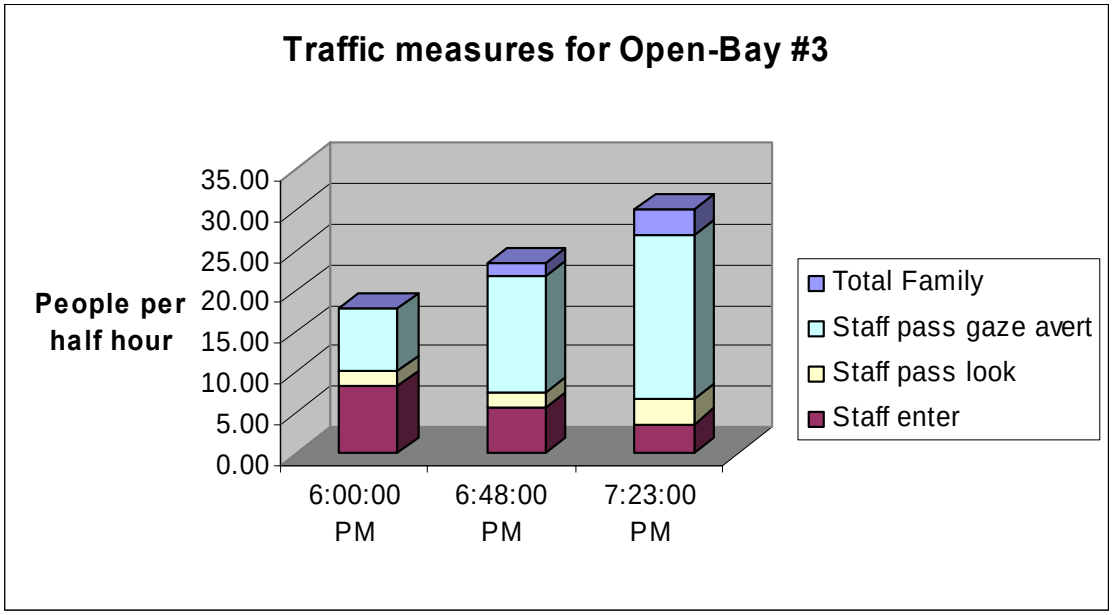


Figure 31. **Average traffic counts showing relative ratios of staff and family traffic for Open-bay #3.**

Table 9. **Mean, maximum, and minimum traffic counts across all half-hour observations, with a calculated total hourly traffic rate for Open-bay #3.**

	People total/hr	People total	Staff enter	Staff pass look	Staff pass gaze avert	Parent enter	Parent pass look	Parent pass gaze avert	Other fam/visit enter	Other fam/visit pass look	Other pass gaze avert
Mean	46.6	23.3	6.1	2.2	13.6	0.4	0.1	0.1	0.4	0.0	0.5
Standard deviation	16.7	8.4	5.2	1.6	7.1	0.7	0.3	0.4	1.0	0.0	1.3
Maximum	76.0	38.0	22.0	6.0	26.0	2.0	1.0	1.0	4.0	0.0	5.0
Minimum	22.0	11.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Calculated mean/hour		46.6	12.2	4.4	27.2	0.7	0.2	0.3	0.8	0.0	0.9
Calculated max/hour		76.0	44.0	12.0	52.0	4.0	2.0	2.0	8.0	0.0	10.0

Individual Control of Space

Environmental dimensions that can be controlled in the unit are temperature, artificial light, daylight, noise, décor, traffic within the space, and privacy. In the SFR unit, each of these, with the exception of temperature, was individually controlled. Temperature control will be included once a retrofit for the HVAC zones is completed in this unit. In the SFR unit, these environmental components are generally controlled by the family with advice from the staff. This guidance takes the form of parent education about developmental care for infants at specific gestational ages and observation of infants' response to environmental stimuli. Parents and staff both felt strongly that the room was the family's space; nurses knocked gently before entering. The single-unit bays in Open-bay #1 were dimly lit for the high-acuity infants in the ECMO bays and well lit for larger, more stable infants in the isolation room, in accordance with each infant's response to stimulation. Staff controlled light levels, although one parent in the single bay requested a light change from staff, and researchers observed that one parent controlled noise around her infant by requesting lowered voices. In the open-bay units light, noise, temperature, and traffic were mainly under staff control. In Open-bay #2 a parent sitting between two infants

who required minimal stimulation played a music video at a low sound level; the nurse assisted with providing this stimulation, which was appropriate to the one family. Maintaining a balance between the minimal-stimulation needs of some infants and some parents' desires for distraction or stimulation for their stable infant was difficult in the open-room configuration. Parents had varied amounts of influence on décor in open-bay units, but all had some control.

Controllable Privacy

One method of controlling privacy is shown in the traffic data over all conditions. Staff avert their gaze as they pass a bed space rather than look into the space. Parents and families showed a preference for gaze aversion as they passed a bed space as well. It was noted in the SFR unit that other family members were likely to look into an empty bed space. It was unclear whether this was because the curtain for an empty bed space was open while occupied rooms had their curtains closed at that time or if the looking was related to a lack of respect for the privacy of other families.

The SFR unit had the highest use of controllable privacy. When they were present, parents were the main controllers of privacy measures (Figure 32). When parents were not present staff members controlled the privacy devices. The most striking finding was that all parents closed the glass sliding doors at least halfway when they were present. The door closure ranged from half closed to fully closed, with 40% of observations showing the door fully closed. Door closure was influenced by temperature control problems. When parents were not present the doors were less likely to be closed, but most were closed at least halfway. Full door closure was used 20% of the time and was reported to be mainly driven by temperature. Except for families getting ready for discharge that day, the curtains were closed at least halfway across the glass front of the room. Both parents and staff left the curtain fully closed 33% of the time when a

room was occupied by an infant. Except for a family readying for discharge, curtains were closed far enough to prevent passersby from seeing the parents.

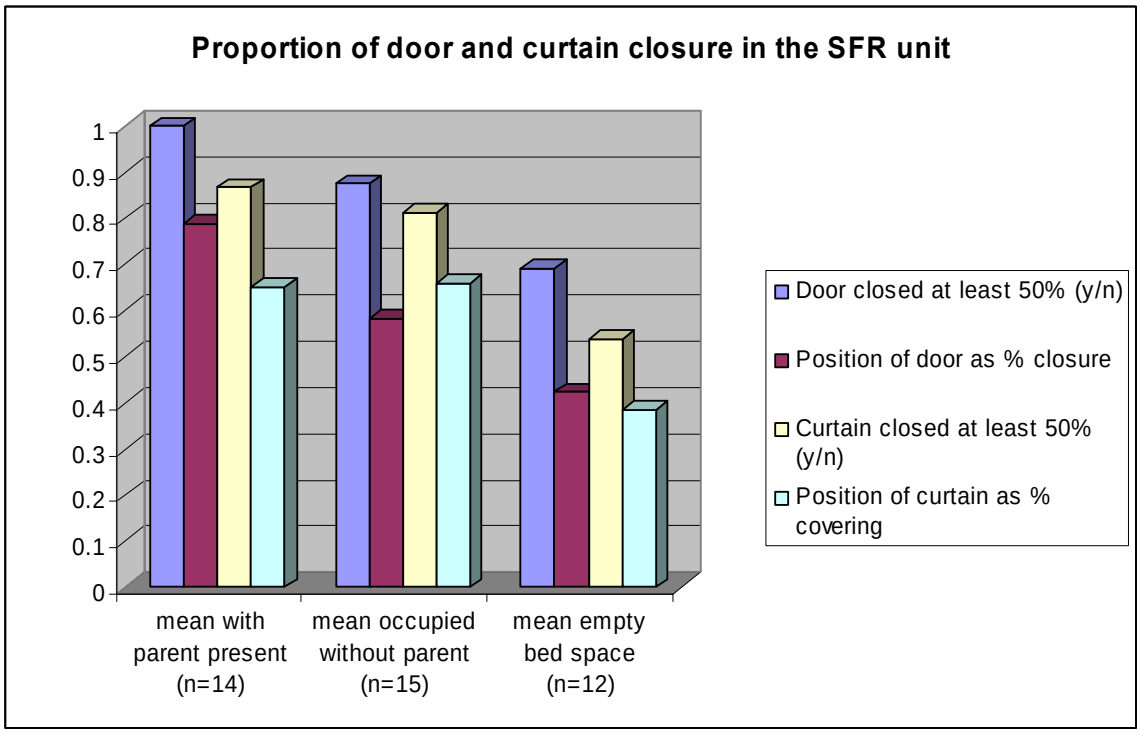


Figure 32. **Proportion of door and curtain use and average position of door and curtain grouped by occupancy condition of the room.**

Privacy in the Open-bay units was accomplished by providing movable screens and by facing families away from traffic. Screens were used 100% of the time for the private open-front bays in Open-bay #1. The door for the occupied isolation room was also closed during the entire visit. For the open portion of Open-bay #1 (excluding the private bays and isolation rooms) unit screens were used to increase privacy for 14% of the parents observed. No screens were in use in Open-bay #2 or Open-bay #3. Open-bay #3 reported frequent use of screens at other times.

Facing parents away from traffic was used frequently as a tool to increase privacy for parents in Open-bay #1, occurring in 50% of the parent observations. Parents used the traffic-facing side of the infant bed both when the nurse was using the other side and when the parents would face each other over the incubator. When nurses were finished using the traffic-backing side, 60% of parents moved to the traffic-backing side of the warmer or incubator. Parents facing away from traffic were also seen 33% of the time in Open-bay #3. Parents in Open-bay #2 faced toward traffic.

Partition wall and partial-wall design affected privacy as well. Open-bay #1 also increased privacy by providing partial walls, which separated the beds around the perimeter into partially divided 2-bed bays. Center pinwheel walls were angled to traffic to provide increased privacy, especially for the side away from main traffic paths. This arrangement allowed sufficient privacy; for instance, when a code was occurring across the unit, parents on the other side of the pinwheels and partial walls were unaware of it. Open-bay #3 was designed with partial walls and pinwheels as well. The partial walls separated the beds around the perimeter into 2-bed bays, but the pinwheels were not angled in order to maximize the visibility of infants to staff. Planned 2-bed rooms at Open-bay #2 were designed to use glass walls and a door to increase privacy and reduce stimulation. These rooms were converted to 4-bed mini-pods with no division between the beds. Open-bay #3 had few walls separating the visual field, but the unit was designed with the long side of the patient care area along the perimeter wall. This orientation increased space between beds and allowed for more auditory privacy.

Infant visibility outside the immediate bedside space was not available in the SFR. When doors or curtains were partially open, the infant incubator was often covered. Central monitoring was available at the unit desk, but not within the unit. Nurses often opened curtains to see the monitors, when parents were not present. Staff wore portable alarms and locator call devices.

Open-bay #1 had 75% of infants visible in the open portion of the unit as observed from locations where nurses worked or gathered. Open-bay #2 had similar results, with 73% of infants visible. Open-bay #3 had more infants covered on the observation visit, with 50% of the infants visible. Blankets draped at the ends of cribs and over incubators provided the infant covering.

Parental Presence and Policies

Polices on parental presence were varied among units visited. As mentioned in the privacy section, 2 units had 24-hour parental presence policies (the SFR unit and Open-bay #3). Open-bay #1 was closed for one hour for each shift change. Open-bay #2 was closed to parents for two hours at each shift change (6–8 a.m. and 6–8 p.m.), during quiet time (1–3 p.m.), and during admissions. Each family who wished to enter Open-bay #2 had to be approved by the infant's nurse via a call from the unit clerk before they could enter. Open-bay unit staff might also ask parents to leave if an infant was coding or if there was a minor surgery occurring on the unit. Open-bay #1 staff asked parents who were near a code to leave, but the pinwheel and partial wall allowed parents on the other side of the room to be relatively unaware of two codes occurring simultaneously; these parents were allowed to stay. The all-SFR unit did not ask parents to leave during admissions, codes, or procedures, since a parent inside one closed room is not generally aware of an admission, death, or procedure inside an adjacent room.

Units also had varied policies concerning the number of people at the bedside. Following advice from staff about noise and how to monitor infant response, the family was allowed to control traffic in the SFR unit. The desk clerk would phone parents when visitors arrived and would allow them to decide whether to visit in the lounge area or to bring the visitor back to the infant care space. Open-bays #1 and #2 enforced or encouraged a limit of two family members/ visitors at the bedside; Open-bay #3 encouraged only two visitors in addition to parents.

The pattern of the amount of time parents were present varied between sites. For the SFR unit, parents tended to stay with their infant inside the room for long stretches of time. An apparent drop in parental presence between 5 and 6 p.m. is due to parents arriving and entering the care space during the 5–6 p.m. observation hour and staying throughout the 6–7 p.m. observation hour. A common pattern was for a parent to leave for an hour to cook a meal, do laundry, or shower in the parent lounge space and then return. Evenings from 5 to 8 p.m. and weekends had the highest number of family members and visitors present, but a large number of parents were present at every observation from early morning to 10 p.m. In the other units parents would stay for shorter periods of time, often an hour or less during the observation days, and would later return for another hour or so. While evenings were still the peak time for parental presence in the unit, some parents were present at other hours open to them. In Open-bay #2, which was closed from 6 to 8 p.m., families were present from 4 to 6 p.m.; they would return after 8 p.m., but they did not usually stay long. The parent waiting room just outside the unit was full during the 6–8 p.m. shift-change closure, with parents spilling out into the hallway as 8 p.m. approached. This unit also had a limit of two people per bedside, so a common pattern emerged: Both parents would come in and then both would leave; the father would then escort each grandparent, sibling, and/or other visitor back to the bedside to stay for a few moments at a time. Mothers were observed at the bedside for one to two hours between quiet time parent closure and shift-change parent closure.

Parent-to-Parent Contact

Parent-to-parent contact at the SFR unit was not very common. The unit was working to improve this situation and was considering options such as hiring a paid parent coordinator.

Parents might see each other in hallways and briefly greet each other, but they did not interact in the lounge, in the rooms, or in the hallways during the observation period.

In the open-bay units, when parents were near their infants there was very little interaction between parents. The only exception was in Open-bay #2 in a semiprivate room that had been converted to a small 4-bed pod. Between 3 and 5 p.m. two mothers in the room were interacting while holding their infants, but they were approximately 4–6 feet from each other. A similar interaction occurred again after 8 p.m. Parents in the open-room areas of the same unit were physically separated; a parent at one bedside might be no closer than approximately 10–12 feet to another parent, without a partial wall obstructing their view. When units were closed to parents for periods of time during the day, parent interaction occurred in the family lounge or hallways while parents waited for the unit to reopen. Open-bay #1 had a large entry lounge, and families would congregate there engaging in differing levels of interaction. Open-bay #2 had a small parent waiting room with a large number of parents waiting for the 8 p.m. unit opening. Parents who were in the lounge and standing in hallways were actively interacting. Contents of conversations were not recorded, but it was not an organized social support activity. All units reported that volunteer parent support groups had cyclical periods of activity, depending on the group of parents present at any one time. Open-bay #3 had parents present in the unit, but there was no in-unit interaction during the observation period. Open-bay #3 has an active and organized parent support group that meets for pizza every two weeks and holds activities like scrapbooking.

Staff Monitoring of Infants

The SFR unit had the most sophisticated monitoring arrangement of the units observed. This unit had a staff locator system, which allowed the unit clerk to know where a staff member

was at any time and allowed staff to see if a nurse was inside a room that was closed. There was a call system associated with these locators, so staff could call silently for assistance. Monitors were at each bedside, central monitoring was available at the front desk, and each staff member wore a central monitor alarm. This central monitor alarm would first alert the staff member assigned to the infant, and then, if there was no response, would alert everyone in the unit. Staff members did not have line of sight to each infant. Staff expressed satisfaction with the system, but when parents were not present they would open the curtain of the infant care room just wide enough to see the monitor. Some stated that they would have preferred central monitors at the substation in addition to their individual alarm systems.

The other 3 units had individual monitors at bedsides, with auditory and/or flashing-light alarms that could be linked for assignments. They all required line of sight to at least one infant's monitor. This system kept nurses close to the infants' bedsides, even when charting. Line of sight was important in nursing assignments and care practices.

Staff Workspace Configuration

Staff workspaces varied across units. Each unit had some work space near the bedside. The SFR unit had a central workroom at the front of the unit and four "pod" substations in addition to bedside counter space. Shared equipment was stored in these areas. These pod substations are used for charting and conferring with colleagues. If a nurse had a "cross pod" assignment, she would generally chart at the pod where another nurse was sitting rather than have a pod to herself for an extended period. For quick tasks, nurses used all the pod spaces, sitting desks, and standing counters. There was efficient charting, collegiality, positive social support, and informal consulting on procedures observed.

Open-bay #1 had a mix of substation desk areas (two) and distributed computers for charting. The substation areas had quiet monitors installed that would light up a "quiet please" sign on the ceiling if excessive sound was detected. Substation areas were more likely used by physicians and nurse practitioners. Charting, collegiality, and informal consulting also occurred in this unit but were more common at the decentralized computer areas near the patient bed spaces. Shared equipment was often left at the bedside where it was last used, and some traffic was due to staff looking for shared equipment. Open-bay #3 had a similar configuration. Open-bay #2 had more nurse activity in or near the patient care space, with little use of the two-sided central desk.

Staff Interaction with Families

All units exhibited positive and welcoming interaction with families. Staff was observed teaching parents, providing reassurance, and explaining medical conditions. Open-bay #2 had the highest staff control of parent presence, since the front desk clerk always asked the nurses' permission to allow parents in, even during "open" hours.

Pedometer Readings

Pedometer readings were used to test the supposition that SFR configurations would increase the amount of walking required by nurses during a shift. The lowest average steps per hour were found with the SFR unit, but the ANOVA shows no significant difference between the units.

Construction Cost Analysis

Construction costs for neonatal intensive care units are presented as average cost per square foot and average cost per infant station. The cost analysis based on the average cost per

square foot suggests that the Combination configuration was the most cost effective, with an average of $204/SF (Figure 33). A $9 difference was found when comparing the average cost per square foot between SFR and Open-bay configurations ($294/SF and $285/SF, respectively). The Double Occupancy configuration had the highest average cost per square foot, with a dollar value of $331/SF.

Interestingly, there was no suggestion of efficiency based on the average size of a unit and the cost per square foot. For instance, with an average unit size of 16,337 SF, the Double Occupancy unit had the highest average cost per square foot, while the Combination configuration had the lowest cost with only 12,237 SF. While the difference in the average cost per square foot was minimal between the SFR and Open-bay configurations, there was a difference in the amount of square feet equal to 3,918 (18,902 SF and 14,984 SF, respectively). The average size of the unit configurations was not a variable that affected cost.

By comparison, the average cost per infant station provides another tool for projecting costs for planning a new NICU (Figure 34). Like the cost-per-square-foot analysis, the Combination configuration had the lowest average cost per infant station, with a price tag of $75,438 and an average number of 33 infant stations. The Double Occupancy configuration had an average cost of $112,498 per infant station, with an average of 48 infant stations. The difference between the cost per infant station for SFR and Open-bay configurations is more significant than the cost per square foot. The Open-bay configuration had an average cost of $138,822 per infant station (average number of 32 infant stations), while the SFR configuration had an average cost of $249,516 per infant station, with an average of 28 infant stations. Interestingly, the cost per infant station and cost per square foot provide two ways to view the data. The cost per infant station for the SFR indicates that the unit had more SF and fewer stations compared to, say, the Double Occupancy configuration, which had many more infant stations

with fewer SF per infant station (Figure 35). Due to the limited number of participants, this analysis does not determine statistically significant differences.

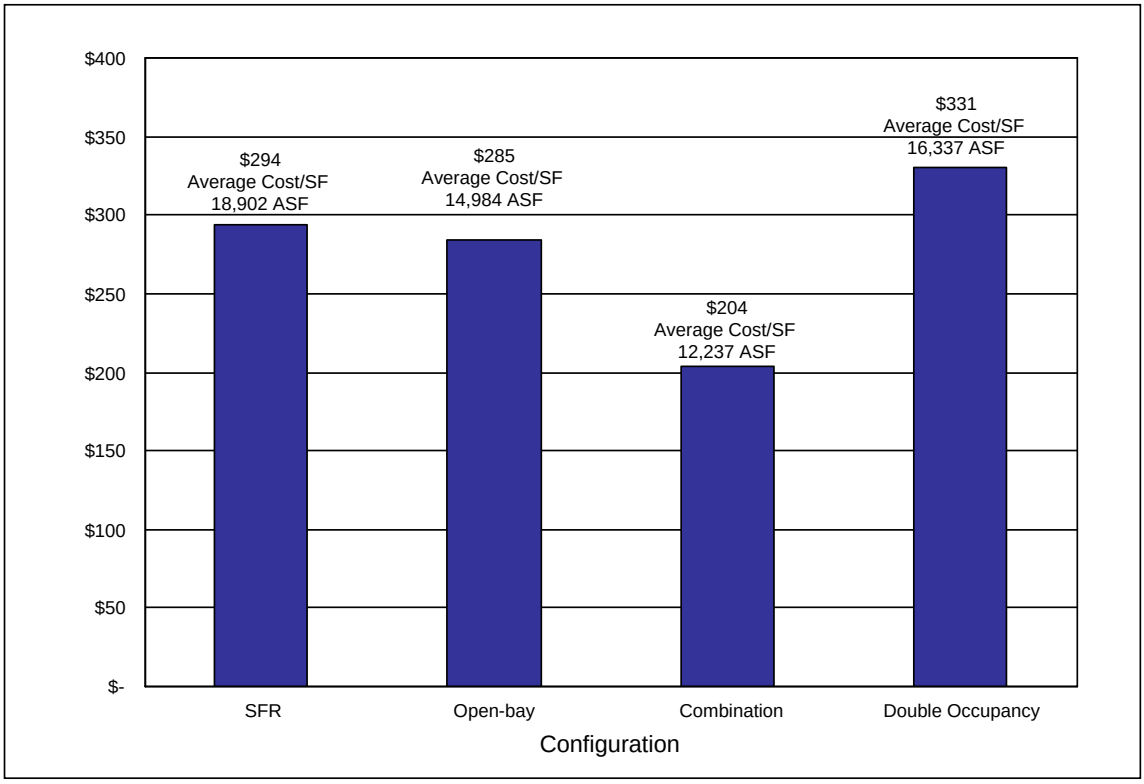


Figure 33: Average cost per square foot, defined by configuration.

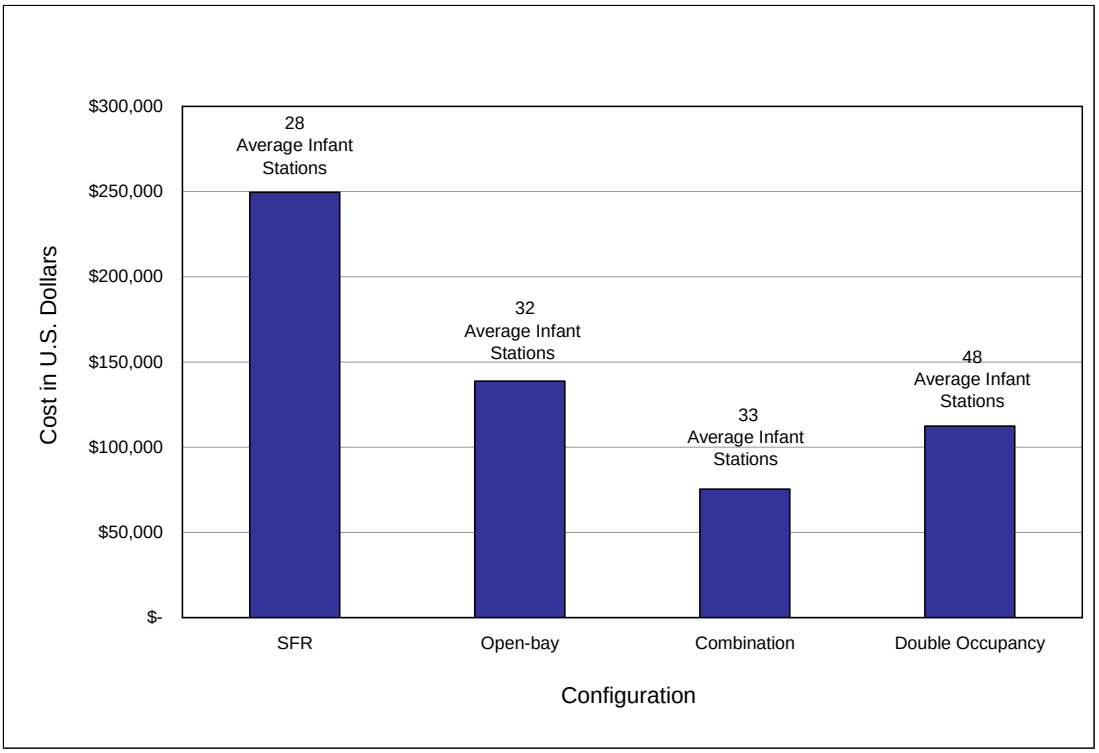


Figure 34. **Average cost per average number of infant stations, defined by configuration.**

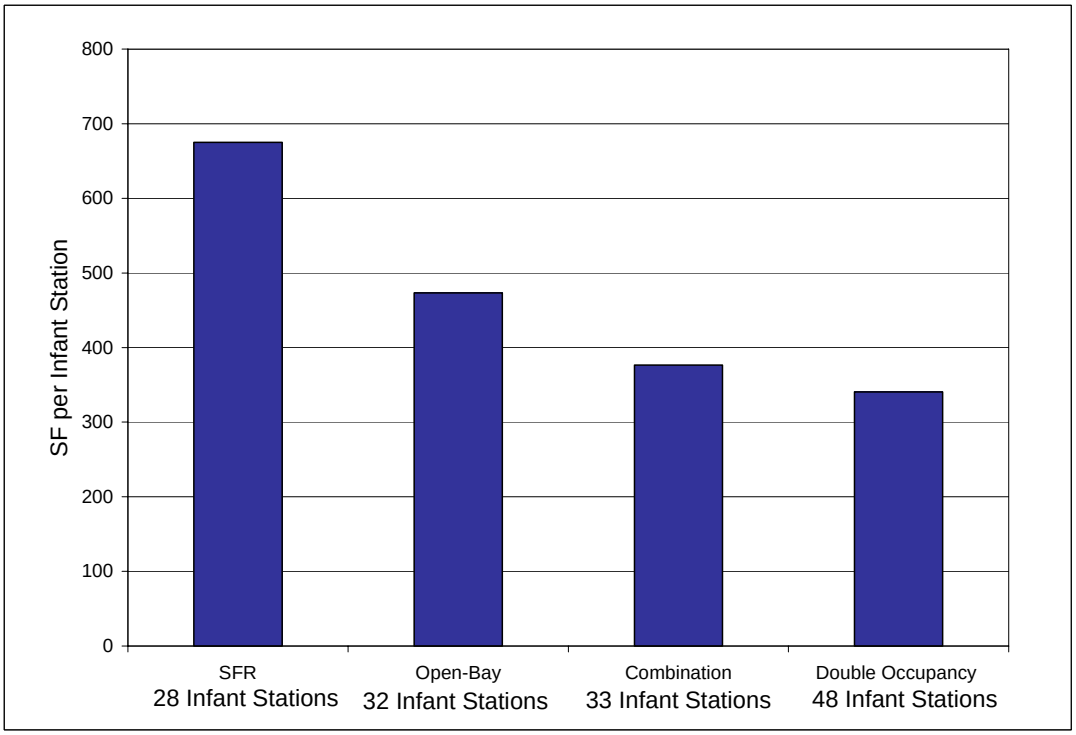


Figure 35. **Mean number of infant stations and mean square feet per infant station by configuration.**

Patient Medical Outcomes

Hospital records for participating hospitals were collected to provide indicators of change in patient outcomes dependent on the move from an old NICU to a new NICU. The move to a new unit included moving from (1) open-bay to SFR, (2) open-bay to combination, and (3) open-bay to open-bay. The collection of data included average daily census (ADC), average length of stay (ALOS), average admissions and discharges, and average numbers of reported nosocomial infections (bloodstream and pneumonia). The results described here are listed in Table 10.

The ADC increased for all three configuration types. The ADC increase for SFR units was 5%; the increase for open-bay units was 11%; and the combination units increased ADC by 6%. This increase generally correlates with the increase of the average number of infant stations for all configurations. The ALOS decreased in open-bay and combination units (2% and 9%, respectively). The ALOS for SFR units increased by 3%.

Average admission rates were reported as inborns and transfers from outside of the unit. The average SFR unit inborn rates decreased 2%, but transfer rates increased 15%. Overall, open-bay unit average rates for inborns and transfers decreased (44% and 37%, respectively). The average admission rates for combination units increased; inborn rates increased 4%, and transfer rates increased 6%.

Average discharges were reported in three categories: (1) discharged home, (2) discharged transfer, and (3) discharged death. Average discharges increased in SFR units (4%) and combination units (20%). Open-bay units decreased by 9%. Alternately, SFR and combination units showed a decrease in patient transfers (15% and 13%, respectively). Open-bay units increased average number of transfers by 9%, the same percentage as the decrease in discharges to home. Open-bay and combination units showed a decrease in infant deaths. Open-bay decreased discharges due to death by 35%, while combination units decreased such

discharges by 16%. SFR units averaged an increase of 15% for discharge of infants due to death, which correlates with the increased percentage of average number of infant stations. It is important to note that, in reporting these particular findings, the complex nature of variables influencing outcomes is not fully explored or explained within the context of this study.

Nosocomial infection rates were reported for bloodstream infections and pneumonia. Average rates of nosocomial bloodstream infections decreased in both SFR units (38%) and open-bay units (40%). Combination units showed an increase of 4% for average rate of reported nosocomial bloodstream infections. The average rates for nosocomial infections for pneumonia decreased in open-bay units (88%) and combination units (22%). However, SFR units showed an increase of 55%. With only five hospitals providing nosocomial infection rates, the data set was very small, and no clear trends were evident.

Table 10. **Difference between preoccupation and postoccupation of a new facility based on configuration.**

	Configuration	Percent Change	
Avg Daily Census	SFR	Increase	0.05
	Open-bay	Increase	0.11
	Combination	Increase	0.06
Avg Length of Stay	SFR	Increase	0.03
	Open-bay	Decrease	0.02
	Combination	Decrease	0.09
Avg Admits Inborn	SFR	Decrease	0.02
	Open-bay	Decrease	0.44
	Combination	Increase	0.04
Avg Admits Transfers	SFR	Increase	0.15
	Open-bay	Decrease	0.37
	Combination	Increase	0.06
Avg Discharge Home	SFR	Increase	0.04
	Open-bay	Decrease	0.09
	Combination	Increase	0.20
Avg Discharge Transfer	SFR	Decrease	0.15
	Open-bay	Increase	0.09
	Combination	Decrease	0.13
Avg Discharge Died	SFR	Increase	0.15
	Open-bay	Decrease	0.35
	Combination	Decrease	0.16
Nosocomial Infections Bloodstream	SFR	Decrease	0.38
	Open-bay	Decrease	0.40
	Combination	Increase	0.04
Nosocomial Infections Pneumonia	SFR	Increase	0.55
	Open-bay	Decrease	0.88
	Combination	Decrease	0.22

Staff and Parent Surveys

The staff survey data included questionnaire responses from 3 groups of staff members: (1) staff in Hospital 1a, an all-single-room NICU; (2) staff working in the open bay of a combined SFR–open bay unit (Hospital 2b); and (3) staff working in the SFR portion of the same combined SFR–open-bay unit (Hospital 2c). The parent survey data included responses from 2 groups of parents: (1) parents in the old open bay of Hospital 2 and (2) parents in the new single rooms of

Hospital 2. See Appendix B for the staff and parent surveys and Appendix C for additional analysis data.

The objective of the statistical analysis was to compare and detect significant differences between single rooms and open bays in the questionnaire survey answers. More specifically, the following hypotheses regarding staff were tested.

1a. Staff members in single rooms are more satisfied with the physical environment than the staff members in the open-bay configuration.

2a. Staff members in single rooms perceive the physical environment to be better than the staff members in open-bay units.

3a. Staff members in single rooms report less stress than the staff members in open-bay units.

4. Staff members in single rooms have higher ratings of job satisfaction than the staff members in the open-bay configuration.

The following hypotheses regarding parents were also tested.

1b. Parents of patients in single rooms are more satisfied with the physical environment than the parents in the open-bay configuration.

2b. Parents of patients in single rooms perceive the physical environment to be better than the parents in open-bay units.

3b. Parents of patients in single rooms report less stress than the parents in open-bay units.

The statistical analysis included three procedures: data input, descriptive analysis, and hypothesis testing.

Regarding data input, the raw data in the questionnaire was first transferred to electronic files using Microsoft Excel. The input was conducted independently by two persons and

compared. Several inconsistencies were discovered and then resolved after examining the original data. This procedure helped to confirm the consistency between electronic files and the original data. In some cases, two numbers were circled on the questionnaire. When two consecutive entries were in one circle, the average was entered. When there were intervening numbers between those circled, the responses were treated as missing. The job titles of staff members were classified into three categories: (1) nurse, (2) respiratory therapist, and (3) physician. One response to the job title was an abbreviation and could not be identified and was treated as missing. Some responses to the question of "years in NICU" or "years in hospital" included a number and a plus sign, such as "2+," or a range, such as "17–18." In the first example, only the number was entered; in the second case, the average was entered. A few respondents described the distance from house to hospital in minutes instead of miles. These responses were converted to miles, using the formula 2 minutes=1 mile. Some respondents wrote "white" as ethnicity. Those cases were categorized into category 3, "Caucasian."

The Parental Stress Scale: Neonatal Intensive Care Unit (PSS:NICU) includes 46 items in 4 subscales: sights and sounds, baby appearance, parent role, and staff relationship and communication[3]. This study also utilizes the Expanded Nurse Stress Scale (ENSS) by French, Lenton, Walters, and Eyles (2000), and the Job Satisfaction Scale (JSS) developed by Harris, Hingley, and Cooper (1988). The data analyses were conducted in Statistical Package for Social Sciences (SPSS). Descriptive statistics—e.g., means, medians, variances—along with plots—e.g., scatter plots, histograms, normality plots of all variables—were produced to check the nature of

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[3] Miles and Funk (1998) described three methods in scoring the PSS:NICU scale: Metric 1--Occurrence of stress ("not applicable" as missing); Metric 2--Overall stress level ("not applicable" as "1, Not at all stressful"); and Metric 3--Frequency (indicated stress as "1", "not applicable" as "0"). The score of a subscale or a scale is simply the average of scores of the included items. Because the study focuses on the overall stress level of parents, the Metric 2 method suggested by Miles and Funk (1998) is used to re-code the PSS: NICU data. The response "not applicable" is re-coded as "1" while other responses don't change.

the data. The normality tests in SPSS demonstrated that the data distributions were not normal. This nature of the data suggested nonparametric tests or data transformation for hypotheses testing. To ensure similarity between groups, the chi-square test, the Kruskal-Wallis *H* test, and the Mann-Whitney *U* test were performed to detect any difference between the groups in demographic characteristics, such as age, gender, work experience, relation to infant, and distance from house to hospital.

Regarding the data of ENSS, PSS:NICU, and JSS, nonparametric tests (Mann-Whitney *U* test) were used to test the hypotheses. In addition to calculating the overall score for each of these scales, scores on subscales were tested individually. The confidence level for this study was 95% (α=0.05). For the data regarding satisfaction and perception of physical environment, tables, charts, and graphs of descriptive statistics were used to compare the groups in different environments.

A total of 75 staff questionnaire responses were received: 21 from Group 1 (Hospital 1, single room), 27 from Group 2 (hospital 2, open bay), and 27 from Group 3 (Hospital 2, single room). Among these groups, there were no significant differences in demographic characteristics, such as age, gender, and job title. Tables 11 and 12 summarize the characteristics of all staff members and nursing staff members, respectively. The population surveyed was predominantly middle-aged Caucasian females. The average number of years working in NICUs was 13.38. Approximately 84% were nursing staff.

The righthand columns of these tables show the test results. All *p*s > 0.10. These results confirm the similarity of groups on these characteristics. Thus the differences in outcomes were more likely to be due to the difference between single rooms and open bays.

Table 11. **Characteristics of staff questionnaire respondents.**

Characteristic		Hospital 1: All single room		Hospital 2: Open bay		Hospital 2: Single room		Total		*p* value
		N	%	N	%	N	%	N	%	
Age	Less than 21 years old	0	0.00%	0	0.00%	0	0.00%	0	0.00%	.286*
	21 to 40 years old	11	52.38%	10	37.04%	9	33.33%	30	40.00%	
	41 to 60 years old	9	42.86%	17	62.96%	18	66.67%	44	58.67%	
	61 and over	1	4.76%	0	0.00%	0	0.00%	1	1.33%	
Gender	Female	19	90.48%	25	92.59%	25	92.59%	69	92.00%	.955*
	Male	2	9.52%	2	7.41%	2	7.41%	6	8.00%	
Ethnicity	African American	0	0.00%	0	0.00%	0	0.00%	0	0.00%	.151*
	Asian	0	0.00%	2	8.00%	0	0.00%	2	2.82%	
	Caucasian	20	100.00%	23	92.00%	26	100.00%	69	97.18%	
	Hispanic	0	0.00%	0	0.00%	0	0.00%	0	0.00%	
	Other	0	0.00%	0	0.00%	0	0.00%	0	0.00%	
Job title	Nurse	16	80.00%	22	84.62%	23	85.19%	61	83.56%	.138*
	Respiratory therapist	0	0.00%	3	11.54%	3	11.11%	6	8.22%	
	Physician	4	20.00%	1	3.85%	1	3.70%	6	8.22%	
Years in this NICU	N		20		27		27		74	.685**
	Mean		11.67		9.95		9.70		10.32	
	Standard deviation		9.97		8.13		7.83		8.48	
Years in this hospital	N		21		27		27		75	.354**
	Mean		13.58		9.90		10.28		11.07	
	Standard deviation		10.12		7.78		7.95		8.58	
Years in any NICU	N		20		27		27		74	.615**
	Mean		14.67		13.76		12.05		13.38	
	Standard deviation		9.76		9.13		9.33		9.31	

Note: The percentage figures above show the fractions within each group and do not include missing values.
* Pearson chi-square, 2-sided
** Kruskal-Wallis test

Table 12. **Characteristics of nursing staff questionnaire respondents.**

Characteristic		Hospital 1: All single room		Hospital 2: Open bay		Hospital 2: Single room		Total		*p* value
		N	%	N	%	N	%	N	%	
Age	Less than 21 years old	0	0.00%	0	0.00%	0	0.00%	0	0.00%	.181*
	21 to 40 years old	9	56.25%	8	36.36%	7	30.43%	24	39.34%	
	41 to 60 years old	6	37.50%	14	63.64%	16	69.57%	36	59.02%	
	61 and over	1	6.25%	0	0.00%	0	0.00%	1	1.64%	
Gender	Female	16	100.00%	22	100.00%	22	95.65%	60	98.36%	.432*
	Male	0	0.00%	0	0.00%	1	4.35%	1	1.64%	
Ethnicity	African American	0	0.00%	0	0.00%	0	0.00%	0	0.00%	.398*
	Asian	0	0.00%	1	4.76%	0	0.00%	1	1.69%	
	Caucasian	16	100.00%	20	95.24%	22	100.00%	58	98.31%	
	Hispanic	0	0.00%	0	0.00%	0	0.00%	0	0.00%	
	Other	0	0.00%	0	0.00%	0	0.00%	0	0.00%	
Years in this NICU	N		15		22		23		61	.336**
	Mean		12.99		8.62		8.55		9.61	
	Standard deviation		11.06		7.78		7.72		8.69	
Years in this hospital	N		16		22		23		61	.113**
	Mean		15.05		9.07		9.19		10.68	
	Standard deviation		11.02		7.86		7.89		9.04	
Years in any NICU	N		15		22		23		60	.640**
	Mean		13.96		12.76		10.88		12.34	
	Standard deviation		10.92		9.33		9.30		9.65	

Note: The percentage figures above show the fractions within each group and do not include missing values.
* Pearson chi-square, 2-sided
** Kruskal-Wallis Test

Twenty-one sets of parent survey responses were received: 16 from parents in single rooms and 5 from parents in open bays. Table 13 summarizes the demographic characteristics of the family respondents. The vast majority were 21 to 40 years of age and Caucasian, and all were mothers. Two-thirds spent more than 8 hours per day in the NICU, and it was the first NICU experience for 86% of them.

Table 13. **Characteristics of parent questionnaire respondents.**

Characteristic		Open bay		Single room		Total		*p* value
		N	%	N	%	N	%	
Age	Less than 21 years old	0	0.00%	0	0.00%	0	0.00%	.361*
	21 to 40 years old	4	80.00%	15	93.75%	19	90.48%	
	41 to 60 years old	1	20.00%	1	6.25%	2	9.52%	
	61 and over	0	0.00%	0	0.00%	0	0.00%	
Gender	Female	5	100.00%	16	100.00%	21	100.00%	***
	Male	0	0.00%	0	0.00%	0	0.00%	
Ethnicity	African American	0	0.00%	1	6.25%	1	4.76%	.567*
	Asian	0	0.00%	0	0.00%	0	0.00%	
	Caucasian	5	100.00%	15	93.75%	20	95.24%	
	Hispanic	0	0.00%	0	0.00%	0	0.00%	
	Other	0	0.00%	0	0.00%	0	0.00%	
Link to infant	Parent	5	100.00%	16	100.00%	21	100.00%	***
	Grandparent	0	0.00%	0	0.00%	0	0.00%	
	Aunt/Uncle	0	0.00%	0	0.00%	0	0.00%	
	Sister/Brother	0	0.00%	0	0.00%	0	0.00%	
	Other	0	0.00%	0	0.00%	0	0.00%	
Language	English	5	100.00%	16	100.00%	21	100.00%	***
	Spanish	0	0.00%	0	0.00%	0	0.00%	
	Chinese	0	0.00%	0	0.00%	0	0.00%	
	Other	0	0.00%	0	0.00%	0	0.00%	
Average hours each day in NICU	Less than 1 hour	0	0.00%	0	0.00%	0	0.00%	.060*
	1 to 3 hours	2	40.00%	0	0.00%	2	9.52%	
	3 to 5 hours	0	0.00%	1	6.25%	1	4.76%	
	5 to 8 hours	1	20.00%	3	18.75%	4	19.05%	
	More than 8 hours	2	40.00%	12	75.00%	14	66.67%	
First experience in NICU	No	0	0.00%	3	18.75%	3	14.29%	.296*
	Yes	5	100.00%	13	81.25%	18	85.71%	
Distance between house and hospital	N	5		15		20		.299**
	Mean	17.40		10.37		12.13		
	Standard deviation	16.83		10.72		12.41		
How many days the child has been in NICU	N	5		16		21		.834**
	Mean	24.00		20.00		20.95		
	Standard deviation	37.01		21.87		25.21		
How many people are usually with you at the hospital	N	5		16		21		.332**
	Mean	2.60		1.94		2.10		
	Standard deviation	1.82		1.99		1.93		

Note: The percentage figures above show the fractions within each group and do not include missing values.
* Pearson chi-square, 2-sided
** Mann-Whitney *U* test
*** Constant across groups

Hypotheses 1a and 2a, that staff members in single rooms are more satisfied with the physical environment than the staff members in the open-bay configuration and perceive the former to be a better environment, are generally supported. Tables 14 and 15 summarize staff responses to satisfaction and perception questions.

Table 14. **Staff's degree of satisfaction with the physical environment.**

Statements	Hospital 1 - Single room (%)						Hospital 2 - Single Room (%)						Hospital 2 - Open unit (%)					
	NA	Not satisfied	A little satisfied	Moder satisfied	Very satisfied	Extreme satisfied	NA	Not satisfied	A little satisfied	Moder satisfied	Very satisfied	Extreme satisfied	NA	Not satisfied	A little satisfied	Moder satisfied	Very satisfied	Extreme satisfied
Quality of physical environment	0.0	0.0	0.0	0.0	33.3	66.7	0.0	12.0	24.0	36.0	28.0	0.0	0.0		11.1	59.3	18.5	3.7
Window views	0.0	0.0	0.0	14.3	81.0	4.8	23.1	69.2	0.0	3.8	0.0	3.8	37.0	59.3	0.0	3.7	0.0	0.0
Natural light	0.0	0.0	0.0	19.0	52.4	28.6	14.8	55.6	7.4	14.8	7.4	0.0	29.6	48.1	7.4	7.4	7.4	0.0
Light level	0.0	0.0	0.0	4.8	38.1	57.1	0.0	14.8	22.2	25.9	29.6	7.4	0.0	11.1	11.1	48.1	29.6	0.0
Noise level	0.0	0.0	0.0	4.8	38.1	57.1	0.0	7.4	11.1	48.1	22.2	11.1	0.0	3.7	22.2	44.4	25.9	3.7
Atmosphere and décor	0.0	0.0	0.0	0.0	42.9	57.1	0.0	0.0	14.8	51.9	25.9	7.4	0.0	3.7	7.4	59.3	22.2	7.4
Waiting and resting space for families outside NICU	0.0	0.0	0.0	14.3	23.8	61.9	0.0	29.6	40.7	22.2	7.4	0.0	0.0	40.7	22.2	14.8	14.8	7.4
Place to sleep in or near NICU	0.0	0.0	9.5	4.8	28.6	57.1	11.5	11.5	26.9	23.1	19.2	7.7	18.5	14.8	25.9	29.6	3.7	7.4
Corridors and signage for finding way in hospital	0.0	0.0	4.8	19.0	52.4	23.8	0.0	7.4	37.0	40.7	14.8	0.0	0.0	0.0	33.3	44.4	18.5	3.7
Place for food and nourishment in or near NICU	4.8	0.0	4.8	28.6	47.6	14.3	0.0	29.6	33.3	14.8	14.8	7.4	3.7	25.9	29.6	25.9	11.1	3.7
The work space for staff	0.0	0.0	4.8	9.5	42.9	42.9	0.0	14.8	14.8	44.4	25.9	0.0	0.0	18.5	22.2	40.7	14.8	3.7
The respite space for staff	0.0	0.0	4.8	28.6	33.3	33.3	0.0	63.0	29.6	7.4	0.0	0.0	0.0	63.0	29.6	7.4	0.0	0.0

Table 15. **Staff's agreement regarding the physical environment.**

Statements	Hospital 1 - Single room (%)						Hospital 2 - Single Room (%)						Hospital 2 - Open unit (%)					
	NA	Strongly disagree	Somewhat disagree	Neutral	Somewh at agree	Strongly agree	NA	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	NA	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Layout allows staff to readily supervise babies	0.0	0.0	0.0	4.8	66.7	28.6	0.0	11.1	22.2	25.9	37.0	3.7	0.0	0.0	11.1	44.4	29.6	14.8
Private rooms for babies and their families are important	0.0	0.0	0.0	0.0	14.3	85.7	0.0	0.0	11.1	25.9	14.8	48.1	0.0	0.0	0.0	18.5	22.2	59.3
Environment supports family's presence and participation	0.0	0.0	0.0	0.0	23.8	76.2	0.0	0.0	7.4	22.2	33.3	37.0	0.0	0.0	11.1	29.6	37.0	22.2
Design allows family members to have privacy	0.0	0.0	0.0	0.0	9.5	90.5	0.0	0.0	29.6	25.9	14.8	29.6	0.0	25.9	44.4	29.6	0.0	0.0
Space between bed allows families to interact privately with babies	38.1	0.0	0.0	0.0	4.8	57.1	0.0	11.5	19.2	23.1	19.2	26.9	0.0	25.9	44.4	18.5	11.1	0.0
Adequate privacy can be created at the bedside for skin-to-skin care	15.0	0.0	0.0	0.0	0.0	85.0	0.0	3.7	7.4	37.0	18.5	33.3	0.0	14.8	22.2	48.1	14.8	0.0
Quiet, private space in or near the unit for family members to be alone	0.0	0.0	0.0	0.0	30.0	70.0	0.0	14.8	25.9	14.8	11.1	33.3	3.7	40.7	29.6	11.1	14.8	0.0
Importance of families to interact with each other	0.0	0.0	0.0	23.8	38.1	38.1	0.0	0.0	3.7	59.3	11.1	25.9	0.0	3.7	3.7	44.4	25.9	22.2
Layout facilitates interaction between parents	0.0	4.8	38.1	33.3	19.0	4.8	0.0	7.4	11.1	44.4	25.9	11.1	0.0	0.0	11.1	44.4	37.0	7.4
Equipments should be hidden so families do not feel uncomfortable	0.0	28.6	23.8	42.9	4.8	0.0	0.0	51.9	29.6	11.1	7.4	0.0	0.0	29.6	33.3	22.2	11.1	3.7
Environment is depressing	4.8	61.9	28.6	0.0	4.8	0.0	0.0	29.6	29.6	25.9	14.8	0.0	0.0	7.4	44.4	40.7	7.4	0.0
Atmosphere is tense and stressful for family members	4.8	42.9	42.9	9.5	0.0	0.0	0.0	7.4	25.9	37.0	25.9	3.7	0.0	0.0	11.1	44.4	29.6	14.8
Atmosphere is tense and stressful for staff	4.8	52.4	33.3	9.5	0.0	0.0	0.0	14.8	29.6	37.0	11.1	7.4	0.0	3.7	18.5	44.4	18.5	14.8

e: The percentile figures above do not include missing values

Figures 36 to 38 illustrate the mean values for staff on each question. These figures show some clear patterns. As revealed in Figure 36, there are large differences between groups. Staff members in Hospital 1 are more satisfied with the physical environment than those in Hospital 2. The 2 groups in Hospital 2 have similar satisfaction levels, although the data trends suggest that staff in the SFR are slightly more satisfied regarding all factors except waiting and resting space for families outside the NICU, and corridors and signage for wayfinding.

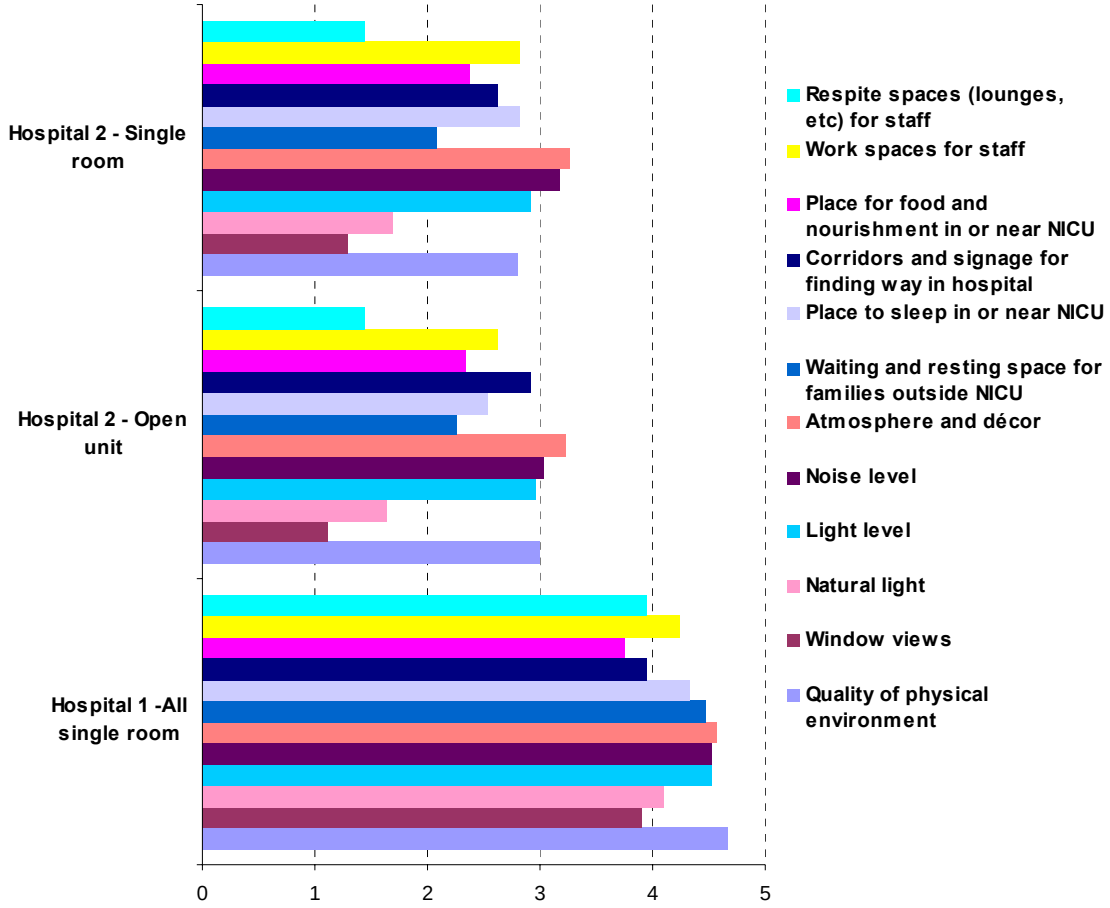

Figure 36. **Staff's degree of satisfaction with the physical environment.**

Figure 37 shows that, in the staff's view, single rooms are superior compared to open bays in terms of providing privacy to families and infants. This is most strongly articulated in Hospital 1, which is limited to SFRs. However, in spite of the fact that some infants were housed in SFRs and some in open units in Hospital 2, very little difference was found in response to "the environment supports the family's presence and participation."

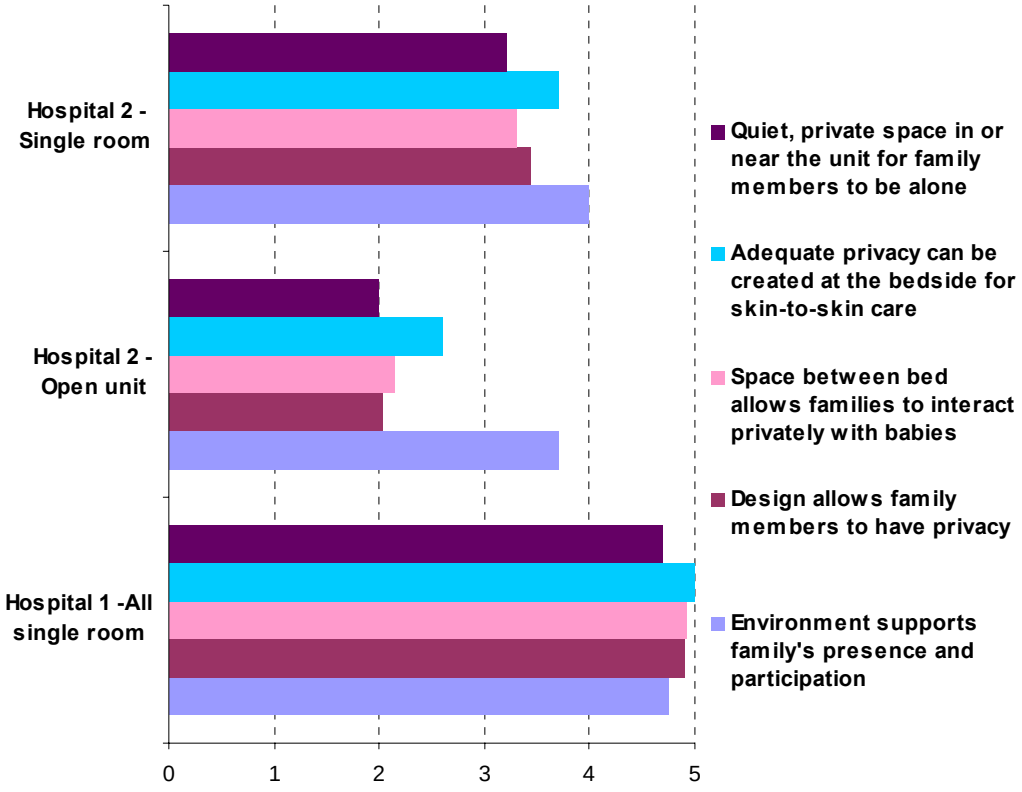

Figure 37. **Staff's levels of agreement regarding the physical environment.**

Figure 38 indicates that single rooms are viewed by staff members to be less stressful for both family and staff members, although the SFR-only NICU is perceived as less stressful than the SFR portion of the combined unit. The SFR-only unit (Hospital 1) was perceived as less than half as stressful for family members (1.6) as the open-bay portion of the combined unit (3.5). A similar pattern was demonstrated with regard to the depression level communicated by the environment.

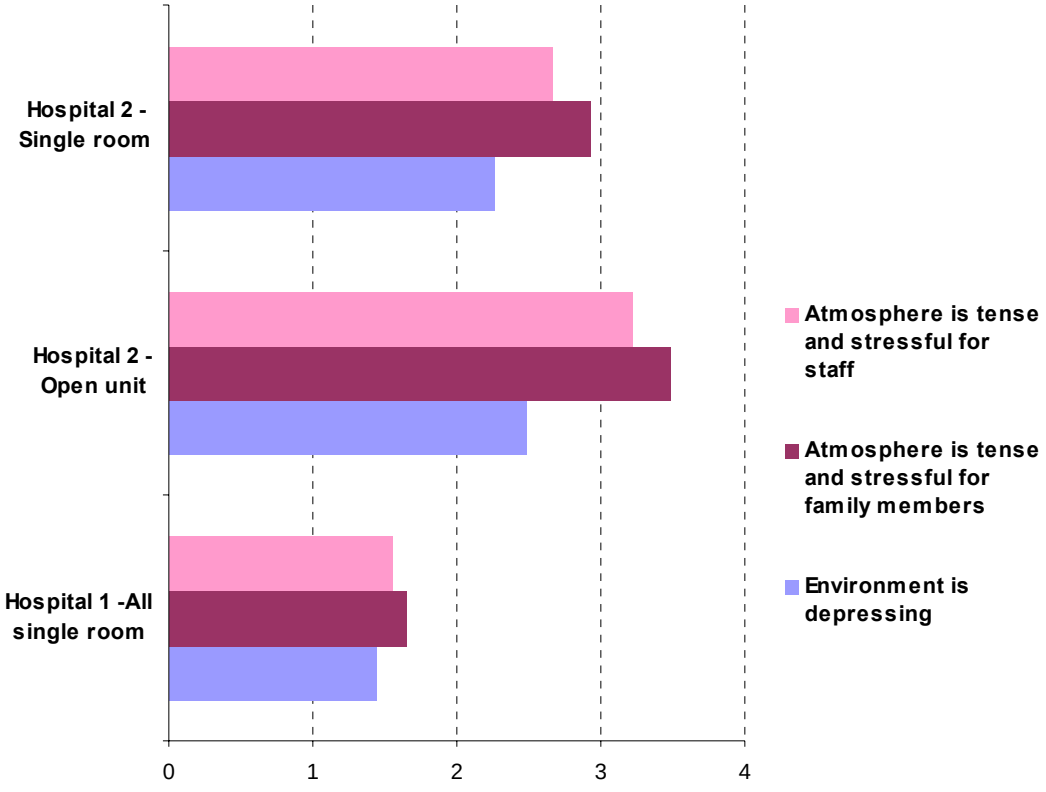

Figure 38. **Staff's levels of agreement regarding stress in the physical environment.**

Regarding hypotheses 1b and 2b, that parents of patients in single rooms are more satisfied with the physical environment than parents in the open-bay configuration and perceive the former to be a better environment, Tables 16 and 17 illustrate their responses.

Table 16. **Parents' degree of satisfaction with the physical environment.**

	Statement	**Open bay (%)**						**Single Room (%)**					
		NA	Not at all satisfied	A little satisfied	Moderately satisfied	Very satisfied	Extremely satisfied	NA	Not at all satisfied	A little satisfied	Moderately satisfied	Very satisfied	Extremely satisfied
1	Quality of physical environment	0.0	0.0	20	0	20	60	0.0	0.0	6.25	6.25	31.25	56.25
2	Window views	0.0	25.0	50.0	0.0	25.0	0.0	6.3	6.3	0.0	25.0	31.3	31.3
3	Natural light	0.0	25.0	25.0	0.0	25.0	25.0	0.0	6.3	6.3	12.5	25.0	50.0
4	Light level	0.0	0.0	0.0	20.0	60.0	20.0	0.0	0.0	6.3	6.3	43.8	43.8
5	Noise level	0.0	20.0	0.0	0.0	0.0	80.0	0.0	6.3	0.0	12.5	31.3	50.0
6	Atmosphere and décor	0.0	25.0	0.0	0.0	50.0	25.0	0.0	0.0	0.0	25.0	12.5	62.5
7	Waiting and resting space for families outside NICU	20.0	20.0	40.0	0.0	0.0	20.0	12.5	0.0	6.3	0.0	50.0	31.3
8	Place to sleep in or near NICU	40.0	40.0	0.0	0.0	0.0	20.0	6.3	18.8	6.3	6.3	25.0	37.5
9	Corridors and signage for finding way in hospital	0.0	0.0	0.0	40.0	40.0	20.0	6.3	6.3	0.0	0.0	31.3	56.3
10	Place for food and nourishment in or near NICU	20.0	0.0	40.0	20.0	0.0	20.0	6.3	0.0	18.8	18.8	25.0	31.3

Note: The percentile figures above do not include missing values

***Table 17.* Parents' agreement regarding the physical environment.**

	Statement	Open bay (%)						Single Room (%)					
		NA	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	NA	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
1	Layout allows staff to readily supervise babies	0.0	0.0	0.0	20.0	40.0	40.0	0.0	6.3	6.3	6.3	12.5	68.8
2	Private rooms for babies and their families are important	0.0	0.0	0.0	20.0	20.0	60.0	0.0	0.0	0.0	0.0	6.3	93.8
3	Environment supports family's presence and participation	0.0	20.0	0.0	0.0	40.0	40.0	0.0	0.0	0.0	6.3	6.3	87.5
4	Design allows family members to have privacy	0.0	40.0	20.0	20.0	0.0	20.0	0.0	6.3	0.0	6.3	0.0	87.5
5	Space between bed allows families to interact privately with babies	0.0	0.0	20.0	80.0	0.0	0.0	50.0	0.0	0.0	0.0	6.3	43.8
6	Adequate privacy can be created at the bedside for skin-to-skin care	20.0	0.0	40.0	40.0	0.0	0.0	6.3	6.3	0.0	0.0	6.3	81.3
7	Quiet, private space in or near the unit for family members to be alone	0.0	0.0	40.0	20.0	40.0	0.0	6.3	6.3	6.3	0.0	0.0	81.3
8	Importance of families to interact with each other	20.0	0.0	20.0	20.0	20.0	20.0	6.3	0.0	0.0	37.5	31.3	25.0
9	Layout facilitates interaction between parents	20.0	0.0	0.0	40.0	0.0	40.0	0.0	6.3	25.0	31.3	12.5	25.0
10	Equipments should be hidden so families do not feel uncomfortable	20.0	0.0	20.0	20.0	40.0	0.0	0.0	43.8	31.3	18.8	0.0	6.3
11	Environment is depressing	0.0	20.0	20.0	40.0	20.0	0.0	0.0	37.5	50.0	0.0	12.5	0.0
12	Atmosphere is tense and stressful for family members	0.0	20.0	20.0	20.0	40.0	0.0	0.0	50.0	37.5	0.0	12.5	0.0

Note: The percentile figures above do not include missing values

Similar to staff members, Figure 39 shows that parents in single rooms seem to be more satisfied with the physical environment. The most significant difference was with regard to window view and place to sleep near infant. Wayfinding support was also perceived as being more effective, although this may be the result of changes outside the unit.

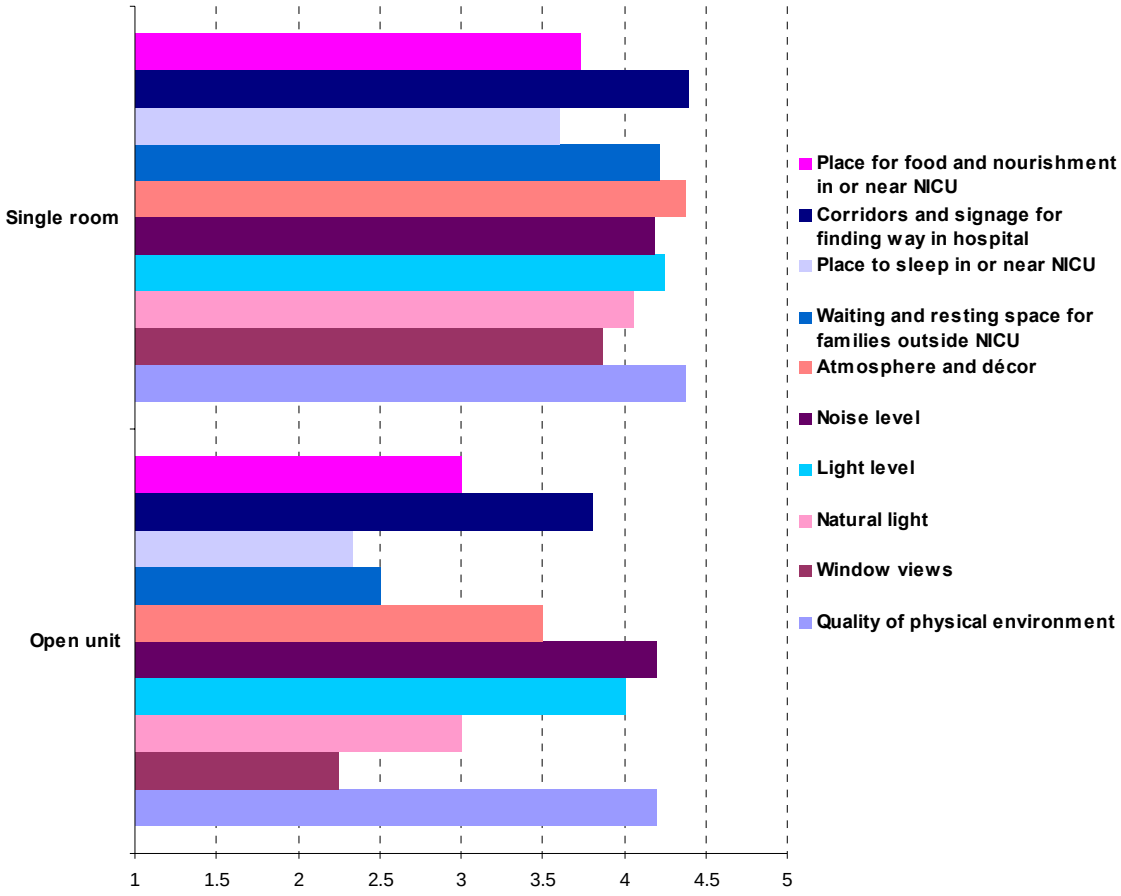

Figure 39. **Parents' degree of satisfaction with the physical environment.**

Figure 40 reveals that parents agree with staff members on the single room's support for privacy and for the family's presence. There are no noticeable differences between single rooms and open bays in terms of ease of supervision. Parents saw the importance of interacting with other families as only slightly more important in the SFRs but noted that the design of the SFRs did not encourage this interaction.

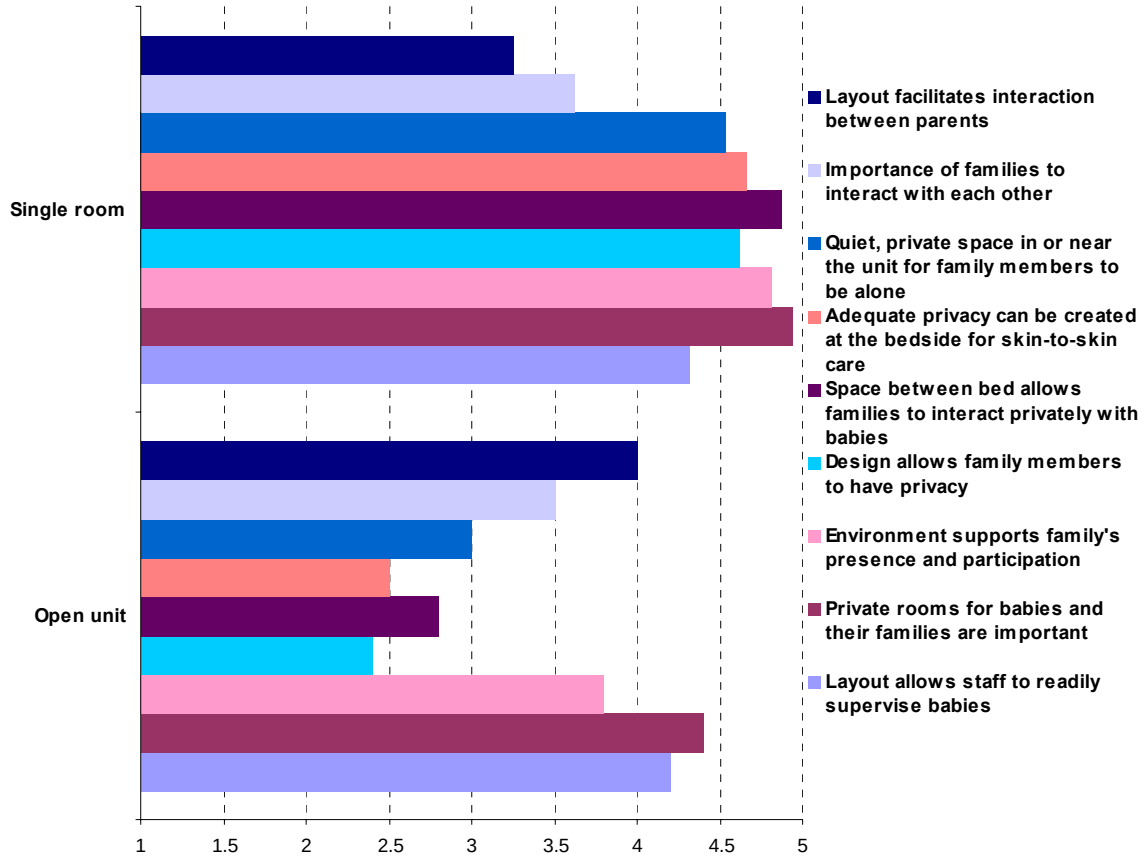

Figure 40. **Parents' levels of agreement regarding the physical environment.**

Again, Figure 41 shows that parents view single rooms as less stressful and less depressing than open bays, which is consistent with the staff members' views. Less need was expressed to hide equipment in single rooms versus open bays.

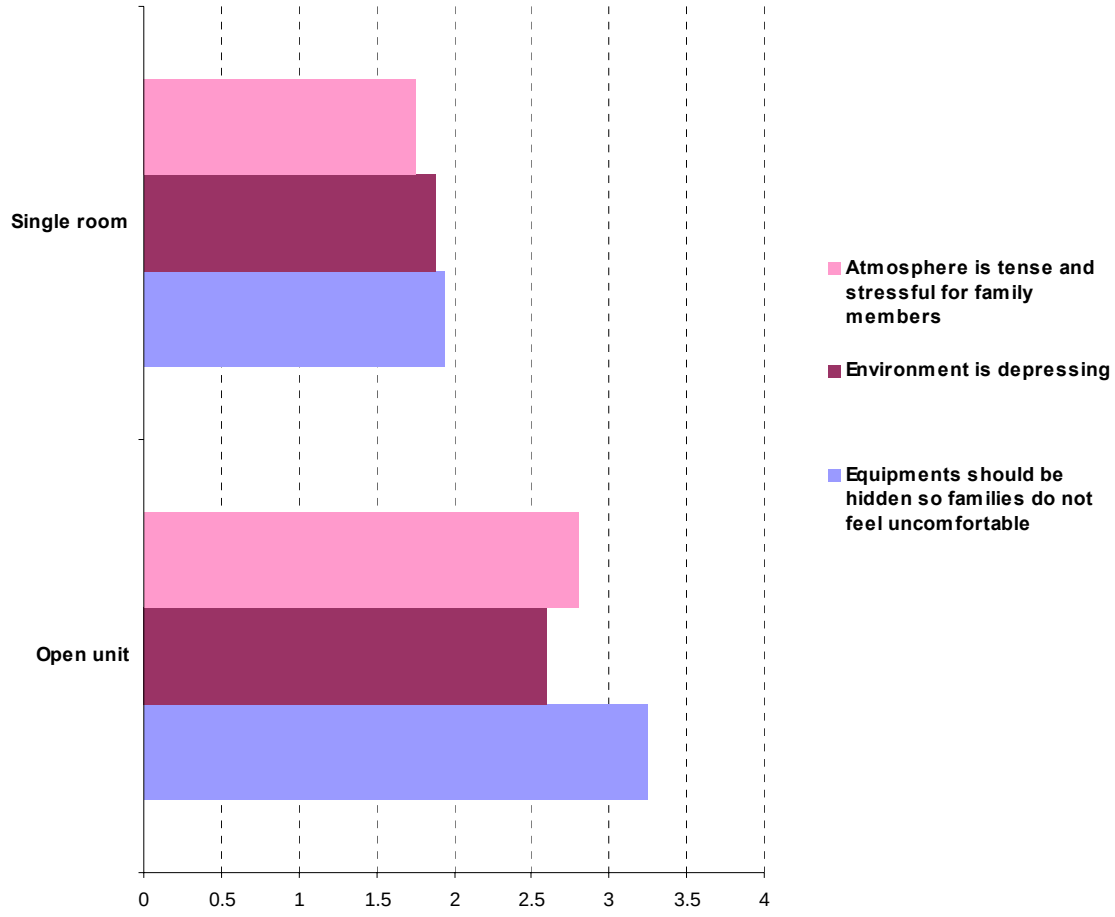

Figure 41. **Parents' levels of agreement regarding stress in the physical environment.**

Regarding hypotheses 3 and 4, because both ENSS and JSS were specifically designed for nursing staff, the data analysis tested the hypotheses based on the stress and satisfaction responses of nursing staff only.

The mean and standard deviation for each group on each scale or subscale are listed in Table 18. Figures 42 and 43 contain the same information as Table 18. Further, they visually demonstrate the difference between single-room and open-bay responses. Both groups with single rooms seem to have lower stress levels and higher job satisfaction levels than the group with the open bay. Consistent with their high ratings of the physical environment, nursing staff members in Hospital 1a report less stress and more satisfaction with their job than their counterparts in Hospital 2. Within this context, the most problematic areas in all three unit types were workload, inadequate preparation, death and dying, and conflicts with physicians, all factors that are typically independent of the physical environment.

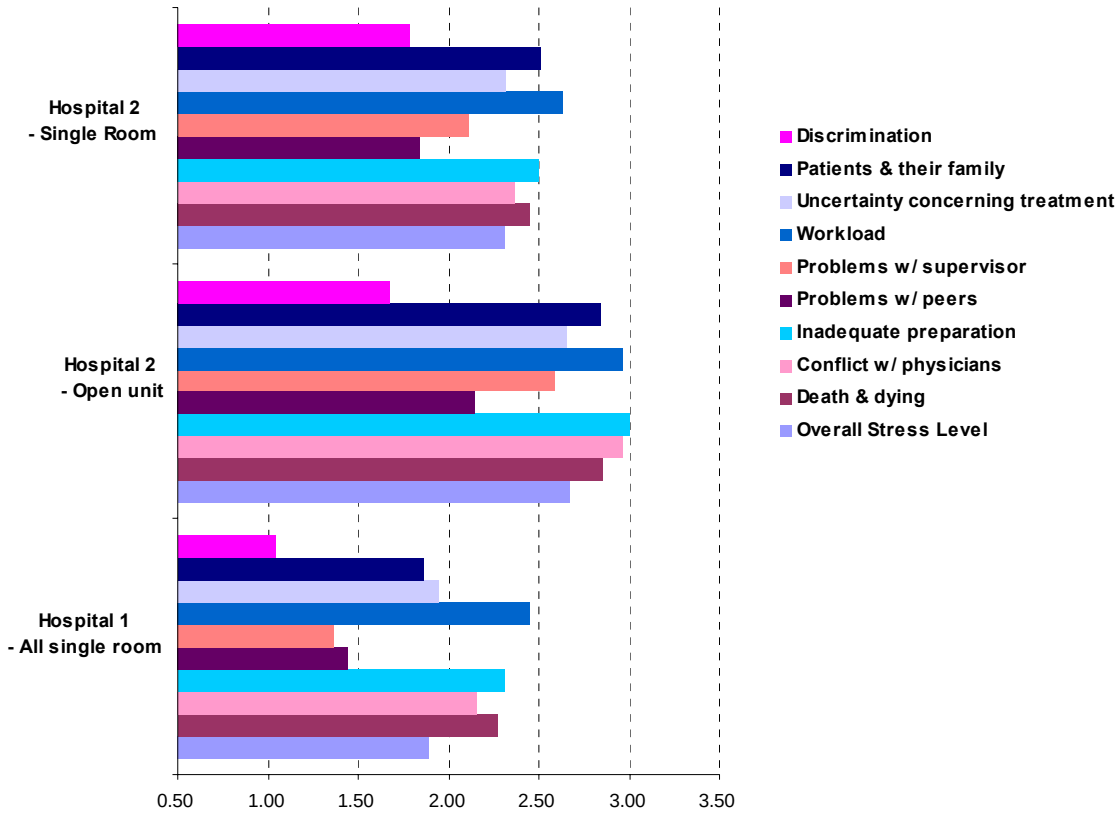

Figure 42. **Nurses' stress levels.**

Figure 43 demonstrates that nurses' job satisfaction is considerably higher in the SFR configurations.

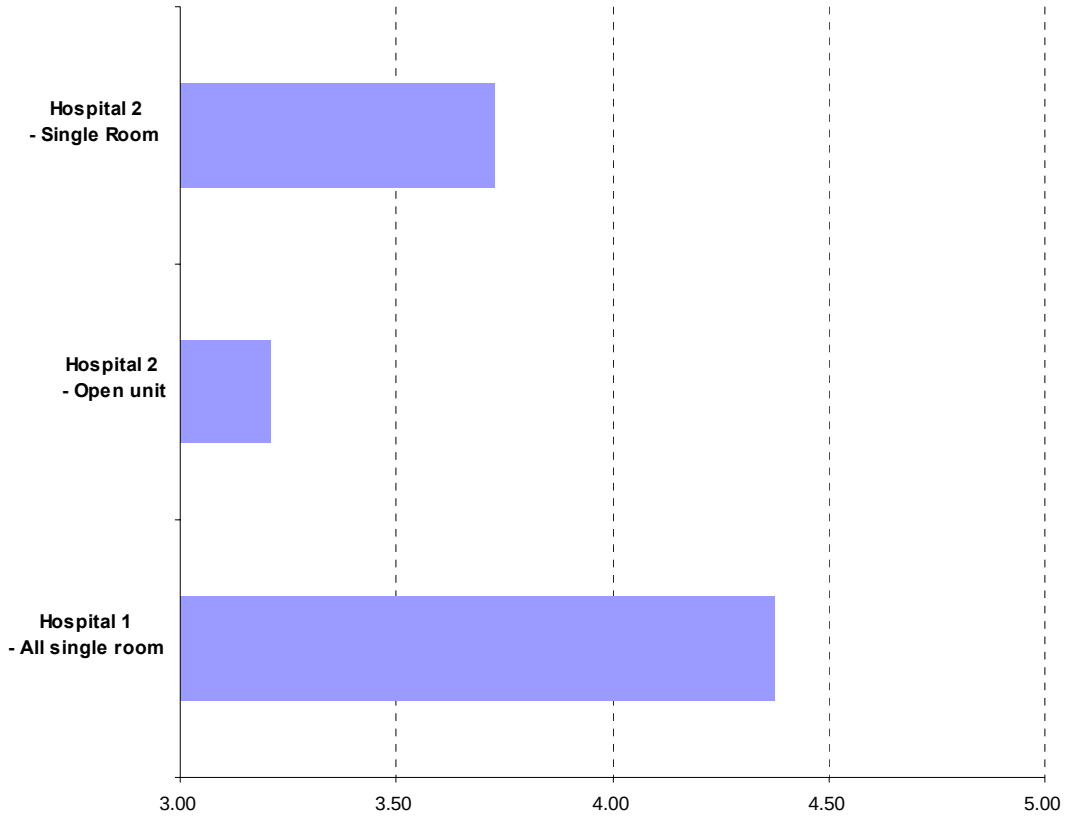

Figure 43. **Nurses' job satisfaction levels.**

The right-hand column of Table 18 lists the results of statistical tests on the hypotheses about nurses' stress and job satisfaction. Both groups in single rooms have significantly lower scores of overall stress level and significantly higher scores of job satisfaction than the groups in the open-bay facility. For subscales of stress, single rooms in Hospital 1a are significantly better than open bays on all 9 subscales of stress. Single rooms in Hospital 2c are significantly better

than open bays on 5 of the 9 subscales: Death & dying, Conflict with physicians, Inadequate preparation, Problems with peers, and Problems with supervisor.

Table 18. **Stress and job satisfaction ratings of nursing staff.**

Outcome measure		Hospital 1: All single room	Hospital 2a: Open bay	Hospital 2b: Single room	Hypotheses testing (*p* value)*
Overall stress level	N	16	22	22	a<b (.000)
	Mean	1.89	2.67	2.31	c<b (.022)
	SD	0.29	0.46	0.61	
-Death & dying	N	16	22	22	a<b (.002)
	Mean	2.28	2.85	2.45	c<b (.018)
	SD	0.54	0.57	0.66	
-Conflict w/physicians	N	16	22	22	a<b (.000)
	Mean	2.15	2.97	2.37	c<b (.006)
	SD	0.52	0.63	0.79	
-Inadequate preparation	N	16	22	22	a<b (.009)
	Mean	2.31	3.00	2.50	c<b (.040)
	SD	0.79	0.87	0.96	
-Problems w/peers	N	16	22	22	a<b (.000)
	Mean	1.44	2.15	1.85	c<b (.025)
	SD	0.35	0.52	0.46	
-Problems w/supervisor	N	16	22	22	a<b (.000)
	Mean	1.37	2.58	2.11	c<b (.030)
	SD	0.25	0.77	0.78	
-Workload	N	15	22	22	a<b (.003)
	Mean	2.45	2.97	2.63	c<b (.056)
	SD	0.44	0.53	0.61	
-Uncertainty concerning treatment	N	15	22	22	a<b (.001)
	Mean	1.94	2.66	2.32	c<b (.058)
	SD	0.55	0.66	0.79	
-Patients & their families	N	16	22	22	a<b (.000)
	Mean	1.86	2.85	2.51	c<b (.082)
	SD	0.37	0.64	0.72	
-Discrimination	N	16	22	22	a<b (.001)
	Mean	1.04	1.67	1.79	c<b (.483)
	SD	0.17	0.86	1.04	
Job satisfaction	N	16	22	22	a<b (.000)
	Mean	4.38	3.21	3.73	c<b (.018)
	SD	0.59	0.85	0.63	

Note: * Mann-Whitney *U* test, 1-sided

Table 19 lists the statistics for stress ratings for parents in hospital 2, which are illustrated in Figure 44. Figure 44 reveals a trend of higher stress for parents in the open bay on the scales of Sights and sounds and Relationship and parent role. But the test results (listed in the right-hand column of Table 19) show significant differences only on the Sights and sounds scale. This difference is marginal. Regarding the Staff behaviors and communication scale, the results run contrary to the hypothesis but are not significant.

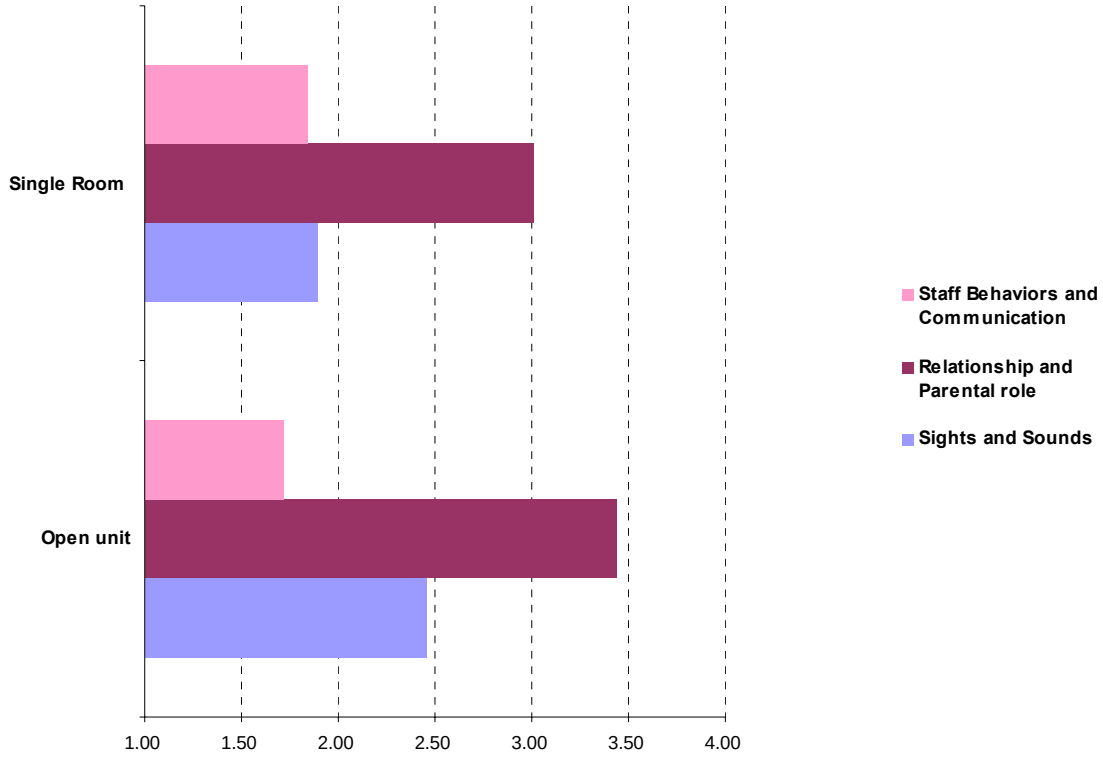

Figure 44. **Parents' stress levels.**

Table 19. **Stress ratings of parents.**

Outcome measure		**Hospital 2: Open bay** (Group a)	**Hospital 2: Single room** (Group b)	**Hypotheses testing (*p* value)***
Sights and sounds	N	5	16	a>b (.068)
	Mean	2.46	1.89	
	SD	0.70	0.70	
Relationship and parental role	N	5	15	a>b (.273)
	Mean	3.44	3.01	
	SD	1.38	1.08	
Staff behaviors and communication	N	5	15	a>b (.374)
	Mean	1.72	1.84	
	SD	0.27	1.06	

Note: * Mann-Whitney *U* test, 1-sided

CHAPTER 5: DISCUSSION

Summary of the Findings

This multi-method study provides a variety of ways to explore meaningful outcomes about the design and planning of neonatal intensive care units. A comparison of configuration types through an investigation of the use of physical space; and of user needs, satisfaction levels, preferences, and perceptions of the NICU environment provides a comprehensive analysis of universal concerns that transcend configuration type and specific issues of a particular unit design. The following is a discussion of each category of research findings. Key points will be discussed in the following chapter, which will also include design guidelines, study limitations, and future directions of research.

Plan Reviews

Unit Configurations and Space Allocation

The plan reviews indicated that 59% of NICU units is allocated to patient, family, and staff programmatic requirements. The remaining area is allocated primarily to unit circulation, systems, and the net-to-gross factor (wall partitions). SFR unit configurations allocated 51% of usable area to patients, families, and staff; open-bay units allocated 58%; double occupancy unit configurations allocated 57%; and combination unit configurations allocated 69%.

The SFR configuration was equal to the aggregate mean of the 4 configurations for unit circulation (26%). Open-bay and double occupancy configurations exceeded the mean, and the

combination configuration was below the mean. Developing design strategies for minimizing circulation to allocate valuable space to families and staff is recommended.

The SFR and open-bay configurations both had a net-to-gross factor of 11%. The means for combination and double occupancy unit configurations were below the average of 10% (they were 7% and 9%, respectively).

A higher number of infant stations indicates a trend toward spatial efficiency. However, this is not specific to the configuration of the unit.

Infant Space Configurations

The infant station or infant room is defined as clear floor space allocated to the patient, family, and staff. Within this area, the SFR had the most space allocated to family (85 SF=50%), while the open-bay and combination configurations had the least (44 SF=39%, 43 SF=40%, respectively). Space allocated to staff had a mean of 38%, with all configurations within +/- 3%. Square feet of configurations for staff space were (1) SFR, 65 SF; (2) open-bay, 41 SF; (3) combination, 43 SF; and (4) double occupancy, 39 SF.

Site Visits

Four NICUs were documented through site visits: 1 SFR and 3 open-bay units. Regarding the materials palette, there were no distinguishable differences in materials and finishes used within the units.

The achievement of privacy was most successful in the SFR unit. Private rooms allow privacy for parent-infant interactions such as kangaroo care, allow private consultation with the physicians, and shield the families from the activity and environmental noise from the unit at large. The open-bay units addressed privacy concerns in a variety of ways, including the

deployment of mobile privacy screens and other objects. These alternatives were less successful in creating visual barriers.

Nurse supervision in the SFR was affected by the parents' ability to close doors and blinds to the single family room. Clearly, the families were exercising their right to privacy. Generally, when family members were not in the SFR, the nurses would partially open the doors and blinds for better visual access. The open units generally had a clear view across the unit, but staff had limited visible access to infants, as the infant stations were covered to shield the infant from light and noise.

The SFR units had decentralized nurse stations in their pod design. Patient satisfaction surveys indicated that noise levels were too high in these areas and that the source was the nursing stations. The open-bay units had centralized nursing stations with a charting area at the bedside. To successfully mitigate noise concerns, one open-bay unit utilized a meter with a flashing-light warning system. Noise continues to be a major concern for all NICUs. This study did not document noise levels, but it is recommended that future research focus on environmental measures to provide context and data for analyzing noise levels.

All of the units had centralized storage with some amount of space allocated to basic supplies at bedside. Central supply is another area that needs additional attention in order to devise strategies to support the healthcare staff in terms of time and travel.

The SFR unit had hand-washing sinks located at the entry to each pod of patient rooms and within each SFR. The open-bay units met minimum standards by providing an adequate number of sinks within 20 feet of the infant stations. It is recommended that providing access to hand-washing sinks, utilizing newly approved portable hand cleaners, and providing continual education for patient safety be strategies for meeting expectations for infection control.

The SFR design supported individualized control of lighting. Also, as the private rooms are enclosed, the lighting is contained within that space and does not intrude on adjacent patients. In rooms with direct access to daylighting, nurses kept the blinds closed for the VLBW infants and opened for infants closer to transitioning. Staff had limited access to natural light. The open-bay units maintained a low level of light throughout the unit. Electric light at the bedside had separate controls, but access to controls varied among the units. The amount of daylight varied in the open-bay units, but adequate levels were provided throughout the space. A variety of shading devices were used to control daylight within the unit.

Security for all units included personal security tracking devices for the infants. The SFR unit utilized CCTV in the corridors, but the stairways were not alarmed. In the open-bay units, all had alarmed entry and exit points with identity-controlled access. A comprehensive security system should be integrated into the design process to coordinate with layout, and identify visual limiting areas that require monitoring and entry/exit points. New technologies will continue to provide opportunities for accomplishing a secure NICU environment.

Postoccupancy Evaluations

Privacy

Ensuring privacy is a multicomponent operation in the NICU. According to HIPAA guidelines, NICU staff must keep infant medical records private and available only to staff involved in care, staff-in-training, and parents of the infant. Parental privacy is also important. Having a child in the NICU is an emotional and sometimes overwhelming experience. Grief behaviors such as crying are common and personal. Being with one's infant is also an intimate experience, and many behaviors (skin-to-skin holding, singing, baby talk, and the like) are private

in nature, especially for introverted parents. Yet many parental coping methods require interaction with others, such as obtaining information and receiving informal training from medical staff, as well as seeking social support from other NICU families. Providing adequate privacy without isolation is difficult to achieve.

Parental Space and Amenities at Bedside and Nearby

The SFR unit had the highest number of parent amenities. The bedside amenities included a small desk with a light, a built-in sofa, a storage area, a kangaroo recliner, and a rocking chair. Nearby were restrooms and a parent lounge that included a large-screen television, kitchen, shower, and laundry. The parent kitchen, shower, and laundry were used during the observation period, but the parent television was not. Parents who stayed the night had a choice between sleeping in a queen-sized bed in a parent sleep room down the hall from their infant or staying on a couch or recliner in the SFR. Parents who stayed overnight overwhelmingly chose the option of sleeping in the room with their infant and were observed pulling the curtain closed between the infant space and their space while they slept. During the observation period, just over one third of the infants had at least one parent stay with them overnight. This had not been the case in reports from Seattle Children's Hospital, where parents do use the sleep rooms upstairs, but Seattle's SFR unit did not have a private place for parents within the infant care room.

The other units had adequate space at the bedside for two parent chairs but had few other amenities for parents. These units did not have options for parents to stay in the unit, except for a sleep room where they could practice staying with the infant before discharge. Open-style units also varied in where parents were allowed at the bedside, with some having a defined staff side and a defined parent side. At Open-bay #1, staff preferred to place parents with their backs to traffic when possible, but that was also the side most likely to be used by staff when conducting

an intervention with the infant, so sometimes parents would be facing traffic and would move over when the nurse was finished. Open-bay #2 had mainly office-type chairs for the parents, but rockers were also present. Open-bay #2 had the largest space for parents at bedside. Open-bay #3 had a variety of seating options that were pulled into the patient space for parent use. The staff in Open-bay #3 expressed that a lack of a space for parents to keep drinking water at the bed space affected how long parents could stay. Two staff people reported that kangaroo care often had to end when the parents had to get something to drink; water was readily available in the unit but not at the bedside.

The amenities provided in the SFR unit as compared with the amenities for the open-bay units suggest that space allocations play a role in determining the amenities to be provided. The limited space allocated to open-bay infant stations restricted the number and types of amenities and furnishings provided at each station.

Walking During Shifts

The question of what effect having individual rooms would have on the amount of walking nurses would have to do during a shift has often been raised in discussions at conferences about SFR design. The hypothesis that SFRs will increase the amount of walking per shift was rejected by this study. The SFR unit had the lowest average number of steps per hour (322) compared to the three open-bay units, but due to the high within-group variability this difference was not significant.

Factors that did appear to influence the number of steps taken per hour included the distance from the bedside to the clean storage, the amount of lockable storage near the bedside, the need to search for shared equipment, and the number of times nurses went to each bedside. The SFR unit had a conveniently placed clean storage room, and the unit reduced travel to the

clean storage by providing an admission cart in each substation area. Once used, shared equipment was generally taken out of the patient care space and placed on work counters near the substation. Nurses also clustered their interactions with each infant and stayed longer during each visit to avoid going back and forth into the care room. When parents were present, reentering the space generally required knocking again.. In open-bay units researchers observed repeated trips to an infant space by the same staff person over a short period of time. During admissions there would be repeated trips to clean storage in the open-bay units. There was also significant traffic entering the patient care space to look for shared equipment.

Traffic

The amount of traffic going into or by patient spaces varied by bed space and unit practice. The SFR design was least sensitive to traffic noise and visual distraction, as when parents were present doors and curtains to the room were usually closed. Traffic is a much more important issue in the open-bay units, since the infant is exposed to the high traffic counts.

"Desirable Beds"

Staff in all units had opinions on which bed spaces were more desirable than others. The SFR patient rooms were relatively immune to generic noise and traffic; however, three rooms on each side did not have windows to allow direct access to daylight. These rooms were considered less desirable. The isolation room had no carpet and was considered too noisy, but the hospital had installed a removable rug to reduce this effect. Staff felt that these differences were relatively minor but did report that a parent occasionally requested to move to a room with a window, if they were in for a long stay. All rooms were conveniently located near a nursing substation, so no one room felt too isolated.

Staff in all open-bay units were concerned about noise and traffic, particularly at those beds that were excessively exposed. Traffic counts during site visits supported some of these concerns, but other beds were often found to have more traffic. High traffic counts were generally accepted to be stressful to the infant. Some beds were located too near noise-generating functions such as staff entrances, pneumatic tube depository, respiratory storage, etc. One surprise of the study was that 3 corner beds in Open-bay #2—which were shielded from traffic, had two full walls, one partial wall, and a window—were rarely used. When asked, three different nurses reported that these baby stations were too isolated because a nurse working within that space did not have a line of sight to another infant on her assignment. Likewise, it was difficult to see the corner infant from other places within the unit. Open-bay #3 also had bed spaces that were considered to be isolated and were used for storage unless the unit was full. The planned semiprivate rooms at Open-bay #2 were intended to be used for low-stimulation infants, but the wall of windows proved too bright, so they were converted to quad mini-pods for healthier infants.

Except for the concerns of isolation and access to daylight, SFRs seem to reduce the number of undesirable bed spaces, since the most common reasons for avoiding these spaces are traffic and noise. It is clear that any bed space, whether enclosed by walls or not, would feel isolated if too far from central activities.

Based on this postoccupancy evaluation, SFR design increases parent privacy and presence; maintains desirable, traffic-protected space for a greater number of infant beds; and achieves higher HIPAA compliance and staff satisfaction. The primary concern for SFR design is to avoid isolation for both parents and staff. It is important to take into account space for staff to spend time together on the unit. Collegial behaviors were observed at all units; such behaviors in the SFR with pod substations took place away from direct patient care space. Isolated one-person

charting/work stations in Open-bay #1 were also sites of collegial behaviors. These behaviors have been shown to be important in nurse job satisfaction and prevention of burnout, and should be included in a plan. Having larger infant care spaces seemed to interrupt parent-to-parent contact within the units. In these models, parents were spaced 10 feet or more apart from each other. The only parent-to-parent interactions observed were in the Open-bay #2 converted quad mini-pods. There mothers were 4 feet or less apart, and they would hold their infants and talk. Any new unit design would have parents farther from each other in order to follow the recommended standards Open-bay #3 had an active parent support program, and parents often interacted at these regularly scheduled events that took place away from the bedside. To mitigate this problem, the SFR unit was writing a grant to hire a parent support coordinator.

Construction Cost Analysis

Construction costs were analyzed based on cost per square foot and cost per infant station. Unit size, regardless of configuration type, did not prove to be an indicator of efficiency. The difference in cost per square foot between the SFR configuration and the open-bay configuration was about 3% per square foot. This difference is negligible considering the inherent variation of factors that determines the final design of any one unit.

In comparison, the cost per infant station indicates, when considering cost per square foot, that there is a trend toward efficiency based on number of infant stations. The units with a higher number of infant stations had a lower cost per infant station, with the exception of the double occupancy configuration. When planning a new NICU, cost is more strongly influenced by the number of licensed beds than by the cost per square foot.

Patient Medical Outcomes

The ADC increased for all configurations along with the increase in number of infant stations for the units. The ALOS showed mixed results, but data was not collected to indicate acuity levels that may be stable in some units but increased in others after infants occupy their new NICU. There were no clear trends for reported nosocomial infections. With only 5 hospitals participating in providing this information, the data set was too small to provide clear indications of change. This is an area of study that needs a careful research design to understand the relationship between environment and man. The links between environment and patient; the links between environment and healthcare worker; and the links between healthcare worker and patient all play a role in infection control. It is recommended that future studies focus on the role of environment on infection-control issues, and nosocomial infections in particular, for the NICU environment.

Staff and Parent Surveys

The objective of the staff and parent surveys was to compare and detect significant differences between single rooms and open bays. More specifically, the following hypotheses were tested.

1a. Staff members in single rooms are more satisfied with the physical environment than the staff members in the open-bay configuration.

2a. Staff members in single rooms perceive the physical environment to be better than the staff members in open-bay units.

3a. Staff members in single rooms report less stress than the staff members in open-bay units.

4. Staff members in single rooms have higher ratings of job satisfaction than the staff members in the open-bay configuration.

1b. Parents of patients in single rooms are more satisfied with the physical environment than the parents in the open-bay configuration.

2b. Parents of patients in single rooms perceive the physical environment to be better than the parents in open-bay units.

3b. Parents of patients in single rooms report less stress than the parents in open-bay units.

Staff members in Hospital 1 are more satisfied with the physical environment than those in Hospital 2. The two groups in Hospital 2 have similar satisfaction levels, although the data trends suggest that staff in the SFR are slightly more satisfied regarding all factors except the provision of waiting and resting space for families outside the NICU, and corridors and signage for wayfinding. As these two environmental factors are identical for Hospital 2, we can assume that the data are inconsequential.

According to staff, single rooms are superior compared to open bays in terms of providing privacy to families and infants. This is most strongly articulated in Hospital 1, which is limited to SFRs. However, in spite of the fact that some infants were housed in SFRs and some in open-bay units in Hospital 2, very little difference was found in response to the question “the environment supports the family’s presence and participation.” The same staff work in both of these unit configurations, and it is likely that shared protocols mitigate the impact of the environment. This phenomenon does not extend itself to stress levels. The SFR-only NICU is perceived as less stressful than the SFR portion of the combined unit.

Similar to staff members, parents in single rooms seem to be more satisfied with the physical environment. The most significant difference was with regard to a window view and a place to sleep near one's infant, the former of which is not necessarily related to SFR versus open-bay arrangements. Previous studies have indicated that window views have a powerful impact on satisfaction and on some measures of healing (e.g., Ulrich, 1984). Future studies should consider the presence or absence of windows as a potentially confounding variable.

Parents agree with staff members on the single room's support for privacy and family's presence. There are no noticeable differences between single rooms and open bays in terms of ease of supervision. Parents saw the importance of interacting with other families as only slightly more important in the SFRs but noted that the design of the SFRs did not encourage this interaction. Future studies might focus on the frequency and potential benefits of interaction between parents.

Parents view single rooms as less stressful and less depressing than the open bay, which is consistent with staff members' views. Parents expressed less need to hide equipment. This finding is corroborated by data indicating that higher stress due to sights and sounds was found for parents in the open bay. It is possible that the single rooms, because they were newer, were more successful in disguising the presence of technology.

Consistent with their high ratings of the physical environment, members of the nursing staff in Hospital 1a report less stress and more satisfaction with their job than their counterparts in Hospital 2. Within this context, the most problematic areas in all three locations were workload, inadequate preparation, death and dying, and conflicts with physicians, all factors that are typically independent of the physical environment.

The study confirmed that nurse job satisfaction can be considerably higher in the SFR configurations. This satisfaction is corroborated by other data indicating lower stress levels and perceptions of a higher quality experience for families. Interestingly, the results of the data supported all the hypotheses, except 3b, that parents of patients in single rooms report less stress than the parents in open-bay units. However, the number of subjects was extremely low, and this result needs to be studied with a larger population in a larger number of hospitals.

Design Guidelines

One of the primary shortcomings of design research is the difficulty associated with translating the data into a format that allows practitioners to apply the results to projects. The following is a distillation of information gathered through the various methodologies associated with this study, presented as design guidelines. For a complete list of guidelines for neonatal intensive care unit design, please consult the Recommended Standards for Newborn ICU Design by the Consensus Committee to Establish Recommended Standards for Newborn ICU Design (2002).

- General Guidelines for all NICUs
    - Increase the usable space for patients, families, and nursing staff; minimize circulation space, unless this space is necessary for the movement of equipment or to provide separation between babies to increase privacy.
    - Provide both centralized nursing stations and charting areas at or near bedside; these dual options support staff members by providing opportunities for collegial interaction and making independent work areas available at or near bedside.

- Provide decentralized clean supply and support areas to minimize time and distance traveled by nursing staff.
- Increase the number of hand-washing sinks throughout the patient area; for SFR units, provide hand-washing sinks in each SFR and additional easily accessible sinks within the unit. Meeting minimum requirements by providing hand-washing stations within 20 feet of all infant stations may not meet the need for easy access; provide waterless hand cleaners and soaps, and institute an ongoing campaign to direct attention to the importance of hand washing as a part of an effective infection-control strategy.
- Provide natural light in family, patient, and staff areas; these light sources should be fitted with shading devices to control quantity of light.
- Provide a comprehensive patient monitoring and security system that has the flexibility to incorporate technology as needed; current solutions may include a staff locating system, call system, and infant monitoring system.
- Minimize exposure to noise (e.g., staff entry, pneumatic tube depository, equipment storage, door closures, and elevators) and traffic that are located in close proximity to nursing work areas.
- Address visual and auditory privacy within the patient area of the unit; provide partitions or moveable screens for manipulation of unit layout.
- Provide line of sight for nursing staff when possible; if possible, provide a remote camera system for patient observation.
- Minimize parents' and families' visual exposure to medical equipment.

- Single Family Room Unit Design
    - The provision of single family room units should be seriously considered when creating an NICU; if this is not possible, a combination of both SFR and open-bay units is recommended.
    - Regardless of allocated space for family at bedside, design SFR units with family space within the unit for parent-to-parent socialization, education, dining, resting, and respite; additional amenities should include laundry and shower facilities.
    - Provide individualized control of environmental conditions, including temperature, artificial light, and daylight.
    - Provide enough space to accommodate families who want to stay with their infants by providing a work surface, sitting/sleeping furniture, storage for personal belongings, and additional seating solutions such as recliners and rockers.
    - Provide meeting space to support organized activities for parent-to-parent and parent-staff interaction.

CHAPTER 6: CONCLUSIONS

Summary of the Conclusions

Based on the results of this study, single family room NICU design provides solutions for increasing parent privacy and presence, supporting HIPAA compliance, minimizing the number of undesirable beds, increasing staff and parent satisfaction, and reducing nursing staff stress. Potential limitations of the SFR design are reduced parent-to-parent social contact and isolation of both parents and staff. In the projects reviewed in this study, construction cost was not influenced by design configuration; therefore, the decision to provide SFR units should not be influenced by financial implications. The primary motivation for employing SFR design should be the provision of an environment that supports quality care for infants and that offers a supportive experience for parents and nursing staff.

Limitations of the Research

Caution must be taken in generalizing the findings from this study. The study was limited to 11 Level III NICUs in hospitals. The size of the participant sample was smaller than expected, limiting the statistical power of the study. All 11 units participated in the plan reviews and construction costs analysis, but the site visits and postoccupancy evaluations were limited to 1 SFR and 3 open-bay units. Patient medical outcomes were limited to data received from 5 participating hospitals. The staff and parent survey was limited to 2 NICUs, and the response to the parent survey was minimal (21 respondents). All hospitals were located in the United States, so some differences may be found relative to other cultures.

Future Directions

The findings in this study indicate a need for additional research on NICU design. This study suggests that SFR design provides privacy, but the impact on nursing supervision is inconclusive. Future studies on SFR units should focus on the frequency and potential benefits of interactions among parents in the NICU. Additional studies with a larger population in a larger number of hospitals should focus on the parents' experiences and stress levels in NICUs. The presence or absence of a window in the patient room was identified as a potentially confounding variable and needs further exploration.

This study reported on nosocomial infection rates in hospitals based on configuration. However, a larger population in a larger number of hospitals is needed to provide meaningful data for analysis. Future studies should use a well-defined research design to focus on nosocomial infections and the influence of the built environment.

Finally, though multiple studies have focused on noise in the NICU, additional studies should measure noise levels in SFRs to determine if SFRs provide opportunities to reduce noise exposure to the infant, families, and staff.

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APPENDIXES

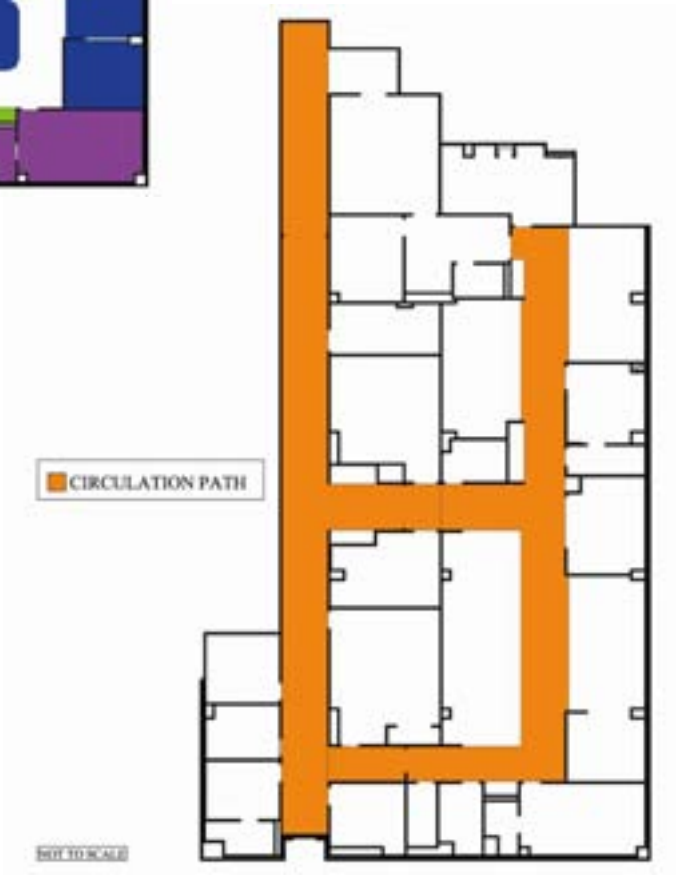
Appendix A: Plan Review Diagrams

The following diagrams are representative of the NICUs that participated in this study. The first diagram for each hospital illustrates space allocations of the unit. The second diagram illustrates the circulation of the unit.

Single Family Room Unit A
Total square footage: 18,112
Number of infant stations: 33

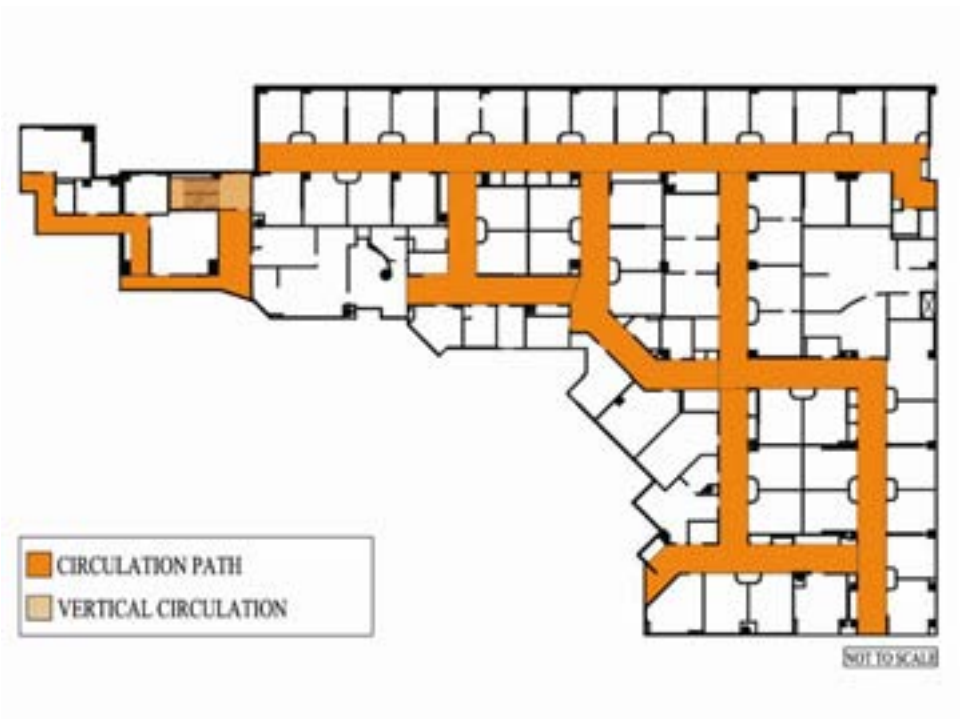
Single Family Room Unit B
Total square footage: 29,198
Number of infant stations: 16

Single Family Room Unit C
Total square footage: 8,791
Number of infant stations: 40

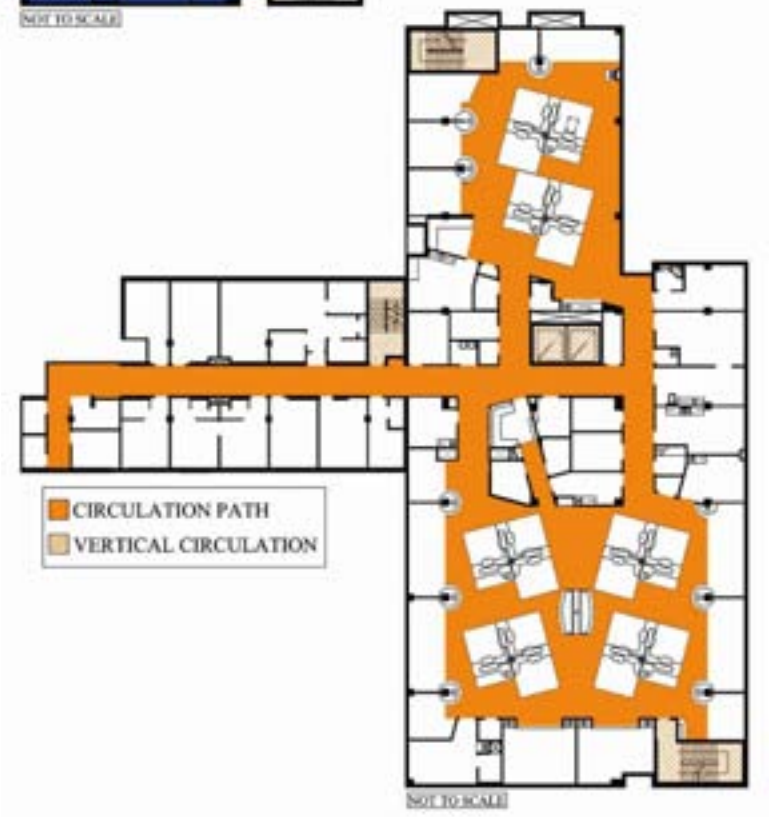


Single Family Room Unit D
Total square footage: 18,130
Number of infant stations: 22

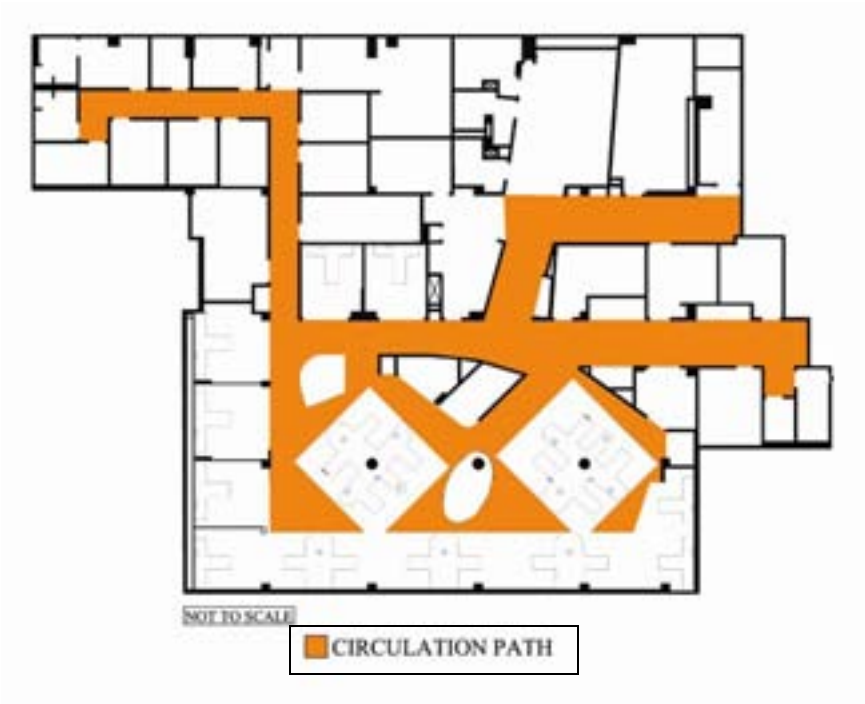
Single Family Room Unit E
Total square footage: 22,569
Number of infant stations: 50



Open-bay Unit A
Total square footage: 20,519
Number of infant stations: 45

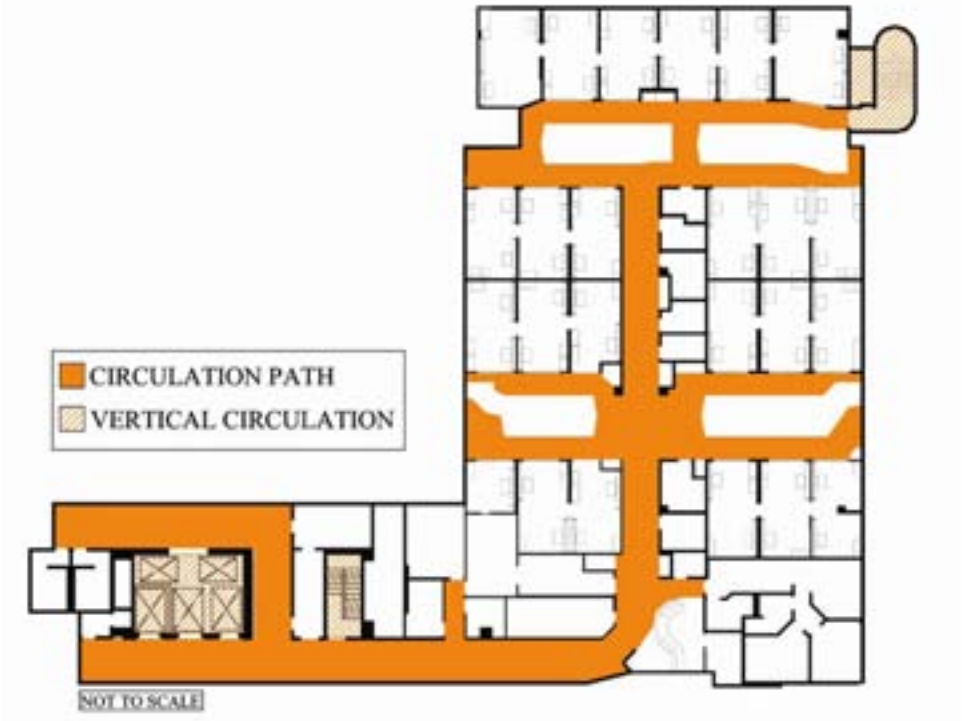


Open-bay Unit B
Total square footage: 10,871
Number of infant stations: 20



Combination Unit
Total square footage: 15,682
Number of infant stations: 35

Double Occupancy Unit
Total square footage: 16,337
Number of infant stations: 48



Appendix B: Healthcare Staff and Parent Questionnaires

STAFF PERCEPTIONS OF THE NEONATAL INTENSIVE CARE UNIT

The first part of the questionnaire will focus on different physical aspects of the space.

1. DEGREE OF SATISFACTION WITH THE PHYSICAL ENVIRONMENT

In the first section we would like to know how satisfied you have felt with the environment in general. Please indicate how satisfied you have been with each item listed below. By satisfied, we mean that the experience has caused you to feel good about the situation with no need or desire to modify it.

1=Not at all satisfied Experience was not satisfying at all and did not meet my needs
2=A little satisfied
3=Moderately satisfied
4=Very satisfied
5=Extremely satisfied Experience was very satisfying and met needs and desires

If you did not have this experience, indicate this by circling N/A meaning that you have "not experienced" this aspect of the NICU.

Now let's take an item for example: The light levels in the NICU.

If for example you feel that the light levels in the neonatal intensive care units were extremely satisfying to you, you would circle the number 5 below.
NA 1 2 3 4 **5**
If you feel the light levels were not satisfying at all, you would circle the number 1 below.
NA **1** 2 3 4 5
If the lights were not on when you visited (not likely) you would circle NA indicating "Not Applicable" as below.
NA 1 2 3 4 5

Circle the number that best represents your level of satisfaction.

	Not at all satisfied					Extremely satisfied
1. The overall quality of the physical environment of the Neonatal Intensive Care Unit	NA	1	2	3	4	5
2. The window views in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
3. The natural light in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
4. The light level in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
5. The noise level in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
6. The atmosphere and décor of the Neonatal Intensive Care Unit	NA	1	2	3	4	5

		Not at all satisfied				Extremely satisfied
7. The waiting and resting space for families outside the Neonatal Intensive Care Unit	NA	1	2	3	4	5
8. A place to sleep in or near the Neonatal Intensive Care Unit	NA	1	2	3	4	5
9. Corridors and signage that made it easy to find your way around the hospital	NA	1	2	3	4	5
10. A place with food and nourishment in or near the Neonatal Intensive Care Unit	NA	1	2	3	4	5
11. The work spaces for staff	NA	1	2	3	4	5
12. The respite spaces (lounges, etc) for staff	NA	1	2	3	4	5

2. LEVEL OF AGREEMENT REGARDING THE PHYSICAL ENVIRONMENT

In the second section, we have identified a few statements about the Neonatal Intensive-Care Unit. We would like to know what you think about them. Please indicate if you agree or disagree with each item listed below. Circle the number that best describes your degree of agreement with the statement.

1=Strongly disagree	I do not agree at all with this comment
2=Somewhat disagree	
3=Neutral	
4=Somewhat agree	
5=Strongly agree	I strongly agree with this comment

		Strongly disagree				Strongly agree
1. The layout of the Neonatal Intensive Care Unit allows staff to readily supervise babies	NA	1	2	3	4	5
2. Private rooms for babies and their families are important to the Neonatal Intensive Care Unit	NA	1	2	3	4	5
3. The environment of the Neonatal Intensive Care Unit supports family's presence and participation	NA	1	2	3	4	5
4. The design of the Neonatal Intensive Care Unit allows family members to have privacy	NA	1	2	3	4	5

		Strongly disagree				Strongly agree
5. The space between each infant's bed allows families to interact privately with their babies	NA	1	2	3	4	5
6. Adequate privacy can be created at the bedside for skin-to-skin care, pumping and breastfeeding with curtains or screens.	NA	1	2	3	4	5
7. There is a quiet, private space in or near the unit for family members to be alone	NA	1	2	3	4	5
8. It is important for families to interact with each other	NA	1	2	3	4	5
9. The layout of the Neonatal Intensive Care Unit facilitates interaction between parents	NA	1	2	3	4	5
10. Technical and medical equipment in the Neonatal Intensive Care Unit should be hidden so families do not feel uncomfortable.	NA	1	2	3	4	5
11. The environment of the Neonatal Intensive Care Unit is depressing	NA	1	2	3	4	5
12. The atmosphere of the Neonatal Intensive Care Unit is tense and stressful for family members	NA	1	2	3	4	5
13. The atmosphere of the Neonatal Intensive Care Unit is tense and stressful for staff	NA	1	2	3	4	5

In the next part of the questionnaire we would like you to indicate how stressful each item listed below has been for you. **By stressful, we mean that the experience has caused you to feel anxious, upset, or tense**. If you have not had the experience, we would like for you to indicate this by circling N/A meaning that you have not experienced this aspect of the Neonatal Intensive-Care Unit.

On the questionnaire, circle the single number that best expresses how stressful each experience has been for you. The numbers indicate the following levels of stress:

1=Never stressful	Experience was never stressful.
2=Occasionally	
3=Frequently	
4=Very frequently stressful	Experience was very frequently stressful.

3. STAFF STRESS LEVEL

This section of the questionnaire focuses on stress. Circle the number that best represents your level of stress.

		Never stressful			Very stressful
1. Performing procedures that patients experience as painful	NA	1	2	3	4
2. Criticism by a physician	NA	1	2	3	4
3. Feeling inadequately prepared to help with the emotional needs of a patient's family	NA	1	2	3	4
4. Lack of opportunity to talk openly with other personnel about problems in the work setting	NA	1	2	3	4
5. Conflict with a supervisor	NA	1	2	3	4
6. Breakdown of computer	NA	1	2	3	4
7. Inadequate information from a physician regarding the medical condition of a patient	NA	1	2	3	4
8. Being sexually harassed	NA	1	2	3	4
9. Conflict with a physician	NA	1	2	3	4
10. Lack of opportunity to share experiences and feelings with other personnel in the work setting	NA	1	2	3	4
11. Floating to other units/services that are short-staffed	NA	1	2	3	4
12. Unpredictable staffing and scheduling	NA	1	2	3	4
13. A physician ordering what appears to be inappropriate treatment for a patient	NA	1	2	3	4
14. Patients' families making unreasonable demands	NA	1	2	3	4
15. Experiencing discrimination because of race or ethnicity	NA	1	2	3	4
16. Fear of making a mistake in treating a patient	NA	1	2	3	4
17. Difficulty in working with a particular nurse (or nurses) in my immediate work setting	NA	1	2	3	4

		Never stressful			Very stressful
18. Difficulty in working with a particular nurse (or nurses) outside my immediate work setting	NA	1	2	3	4
19. Not enough time to provide emotional support to the patient	NA	1	2	3	4
20. A physician not being present in a medical emergency	NA	1	2	3	4
21. Being blamed for anything that goes wrong	NA	1	2	3	4
22. Experiencing discrimination on the basis of sex	NA	1	2	3	4
23. The death of a patient	NA	1	2	3	4
24. Disagreement concerning the treatment of a patient	NA	1	2	3	4
25. Feeling inadequately trained for what I have to do	NA	1	2	3	4
26. Lack of support from my immediate supervisor	NA	1	2	3	4
27. Criticism by a supervisor	NA	1	2	3	4
28. Not enough time to complete all of my nursing tasks	NA	1	2	3	4
29. Being the one that has to deal with patients' families	NA	1	2	3	4
30. Being exposed to health and safety hazards	NA	1	2	3	4
31. Making a decision concerning a patient when the physician is unavailable	NA	1	2	3	4
32. Being in charge with inadequate experience	NA	1	2	3	4
33. Lack of support by nursing administrators	NA	1	2	3	4
34. Too many non-nursing tasks required, such as clerical work	NA	1	2	3	4
35. Not enough staff to adequately cover the unit	NA	1	2	3	4
36. Uncertainty regarding the operation and functioning of specialized equipment	NA	1	2	3	4
37. Not enough time to respond to the needs of patients' families	NA	1	2	3	4

		Never stressful			Very stressful
38. Being held accountable for things over which I have no control	NA	1	2	3	4
39. Physician(s) not being present when a patient dies	NA	1	2	3	4
40. Having to organize doctors' work	NA	1	2	3	4
41. Lack of support from other health care administrators	NA	1	2	3	4
42. Difficulty in working with nurses of the opposite sex	NA	1	2	3	4
43. Having to deal with abuse from patients' families	NA	1	2	3	4
44. Watching a patient suffer	NA	1	2	3	4
45. Criticism by nursing administration	NA	1	2	3	4
46. Having to work through breaks	NA	1	2	3	4
47. Not knowing whether patients' families will report you for inadequate care	NA	1	2	3	4
48. Having to make decisions under pressure	NA	1	2	3	4

4. JOB SATISFACTION

This section of the questionnaire focuses on job satisfaction. Please circle the number that best represents your level of agreement with regard to job satisfaction.

1=Strongly disagree	I do not agree at all with this comment
2=Somewhat disagree	
3=Neutral	
4=Somewhat agree	
5=Strongly agree	I agree completely with this comment

		Strongly disagree			Strongly agree
1. I am satisfied with my current situation at work	NA	1	2	3	4	5
2. I am satisfied with my present level of involvement in decision-making at work	NA	1	2	3	4	5

		Strongly disagree				Strongly agree
3. I am satisfied with the degree of support I receive in my job	NA	1	2	3	4	5
4. I seldom think about finding another job within Nursing	NA	1	2	3	4	5
5. I seldom think about finding an occupation other than nursing	NA	1	2	3	4	5

5. STAFF INFORMATION

1. What is your age? (circle one)
   Less than 21 years 41 to 60 years old
   21 to 40 years old 61 and over
2. Are you (circle one): Female Male
3. What is your ethnicity (circle one)?
   African-American Asian Caucasian
   Hispanic Other _____
4. What is your job title in the NICU? _____
5. How many years/months have you worked in this NICU? _____
6. How many years/months have you worked at this hospital? _____
7. How many years/months have you worked in any NICU? _____
8. Please make additional comments on the back of this page, if you wish.

If you have questions, please do not hesitate to contact Dr. Mardelle Shepley at (979) 845-7877 or through email: mardelle@archone.tamu.edu. Thank you very much! Your collaboration on this study is greatly appreciated!

PARENT PERCEPTIONS OF THE NEONATAL INTENSIVE CARE UNIT

1. DEGREE OF SATISFACTION

Architects and medical staff who design neonatal intensive care units are interested in how the experience of having a sick baby hospitalized affects parents. We would like to know what aspects of your experience were satisfying to you. **By satisfying, we mean that the experience has caused you to feel good about the situation with no need or desire to modify it.** The first part of the questionnaire will focus on different aspects of the space.

1=Not at all satisfied — Experience was not satisfying at all and did not meet my needs
2=A little satisfied
3=Moderately satisfied
4=Very satisfied
5=Extremely satisfied — Experience was very satisfying and met needs and desires

If you did not have this experience, indicate this by circling N/A meaning that you have "not experienced" this aspect of the NICU.

Now let's take an item for example: The light levels in the NICU.

If for example you feel that the light levels in the neonatal intensive care units were extremely satisfying to you, you would circle the number 5 below.
NA 1 2 3 4 **5**
If you feel the light levels were not satisfying at all, you would circle the number 1 below.
NA **1** 2 3 4 5
If the lights were not on when you visited (not likely) you would circle NA indicating "Not Applicable" as below
NA 1 2 3 4 5

Circle the number that best represents your level of satisfaction.

		Not at all satisfied				Extremely satisfied
1. The overall quality of the physical environment of the Neonatal Intensive Care Unit	NA	1	2	3	4	5
2. The window views in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
3. The natural light in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
4. The light level in the Neonatal Intensive Care Unit	NA	1	2	3	4	5
5. The noise level in the Neonatal Intensive Care Unit	NA	1	2	3	4	5

		Not at all satisfied				Extremely satisfied
6. The atmosphere and décor of the Neonatal Intensive Care Unit	NA	1	2	3	4	5
7. The waiting and resting space for families outside the Neonatal Intensive Care Unit	NA	1	2	3	4	5
8. A place to sleep in or near the Neonatal Intensive Care Unit	NA	1	2	3	4	5
9. Corridors and signage that made it easy to find your way around the hospital	NA	1	2	3	4	5
10. A place with food and nourishment in or near the Neonatal Intensive Care Unit	NA	1	2	3	4	5

2. LEVEL OF AGREEMENT

In the second section, we have identified a few statements about the Neonatal Intensive-Care Unit. We would like to know what you think about them. Please indicate if you agree or disagree with each item listed below. Circle the number that best describes your degree of agreement with the statement.

1=Strongly disagree	I do not agree at all with this comment
2=Somewhat disagree	
3=Neutral	
4=Somewhat agree	
5=Strongly agree	I strongly agree with this comment

		Strongly disagree				Strongly agree
1. The layout of the Neonatal Intensive Care Unit allows staff to readily supervise my baby.	NA	1	2	3	4	5
2. Private rooms for babies and their families are important to the Neonatal Intensive Care Unit	NA	1	2	3	4	5
3. The environment of the Neonatal Intensive Care Unit supports family's presence and participation	NA	1	2	3	4	5
4. The design of the Neonatal Intensive Care Unit allows me to have some privacy with my spouse and/or other family members	NA	1	2	3	4	5

		Strongly disagree				Strongly agree
5. The space between each infant's bed in the nursery is large enough to give me privacy with my baby	NA	1	2	3	4	5
6. Adequate privacy can be created at the bedside for skin-to-skin care, pumping and breastfeeding with curtains or screens.	NA	1	2	3	4	5
7. There is a quiet, private space in or near the unit for me to be alone or be with just my family	NA	1	2	3	4	5
8. It is important to be able to interact with other families who are going through a similar experience	NA	1	2	3	4	5
9. The layout of the Neonatal Intensive Care Unit facilitates interaction with other parents	NA	1	2	3	4	5
10. Technical and medical equipment in the Neonatal Intensive Care Unit should be hidden so families do not feel uncomfortable.	NA	1	2	3	4	5
11. The environment of the Neonatal Intensive Care Unit is depressing	NA	1	2	3	4	5
12. The atmosphere of the Neonatal Intensive Care Unit is tense and stressful for family members	NA	1	2	3	4	5

In the next part of the questionnaire we would like you to indicate how stressful each item listed below has been for you. **By stressful, we mean that the experience has caused you to feel anxious, upset, or tense.** If you have not had the experience, we would like for you to indicate this by circling N/A meaning that you have not experienced this aspect of the Neonatal Intensive-Care Unit.

On the questionnaire, circle the single number that best expresses how stressful each experience has been for you. The numbers indicate the following levels of stress:

1=Not at all stressful	Experience did not cause you to feel upset, tense, or anxious
2=A little stressful	
3=Moderately stressful	
4=Very stressful	
5=Extremely stressful	Experience caused a lot of anxiety or tension

3. SIGHTS AND SOUNDS

Below is a list of various SIGHTS AND SOUNDS commonly experienced in an Intensive-Care Unit. We are interested in knowing about your view of how stressful these SIGHTS AND SOUNDS are for you. Circle the number that best represents your level of stress. If you did not see or hear the item, circle the N/A meaning "not applicable."

		Not at all Stressful				Extremely Stressful
1. The presence of monitors and equipment	N/A	1	2	3	4	5
2. The constant noises of monitors and equipment	N/A	1	2	3	4	5
3. The sudden noises of monitor alarms	N/A	1	2	3	4	5
4. The other sick babies in the room	N/A	1	2	3	4	5
5. The other 'more well' babies in the room	N/A	1	2	3	4	5
6. The large number of people working in the unit	N/A	1	2	3	4	5
7. Having a machine (respirator) breathe for my baby	N/A	1	2	3	4	5

4. RELATIONSHIP AND PARENTAL ROLE

We also want to ask you about how you feel about your own RELATIONSHIP with the baby and your parental role. If you have experienced the following situations or feelings, indicate how stressful you have been made by them by circling the appropriate number. Again, circle N/A if you did not experience the item.

		Not at all stressful				Extremely Stressful
1. Being separated from my baby	N/A	1	2	3	4	5
2. Feeling helpless and unable to protect my baby from pain and painful procedures	N/A	1	2	3	4	5
3. Feeling helpless about how to help my baby during this time	N/A	1	2	3	4	5
4. Being afraid of touching or holding my baby	N/A	1	2	3	4	5
5. Not feeding my baby myself	N/A	1	2	3	4	5

		Not at all stressful				Extremely Stressful
6. Not being able to care for my baby myself (for example, diapering, bathing)	N/A	1	2	3	4	5
7. Not being able to hold my baby when I want	N/A	1	2	3	4	5
8. Not having time to be alone with my baby	N/A	1	2	3	4	5
9. Sometimes forgetting what my baby looks like	N/A	1	2	3	4	5
10. Not being able to share my baby with other family members	N/A	1	2	3	4	5
11. Feeling staff is closer to my baby than I am	N/A	1	2	3	4	5

5. STAFF BEHAVIORS AND COMMUNICATION

We are interested in whether you experienced any stress related to STAFF BEHAVIORS and COMMUNICATION. Again, if you experienced the item, indicate how stressful it was by circling the appropriate number. If you did not experience the item, circle the N/A meaning "not applicable." Remember, your answers are confidential and will not be shared or discussed with any staff member.

		Not at all Stressful				Extremely Stressful
1. Staff explaining things too quickly	N/A	1	2	3	4	5
2. Staff using words I don't understand	N/A	1	2	3	4	5
3. Staff telling me different (conflicting) things about my baby's condition	N/A	1	2	3	4	5
4. Staff not telling me enough about tests and treatments being done to my baby	N/A	1	2	3	4	5
5. Staff not talking to me enough	N/A	1	2	3	4	5
6. Too many different people (doctors, nurses, others) talking to me	N/A	1	2	3	4	5
7. Difficulty in getting information or help when I visit or telephone the unit	N/A	1	2	3	4	5

		Not at all Stressful				Extremely Stressful
8. Not feeling sure that I will be called about changes in my baby's condition	N/A	1	2	3	4	5
9. Staff looking worried about my baby	N/A	1	2	3	4	5
10. Staff acting as if they did not want parents around	N/A	1	2	3	4	5
11. Staff acting as if they did not understand my baby's behavior or special needs	N/A	1	2	3	4	5
12. The location where interactions with the staff take place	N/A	1	2	3	4	5

6. PARENT INFORMATION

1. What is your age? (circle one)
   Less than 21 years 41 to 60 years old
   21 to 40 years old 61 and over

2. Are you (circle one): Female Male

3. What is your ethnicity (circle one)? African-American Asian Caucasian
   Hispanic Other _____

4. What is your family link with the baby hospitalized in the Intensive-Care Unit? (circle one)
   Parent Grandparent Aunt/Uncle
   Sister/Brother Other _____

5. In what state do you live? _____
   What is the approximate distance between your house and the hospital? _____

6. Which languages are spoken at your house? (circle all that apply)
   English Spanish
   Chinese Other: _____

7. How many days has your child been hospitalized in the Intensive-Care Unit? _____

8. Estimate the average number of hours you spend each day in the Intensive-Care Unit? (circle one)
   Less than 1 hour 1 to 3 hours 3 to 5 hours
   5 to 8 hours More than 8 hours

9. Where do you usually go in the hospital between your visits in the Neonatal Intensive-Care Unit? _____

10. Is this your first experience as a visitor in a Neonatal Intensive-Care Unit? (circle one)
Yes No

11. How many people (family & friends) are usually with you at the hospital (excluding yourself)? _____

12. Did you and your baby stay in a private room while in the Neonatal Intensive Care Unit? (circle one) Yes No

13. Please make additional comments on the back of this page, if you wish.

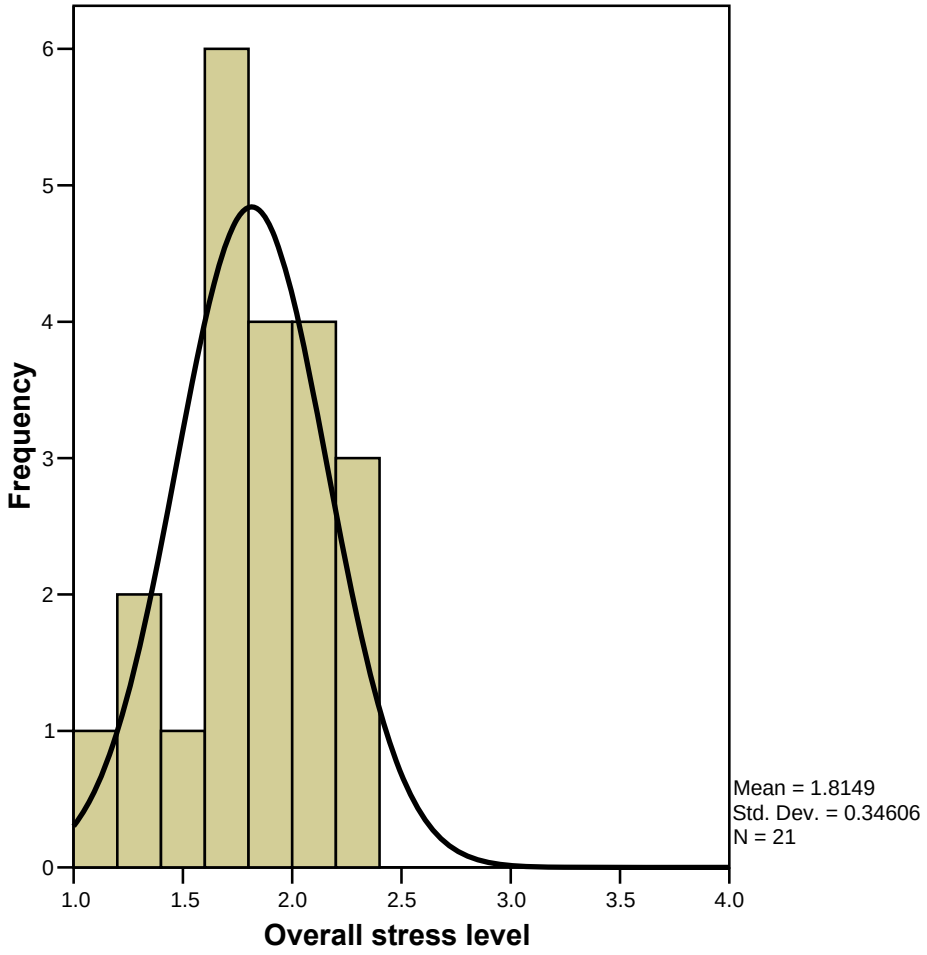
If you have questions, please do not hesitate to contact Dr. Mardelle Shepley at (979) 845-7877 or through email: mardelle@archone.tamu.edu. Thank you very much! Your collaboration on this study is greatly appreciated!

Appendix C: Healthcare Staff and Parent Questionnaire Results

1. **Overall stress level and job satisfaction.** Group 1 = Hospital 1; Group 2 = Hospital 2a; Group 3 = Hospital 2b.

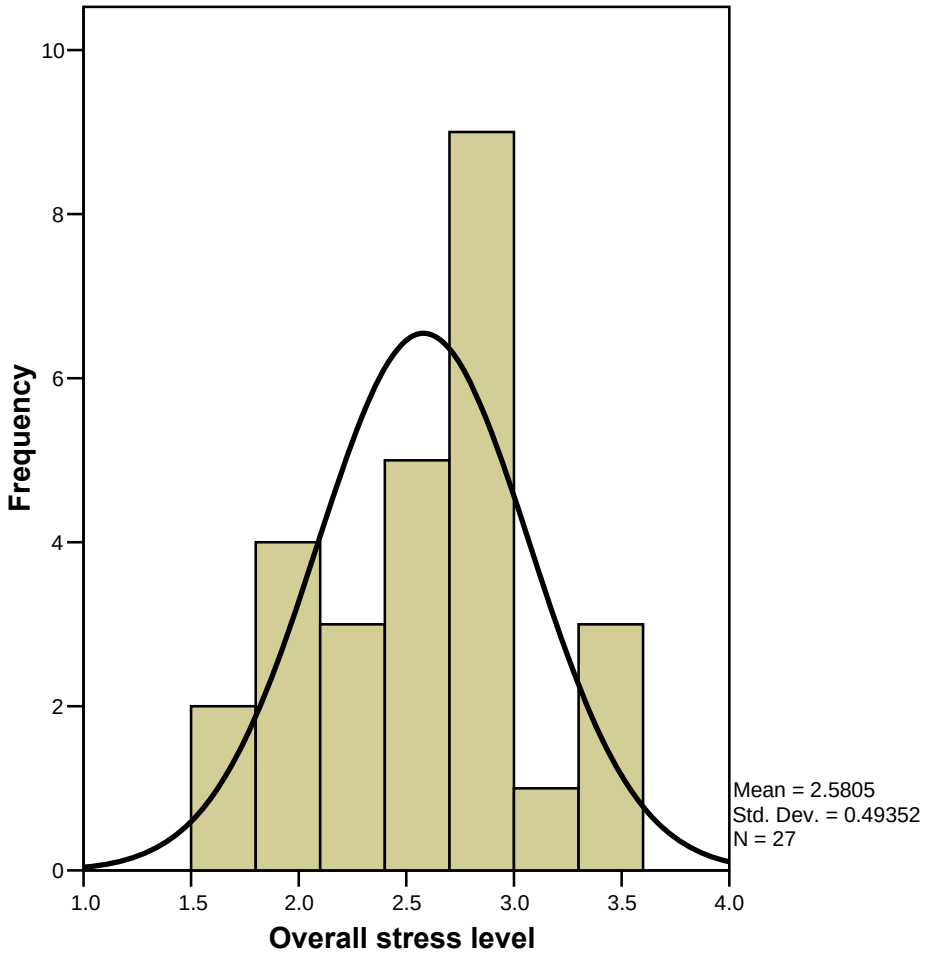
Overall Stress Level

Group 1



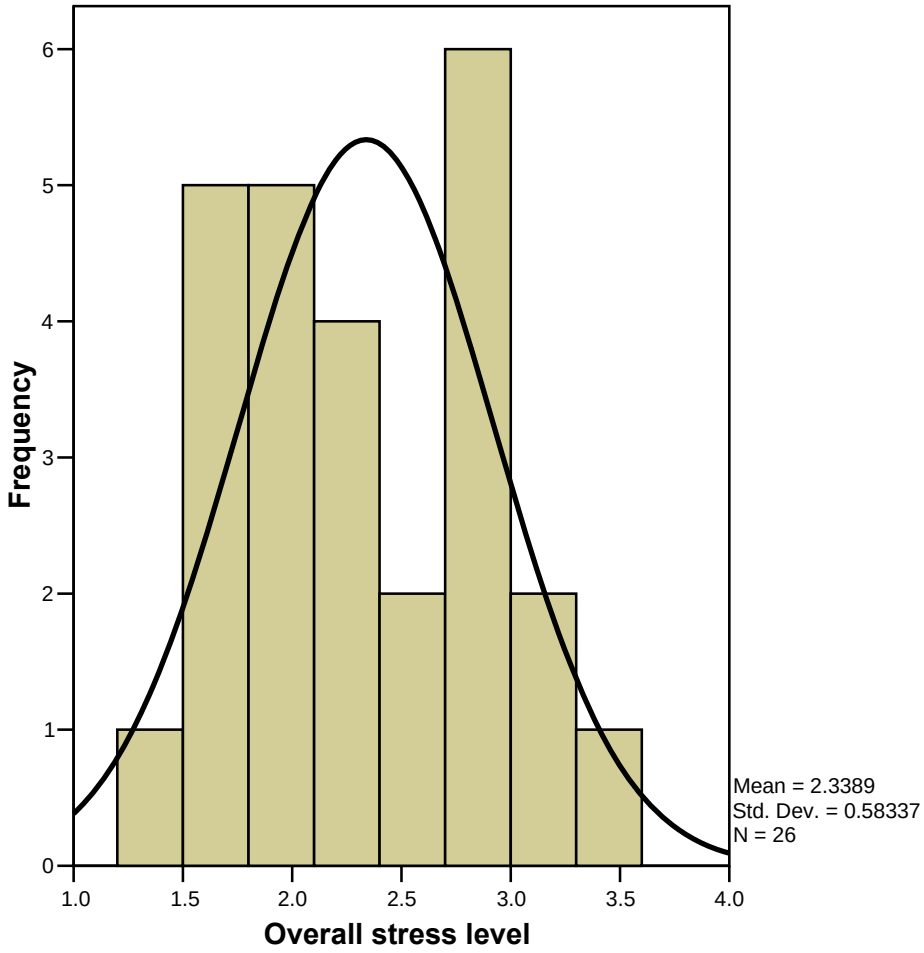
Overall Stress Level

Group 2



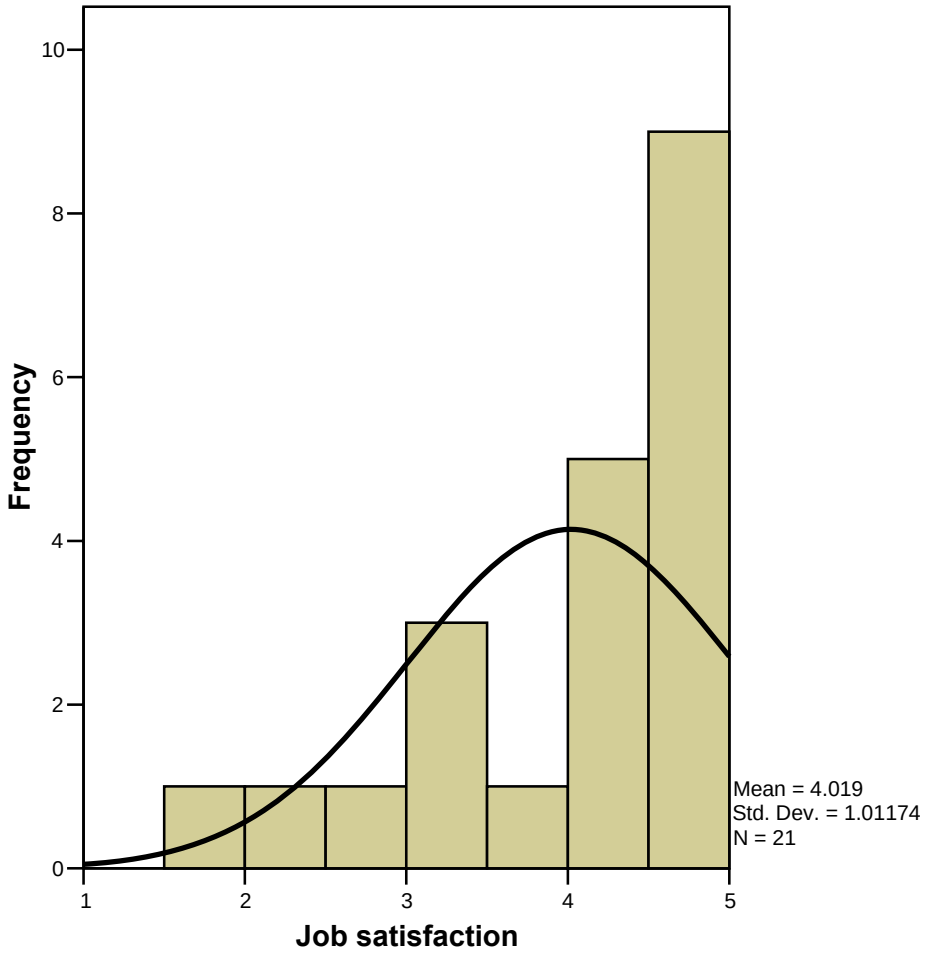
Overall Stress Level

Group 3



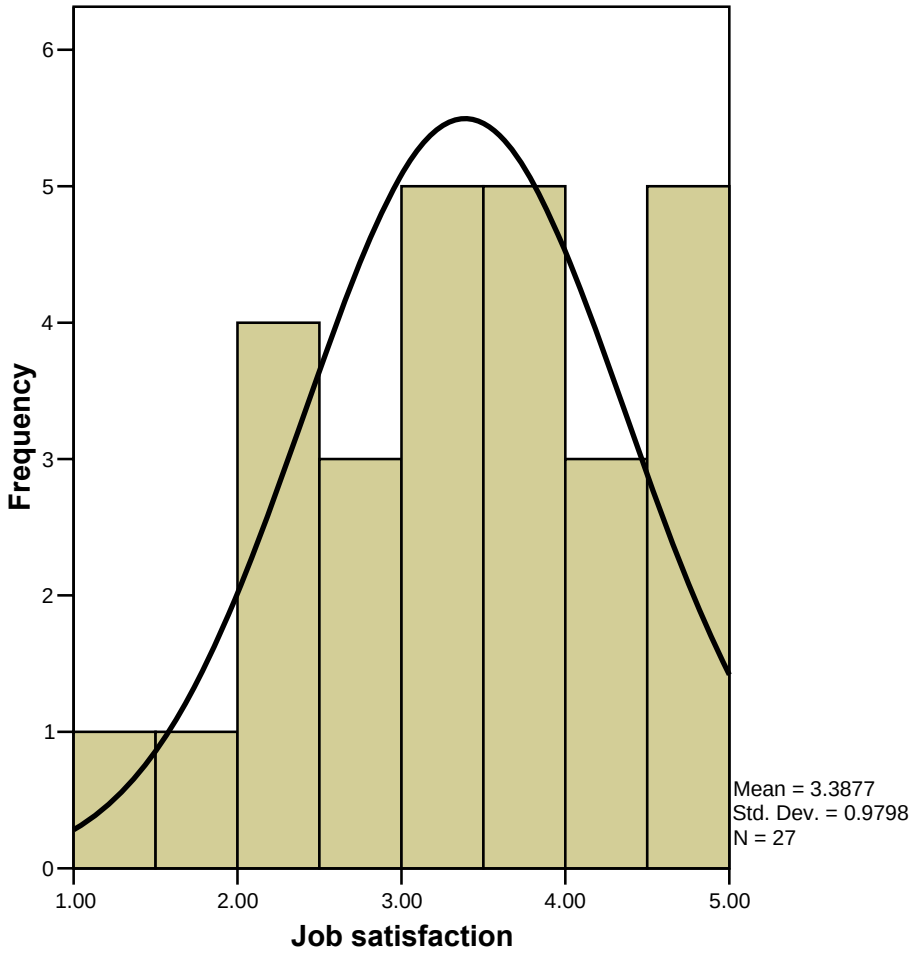
Job Satisfaction

Group 1



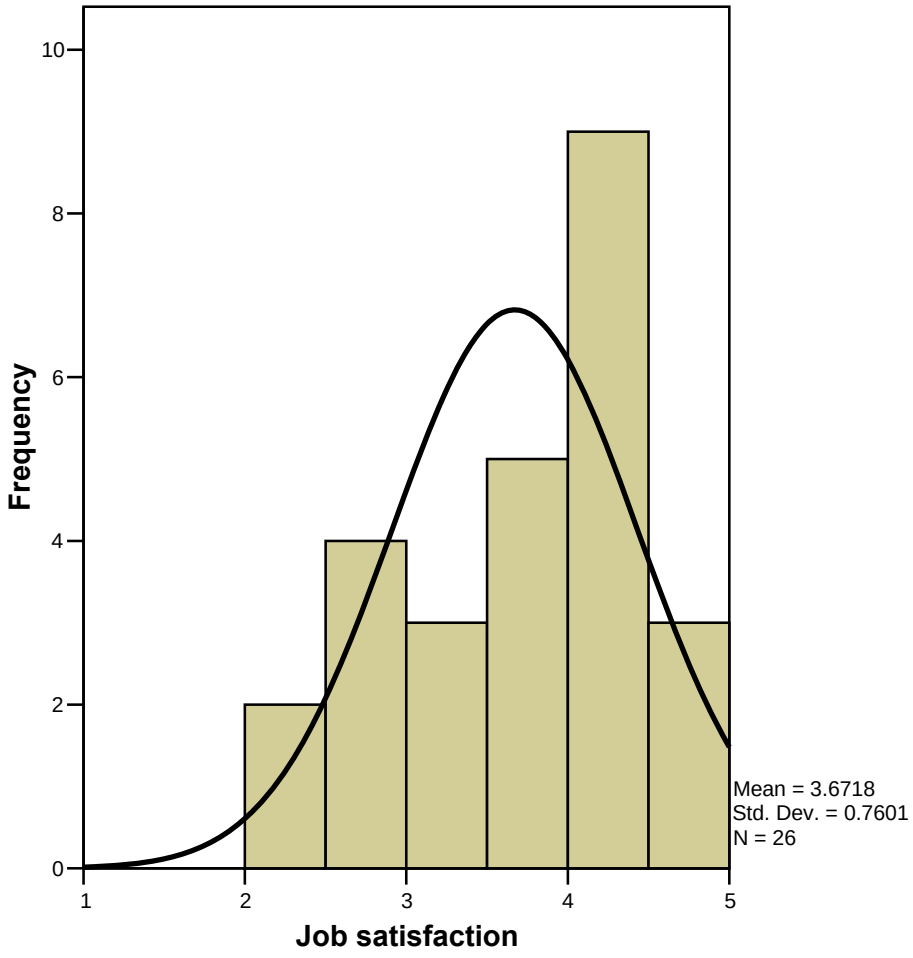
Job Satisfaction

Group 2



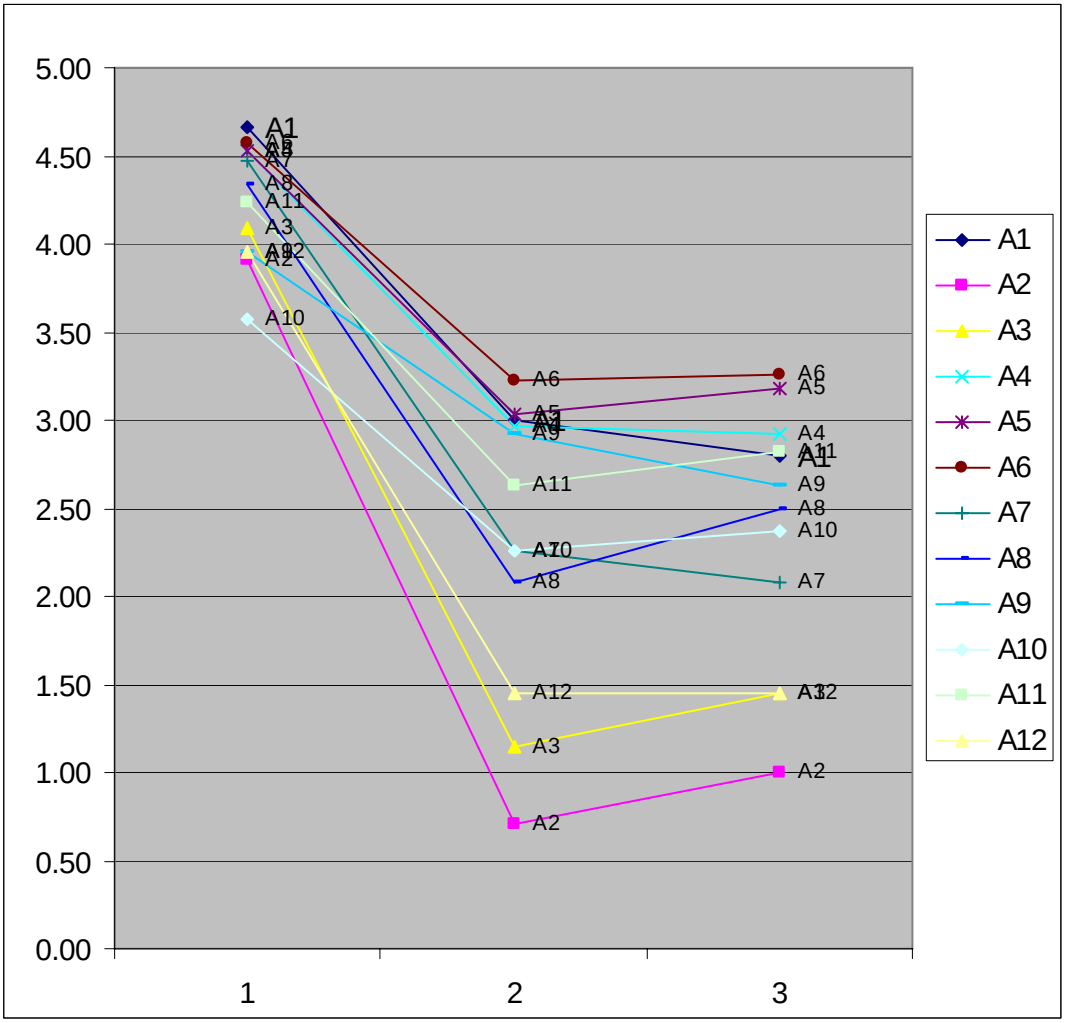
Job Satisfaction

Group 3



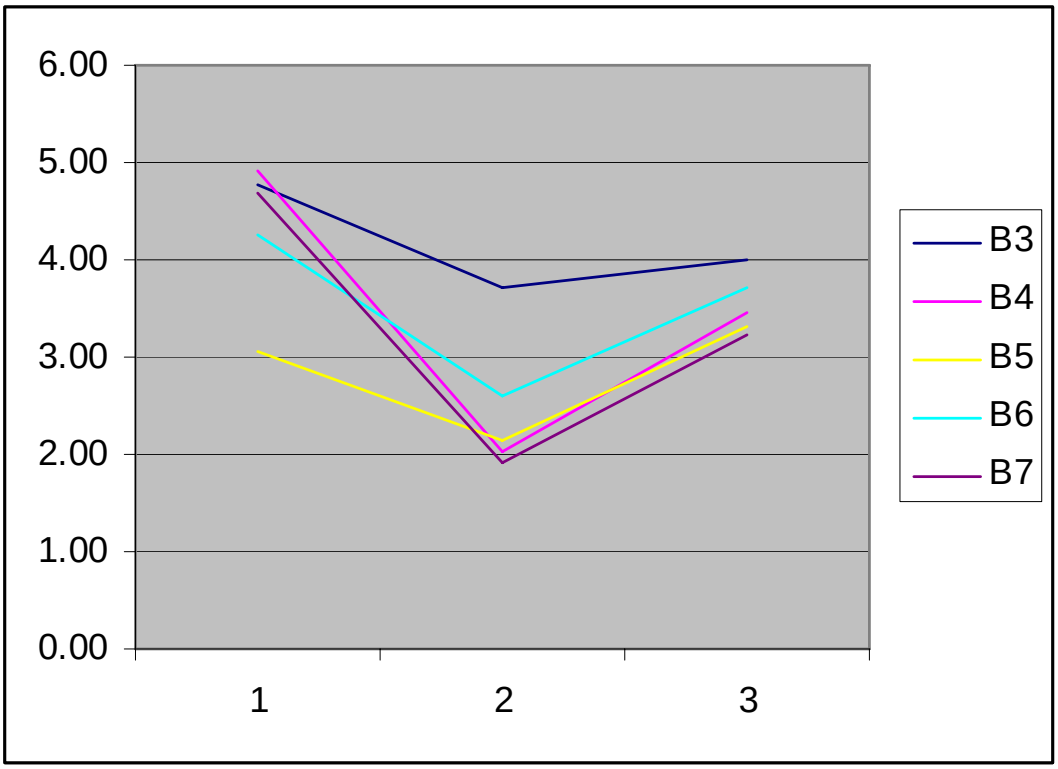
2. Overviews of staff satisfaction and agreement

Degree of Satisfaction with the Physical Environment



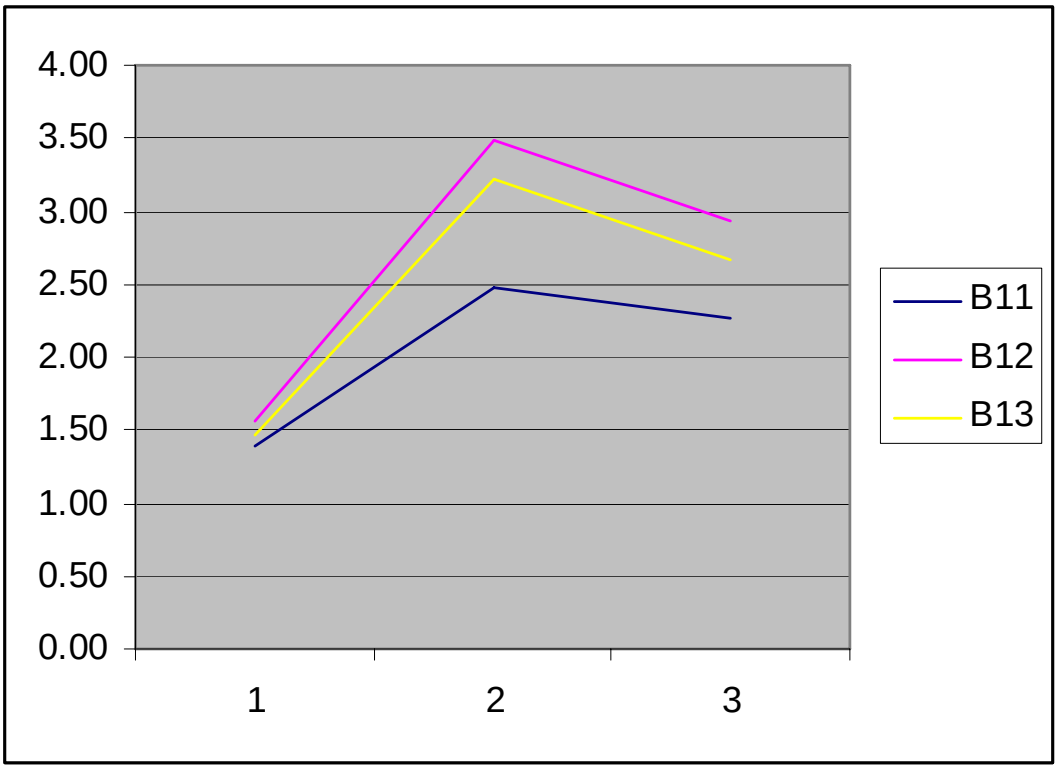
A1. Quality of physical environment
A2. Window views
A3. Natural light
A4. Light level
A5. Noise level
A6. Atmosphere and décor
A7. Waiting and resting space for families outside NICU
A8. Place to sleep in or near NICU
A9. Corridors and signage for finding way in hospital
A10. Place for food and nourishment in or near NICU
A11. The work space for staff
A12. The respite space for staff

Level of Agreement Regarding Privacy and the Physical Environment



B1. Layout allows staff to readily supervise babies
B2. Private rooms for babies and their families are important
B3. Environment supports family's presence and participation
B4. Design allows family members to have privacy
B5. Space between beds allows families to interact privately with babies
B6. Adequate privacy can be created at the bedside for skin-to-skin care
B7. Quiet, private space in or near the unit for family members to be alone
B8. Importance of families to interact with each other
B9. Layout facilitates interaction between parents
B10. Equipment should be hidden so families do not feel uncomfortable
B11. Environment is depressing
B12. Atmosphere is tense and stressful for family members
B13. Atmosphere is tense and stressful for staff

Level of Agreement Regarding Stress and Depression and the Physical Environment



B1. Layout allows staff to readily supervise babies
B2. Private rooms for babies and their families are important
B3. Environment supports family's presence and participation
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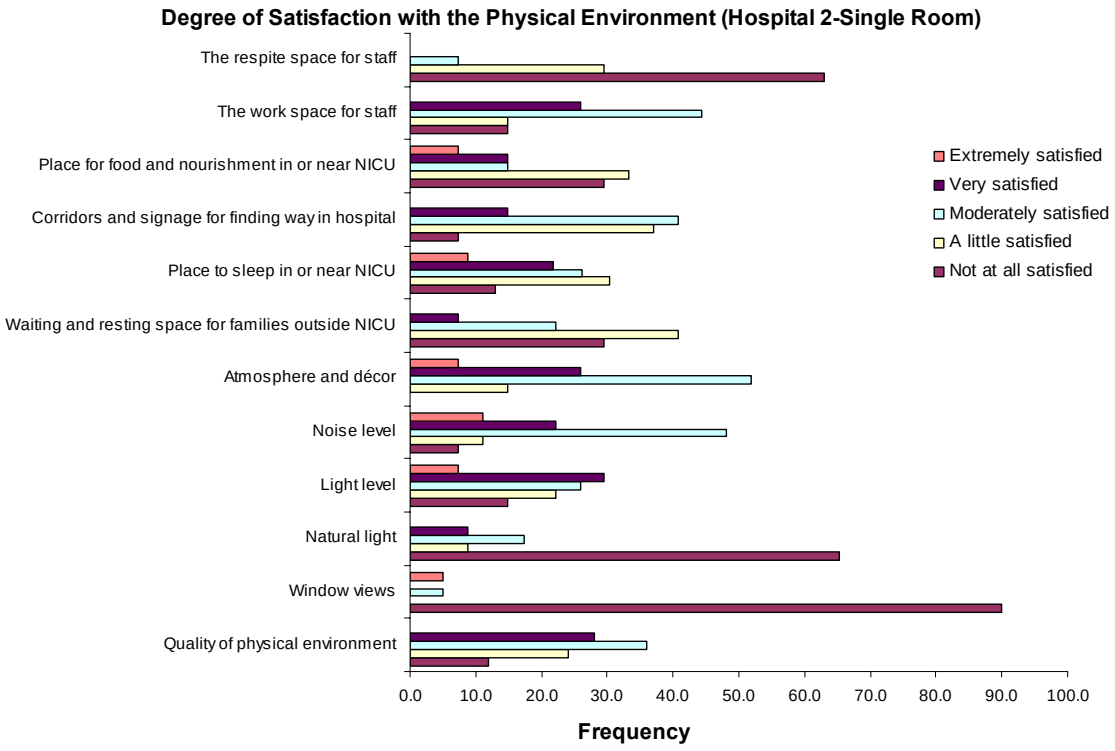
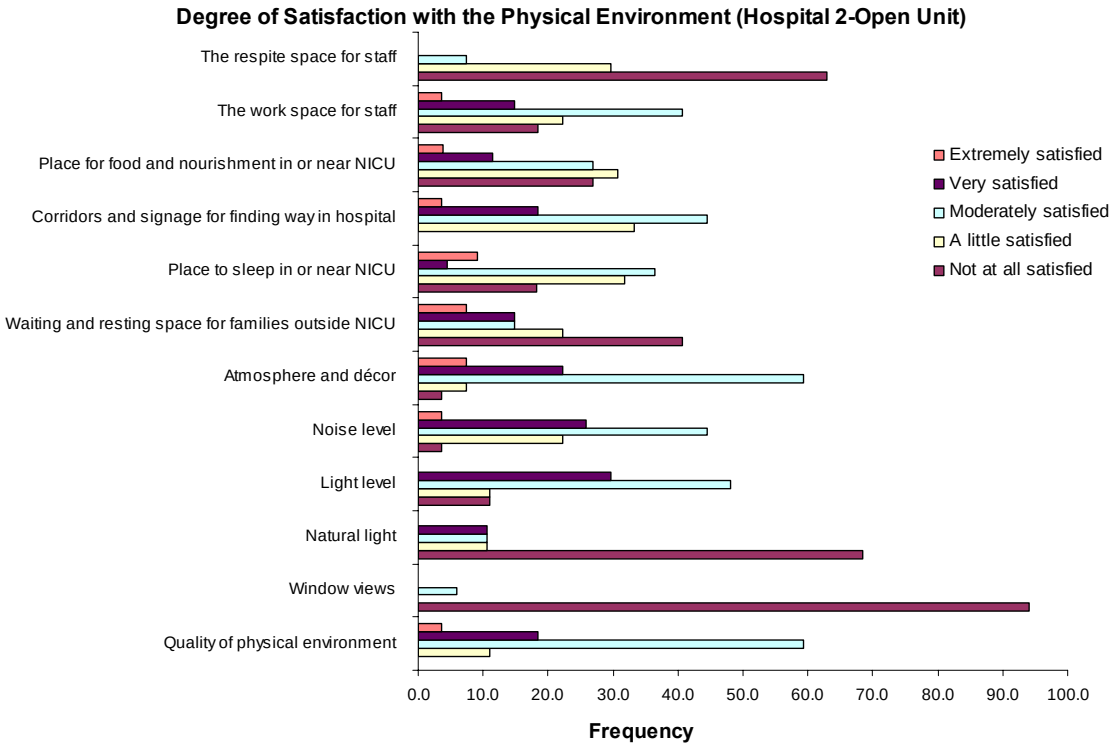
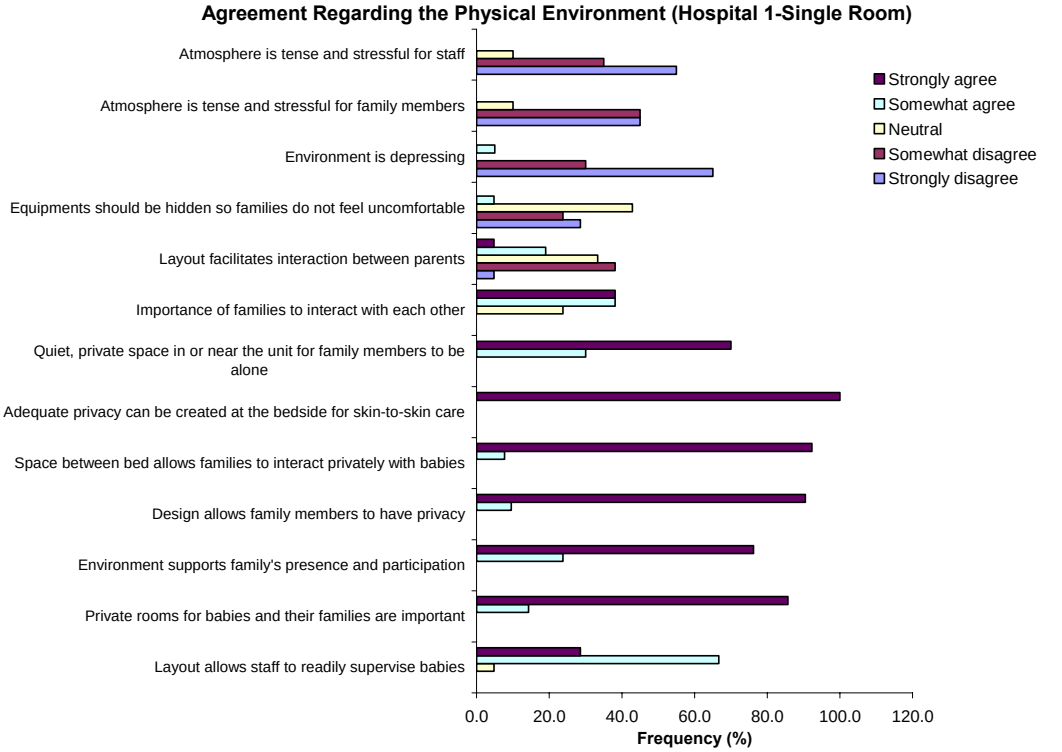
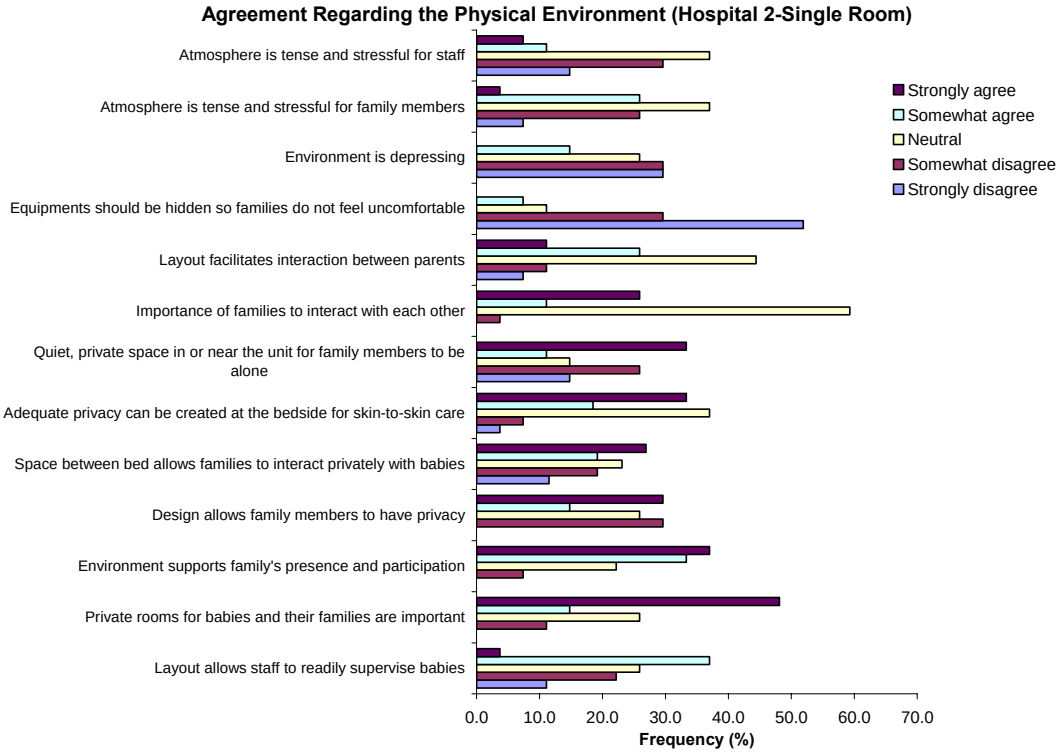
B9. Layout facilitates interaction between parents
B10. Equipment should be hidden so families do not feel uncomfortable
B11. Environment is depressing
B12. Atmosphere is tense and stressful for family members
B13. Atmosphere is tense and stressful for staff

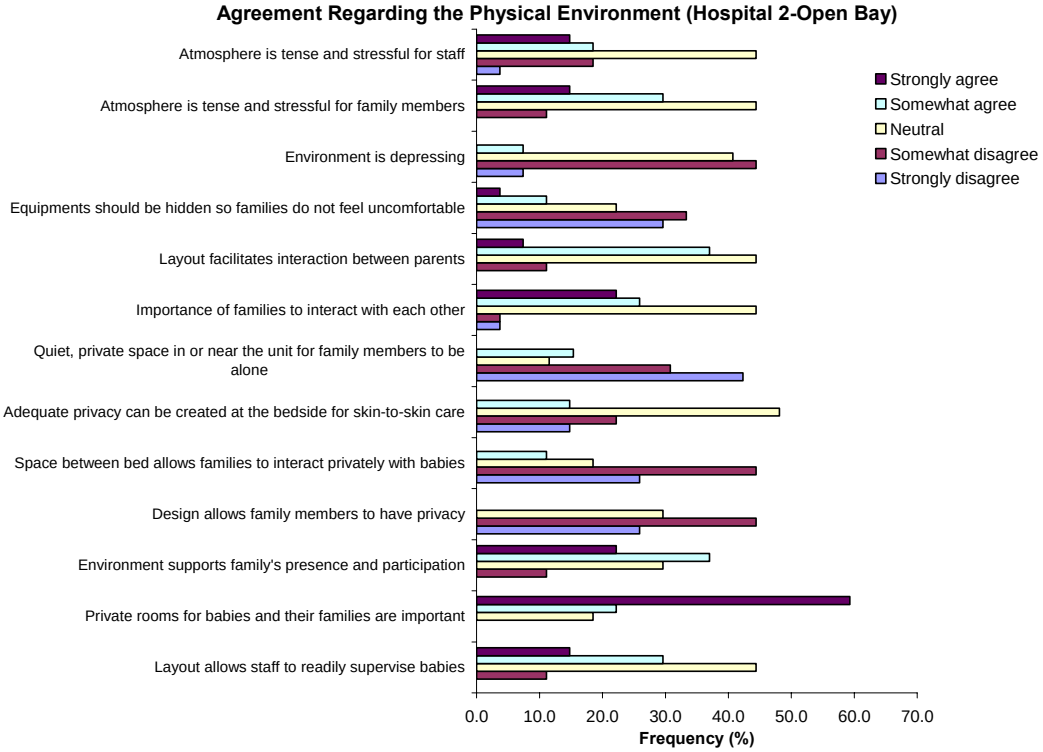
3. Degree of Staff Satisfaction and Agreement





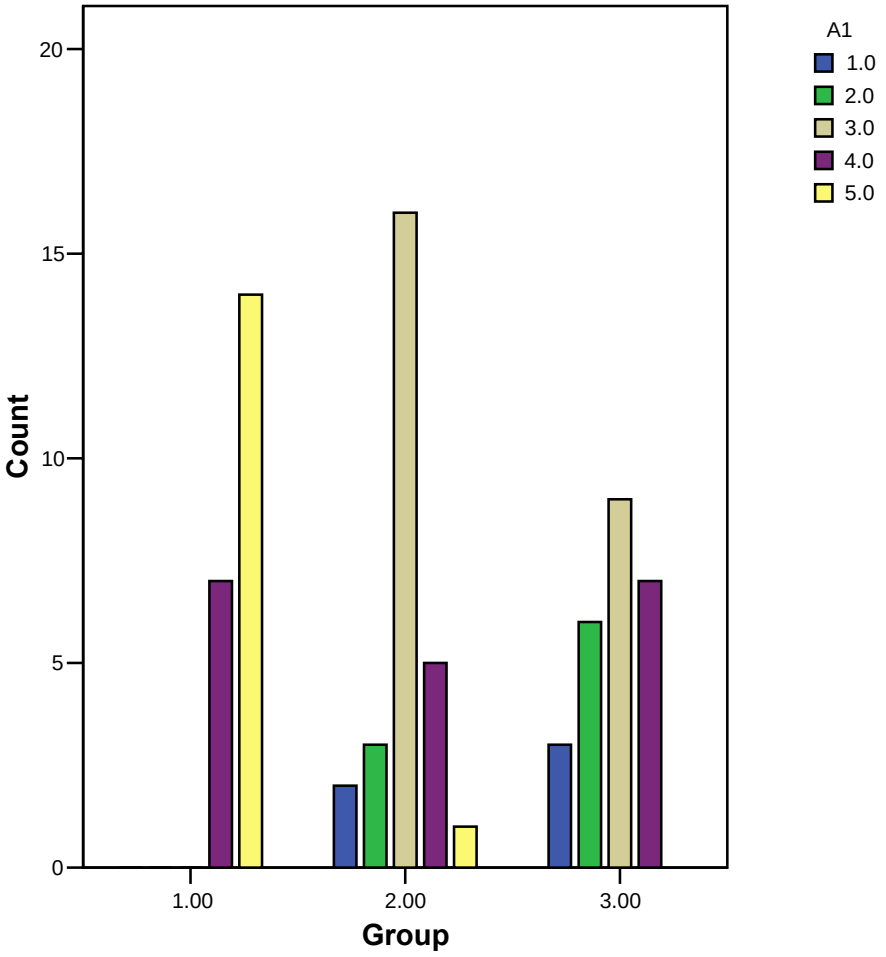

Agreement Regarding the Physical Environment (Hospital 1-Single Room)
Atmosphere is tense and stressful for staff
Atmosphere is tense and stressful for family members
Environment is depressing
Equipments should be hidden so families do not feel uncomfortable
Layout facilitates interaction between parents
Importance of families to interact with each other
Quiet, private space in or near the unit for family members to be alone
Adequate privacy can be created at the bedside for skin-to-skin care
Space between bed allows families to interact privately with babies
Design allows family members to have privacy
Environment supports family's presence and participation
Private rooms for babies and their families are important
Layout allows staff to readily supervise babies
Strongly agree
Somewhat agree
Neutral
Somewhat disagree
Strongly disagree
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Frequency (%)


Agreement Regarding the Physical Environment (Hospital 2-Single Room)
Atmosphere is tense and stressful for staff
Atmosphere is tense and stressful for family members
Environment is depressing
Equipments should be hidden so families do not feel uncomfortable
Layout facilitates interaction between parents
Importance of families to interact with each other
Quiet, private space in or near the unit for family members to be alone
Adequate privacy can be created at the bedside for skin-to-skin care
Space between bed allows families to interact privately with babies
Design allows family members to have privacy
Environment supports family's presence and participation
Private rooms for babies and their families are important
Layout allows staff to readily supervise babies
Strongly agree
Somewhat agree
Neutral
Somewhat disagree
Strongly disagree
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Frequency (%)

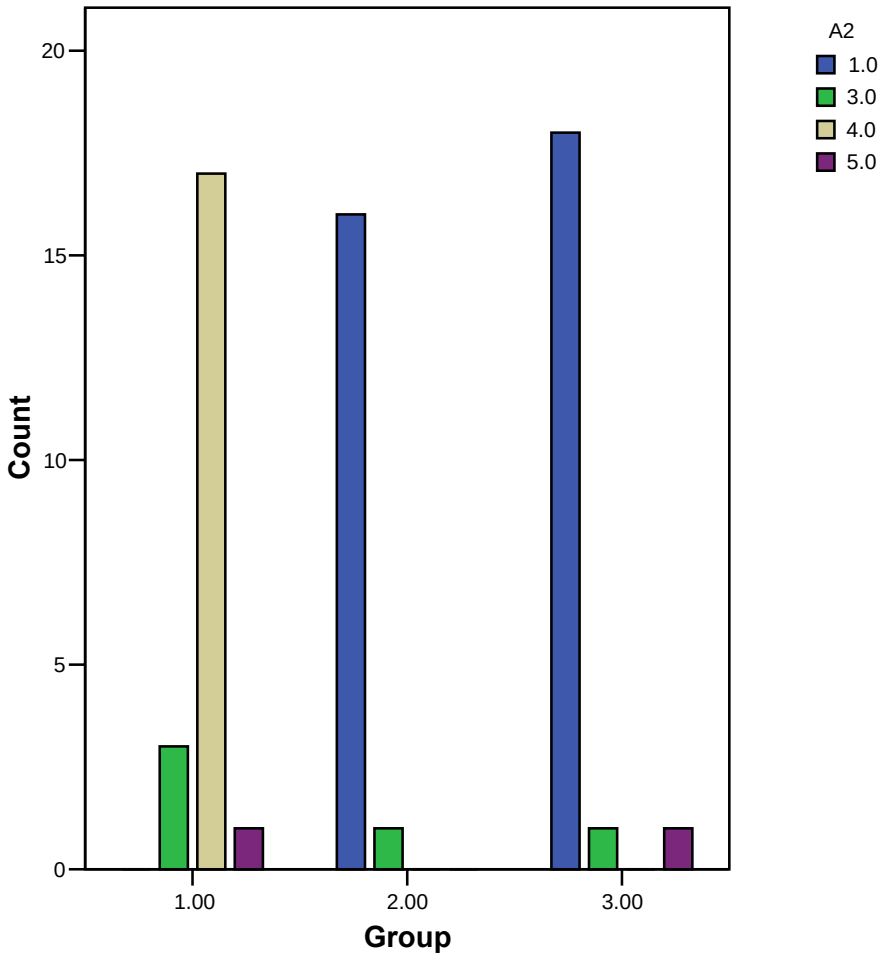

Agreement Regarding the Physical Environment (Hospital 2-Open Bay)
Atmosphere is tense and stressful for staff
Atmosphere is tense and stressful for family members
Environment is depressing
Equipments should be hidden so families do not feel uncomfortable
Layout facilitates interaction between parents
Importance of families to interact with each other
Quiet, private space in or near the unit for family members to be alone
Adequate privacy can be created at the bedside for skin-to-skin care
Space between bed allows families to interact privately with babies
Design allows family members to have privacy
Environment supports family's presence and participation
Private rooms for babies and their families are important
Layout allows staff to readily supervise babies
Strongly agree
Somewhat agree
Neutral
Somewhat disagree
Strongly disagree
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Frequency (%)

4. Staff responses to single variables. Group 1 = Hospital 1; Group 2 = Hospital 2a; Group 3 = Hospital 2b. Count is the number of respondents who rated that variable at a particular level. Levels are indicated by color. Yellow is the highest level; blue is the lowest. For example, 9 staff in Hospital 2b rated the quality of the physical environment at a 3.0.

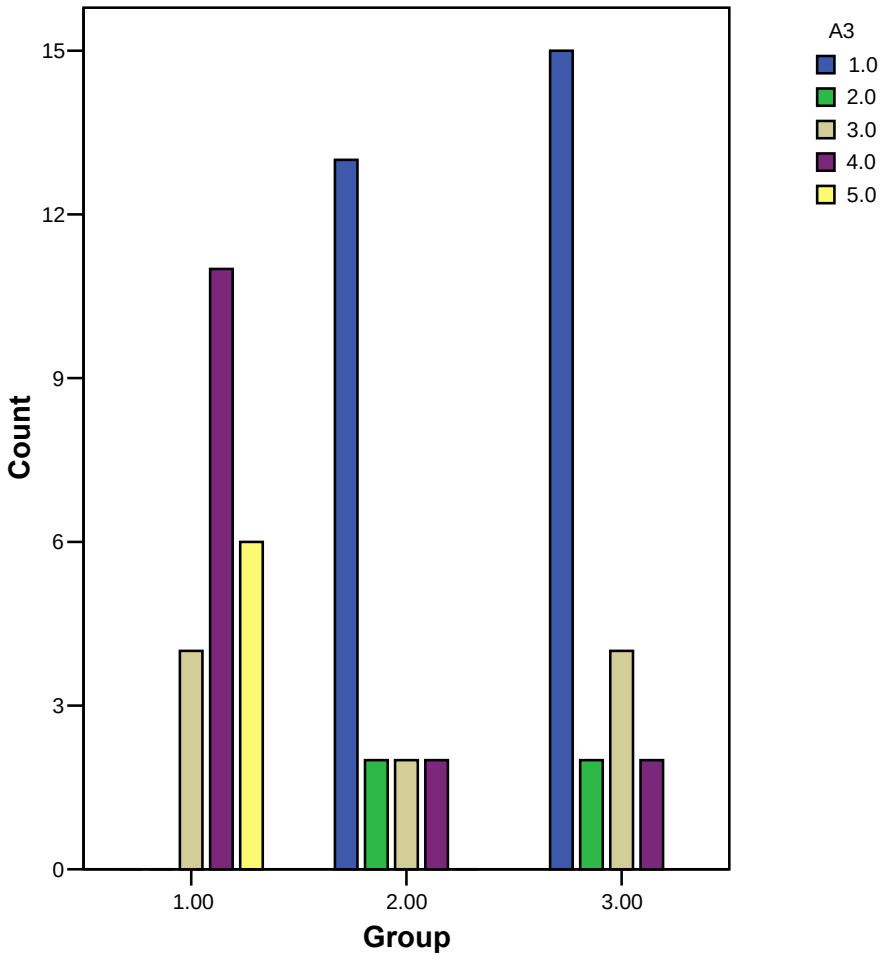
Quality of physical environment



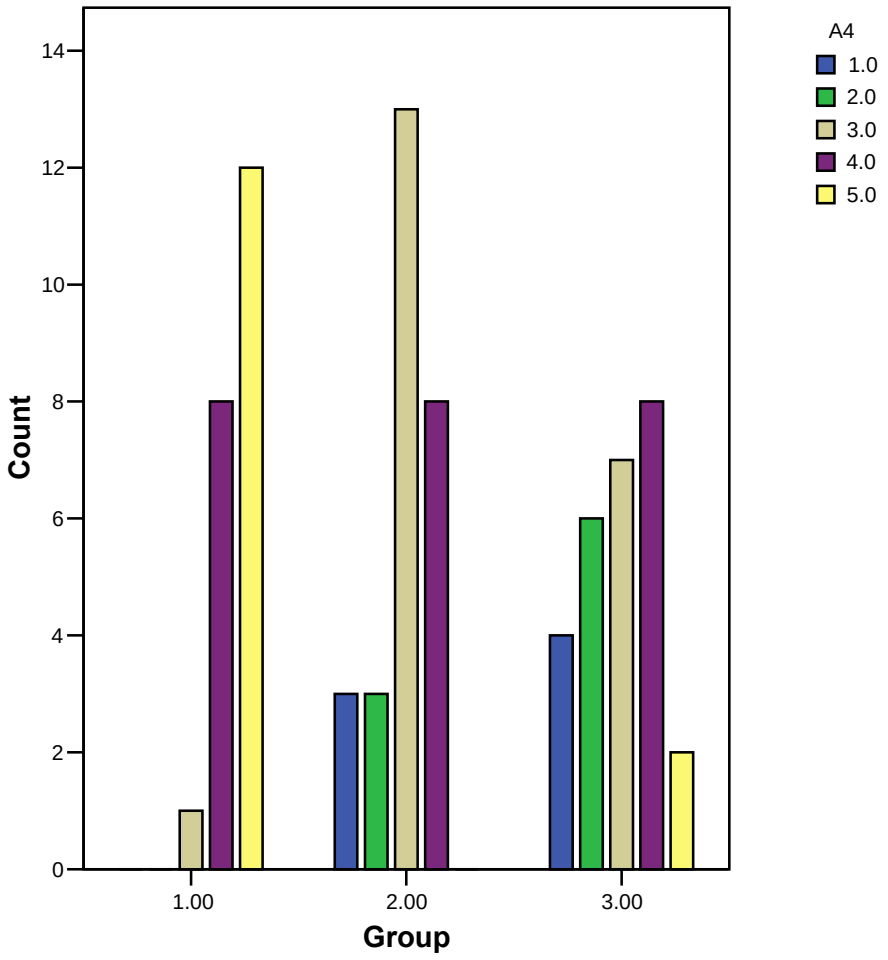
Window views



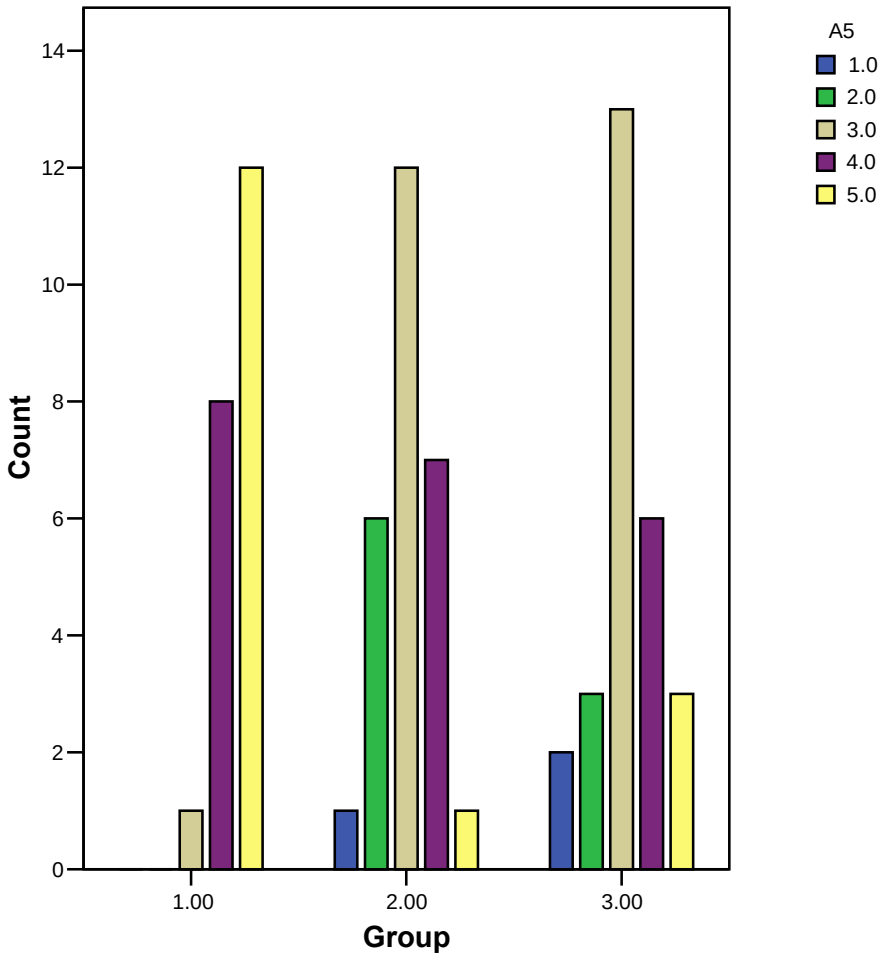
Natural light



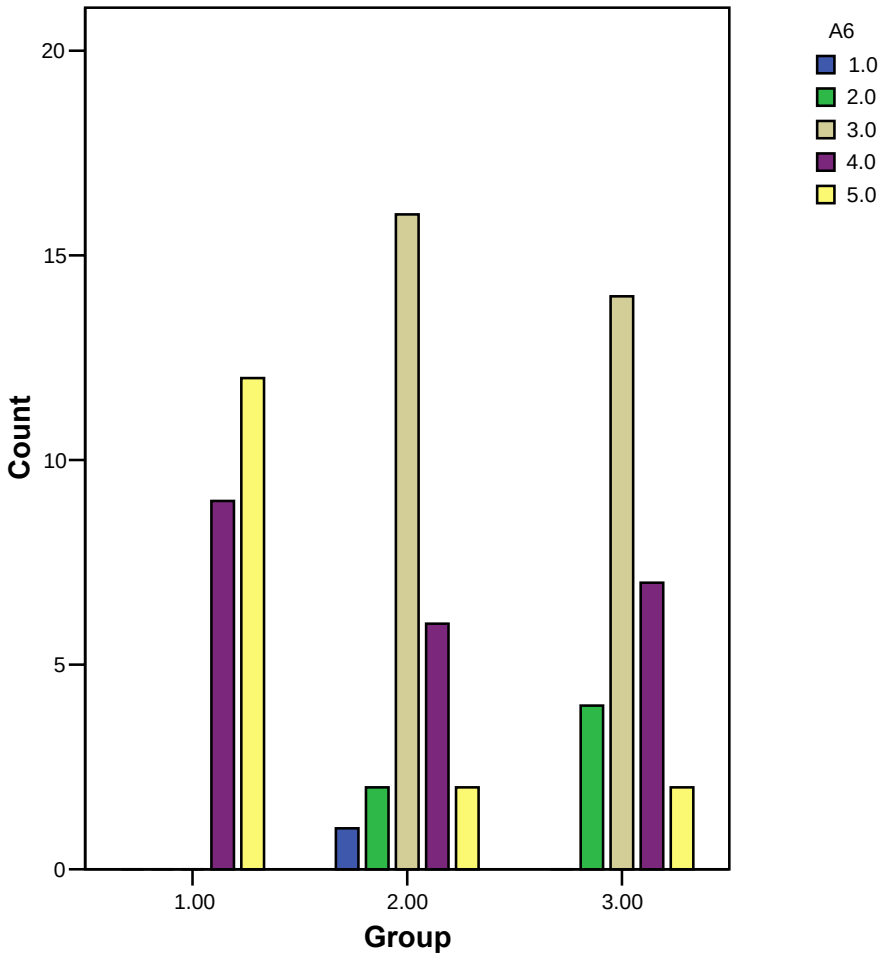
Light level



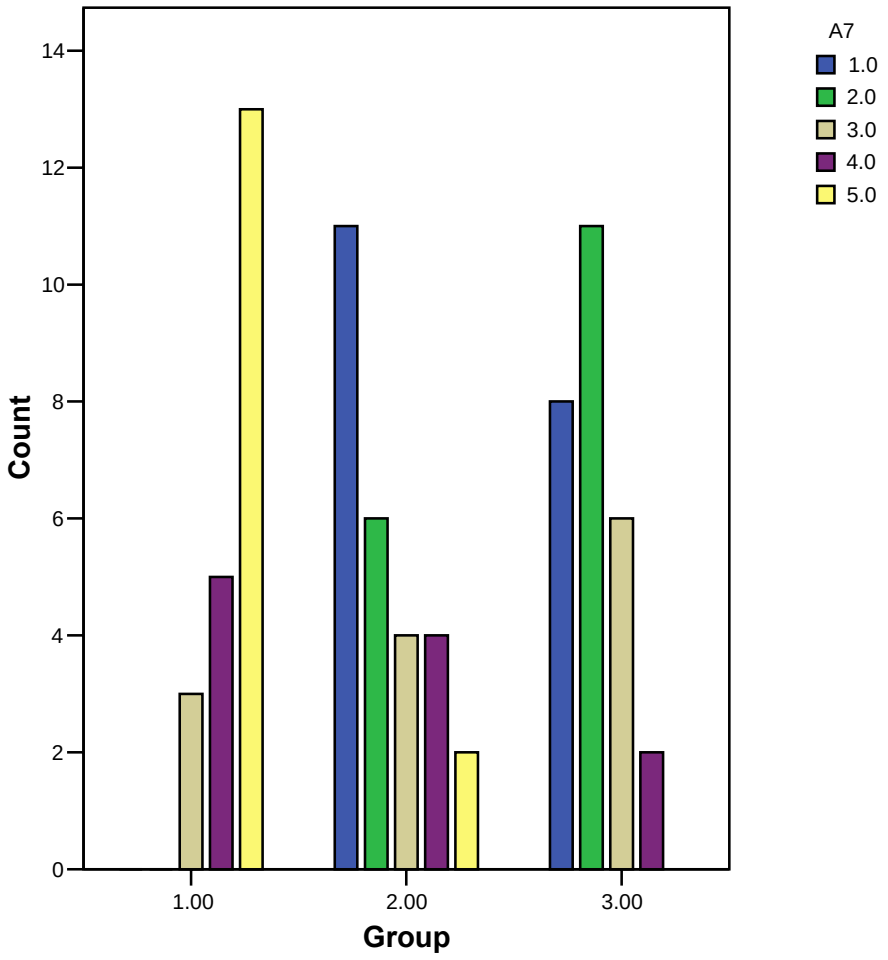
Noise level



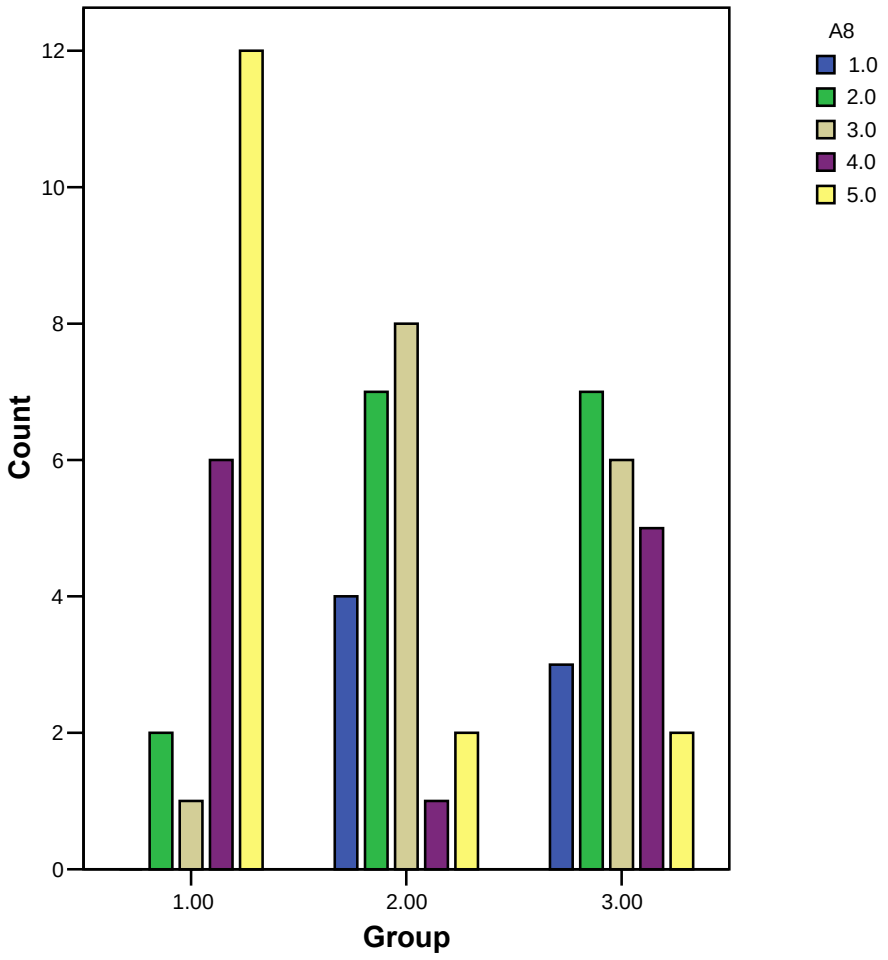
Atmosphere and décor



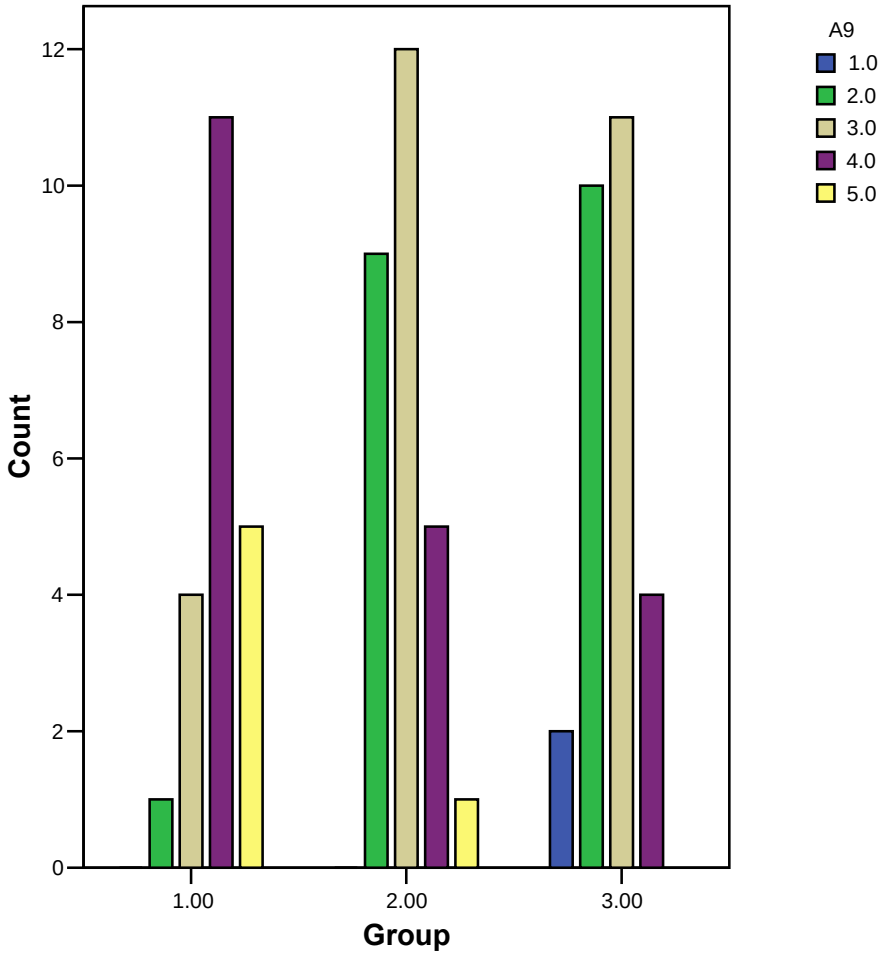
Waiting and resting space for families outside NICU



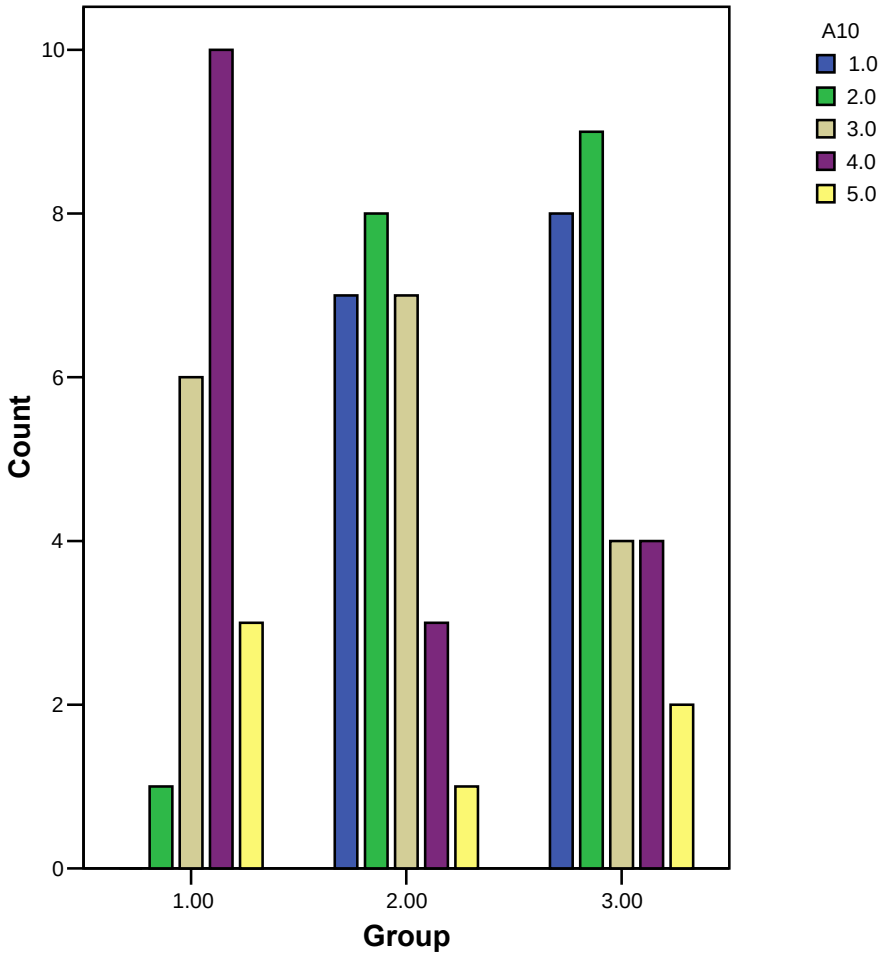
Place to sleep in or near NICU



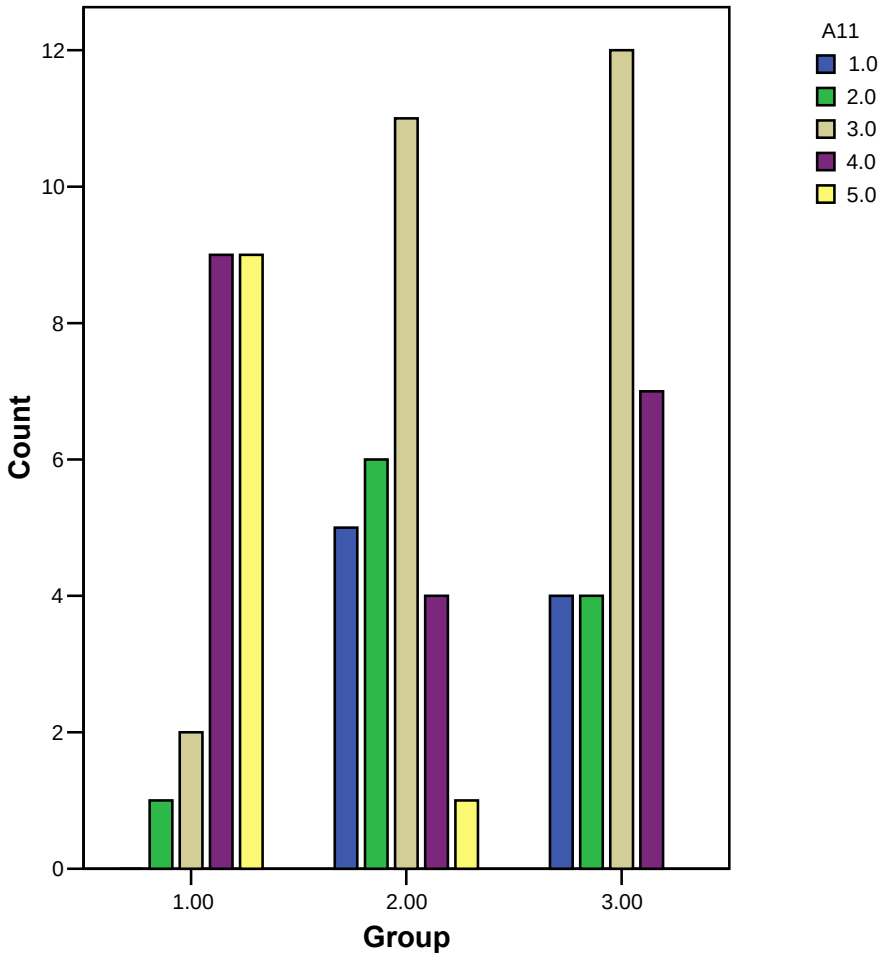
Corridors and signage for finding way in hospital



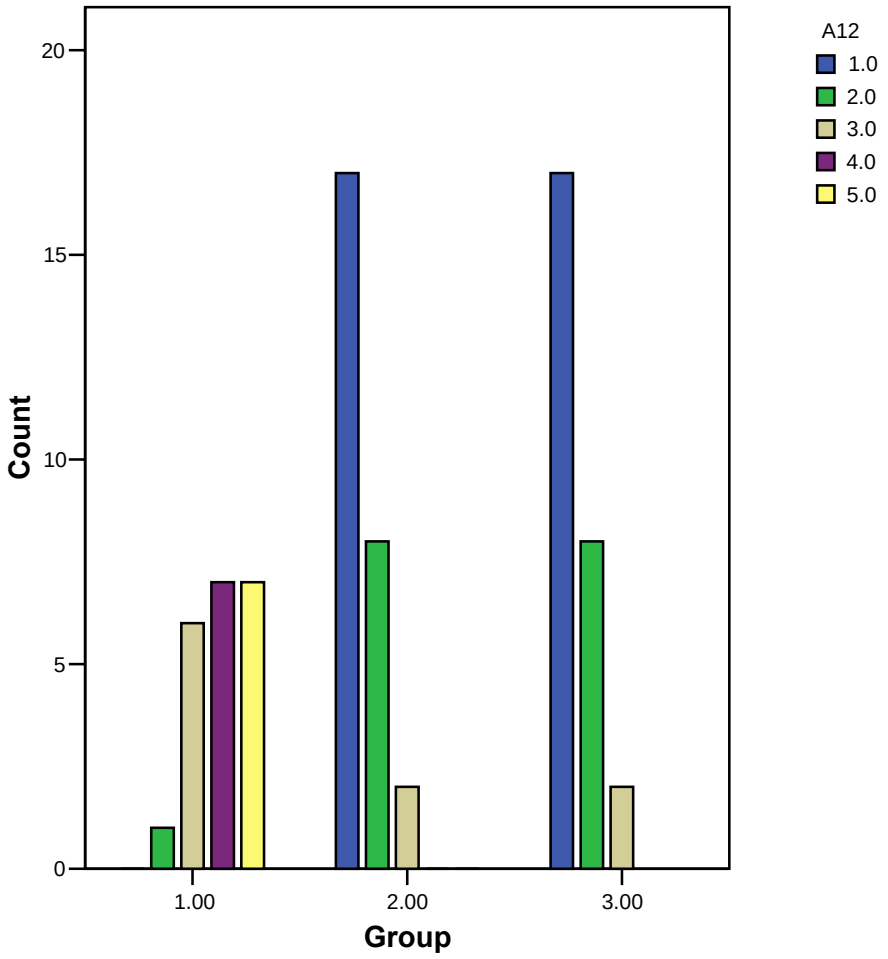
Place for food and nourishment in or near NICU



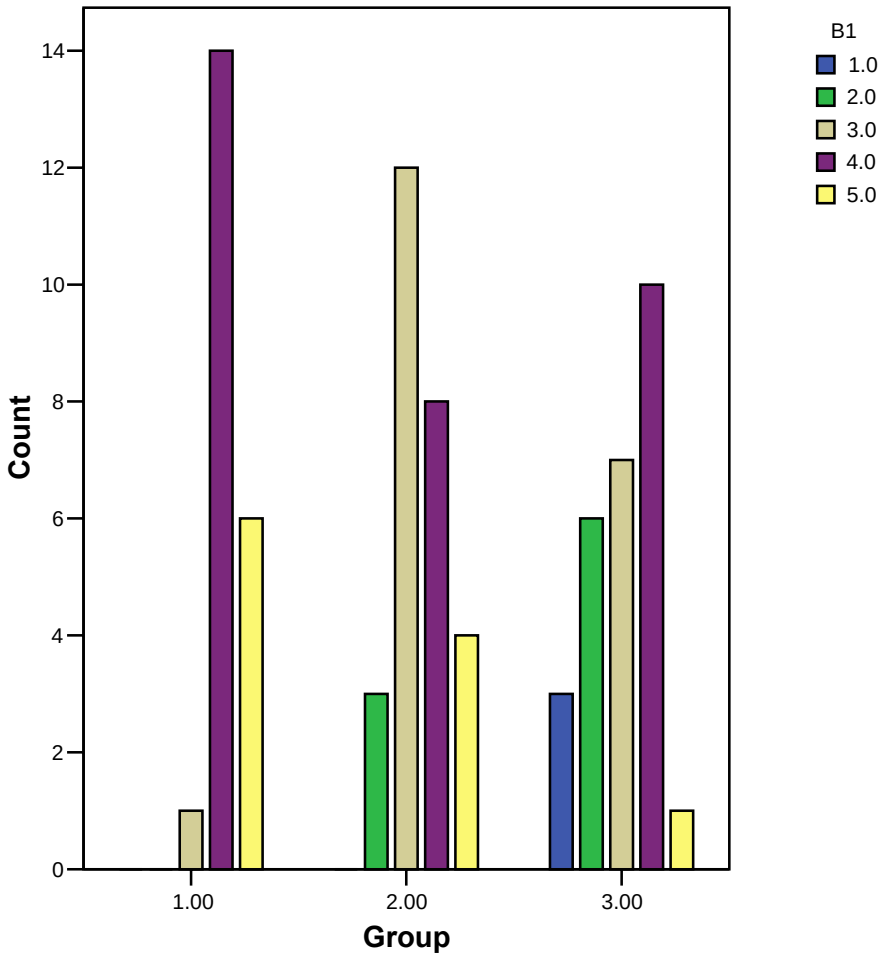
The work space for staff



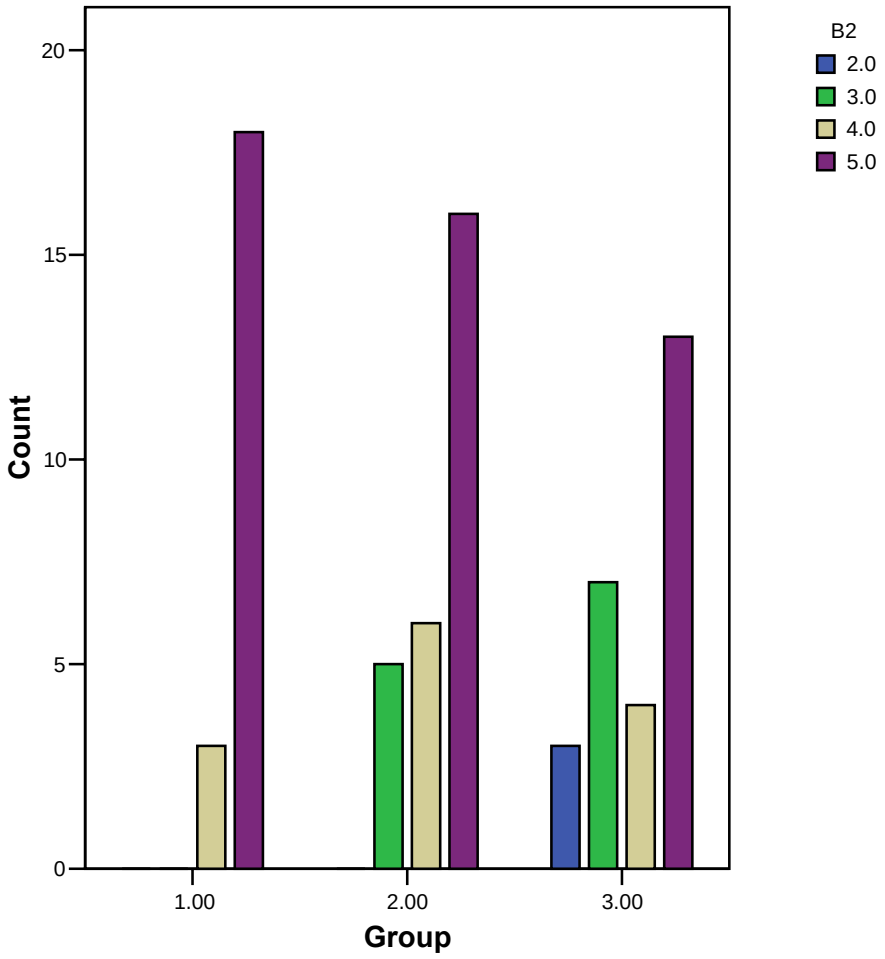
The respite space for staff



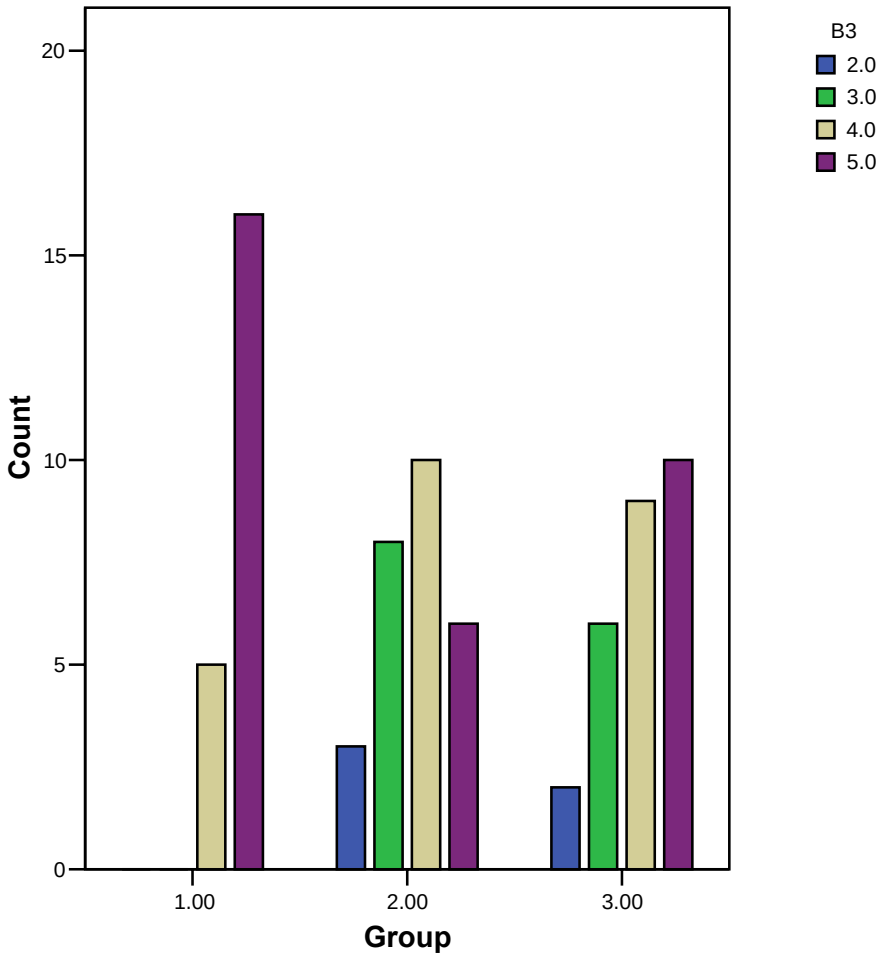
Layout allows staff to readily supervise babies



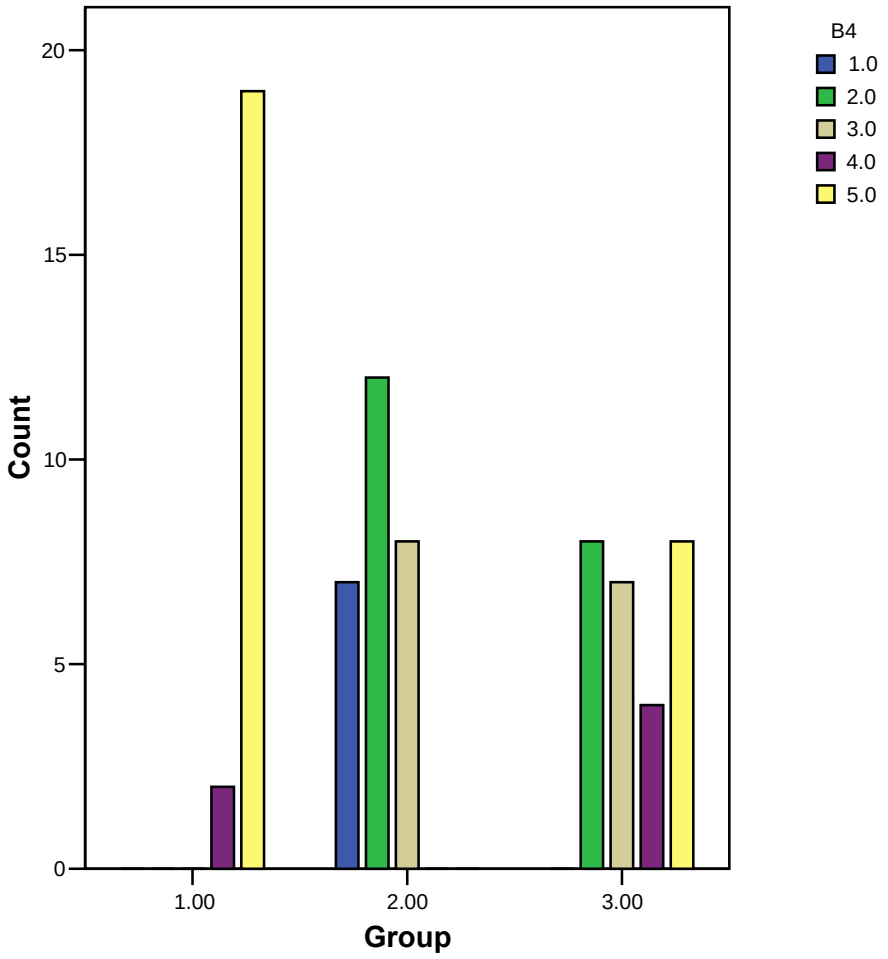
Private rooms for babies and their families are important



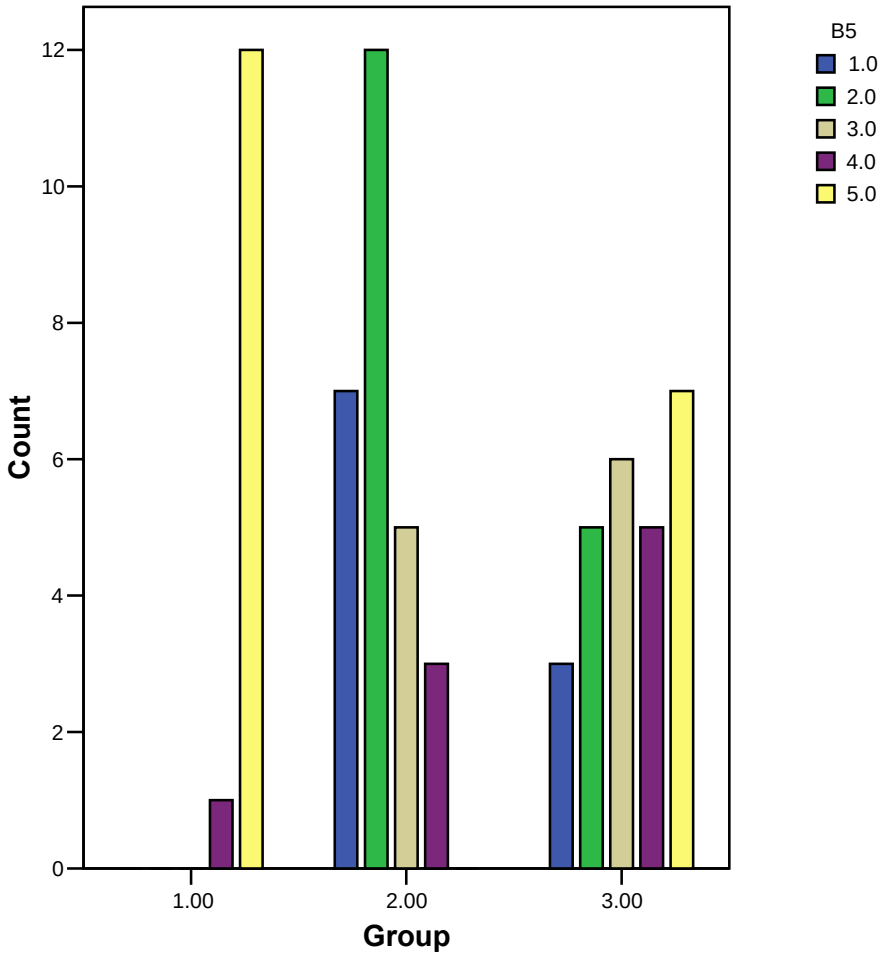
Environment supports family's presence and participation



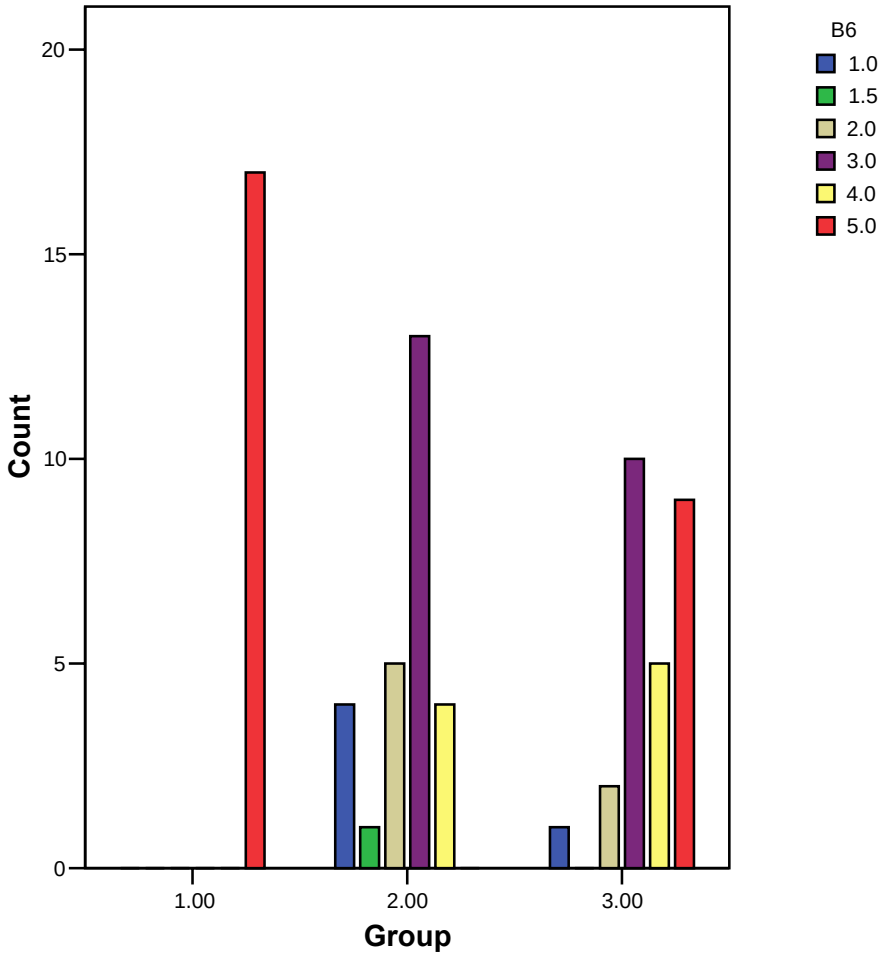
Design allows family members to have privacy



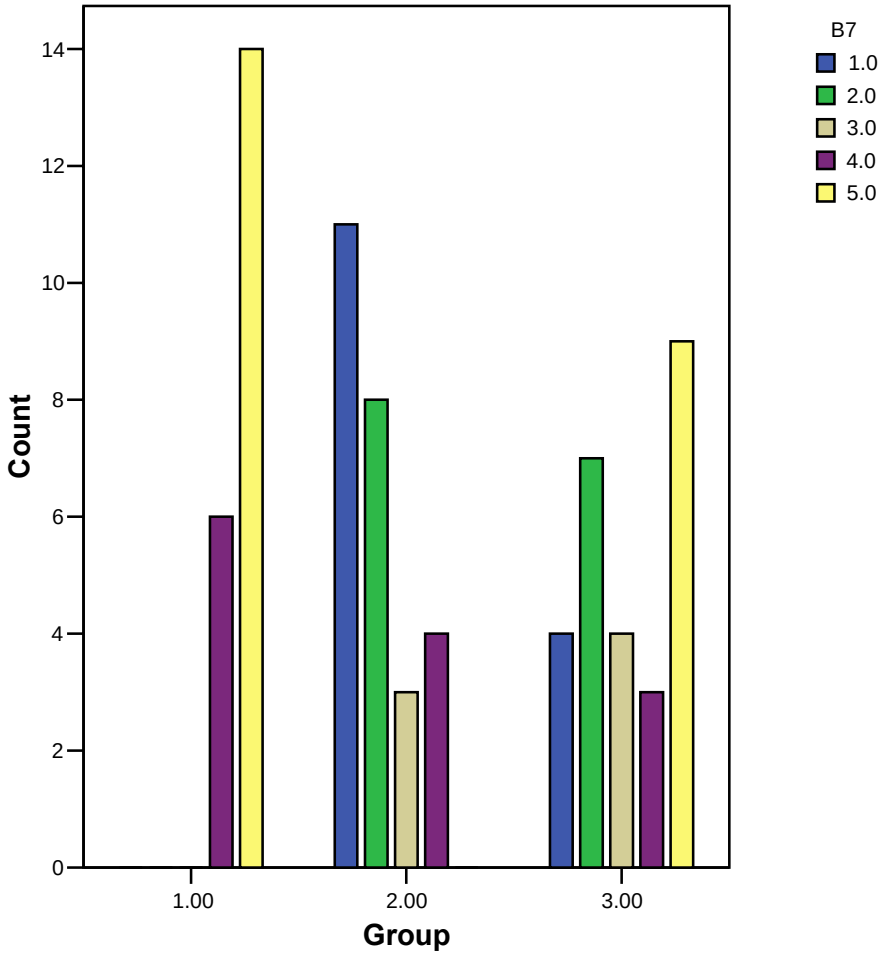
Space between beds allows families to interact privately with babies



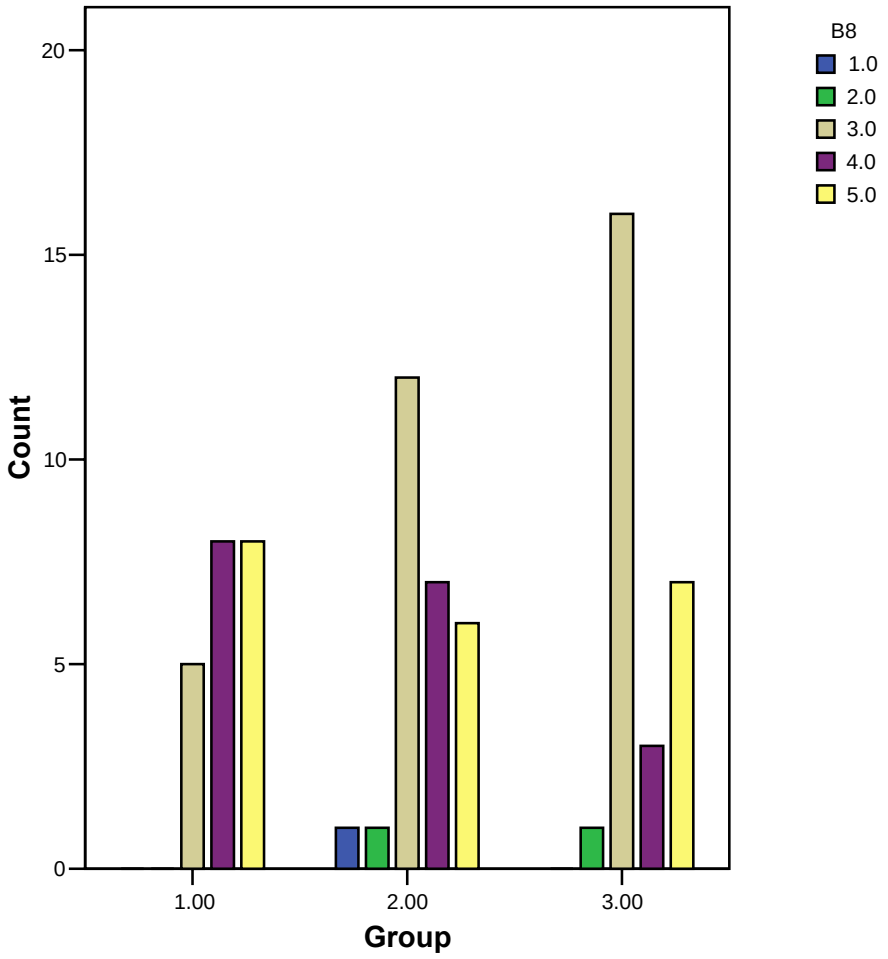
Adequate privacy can be created at the bedside for skin-to-skin care



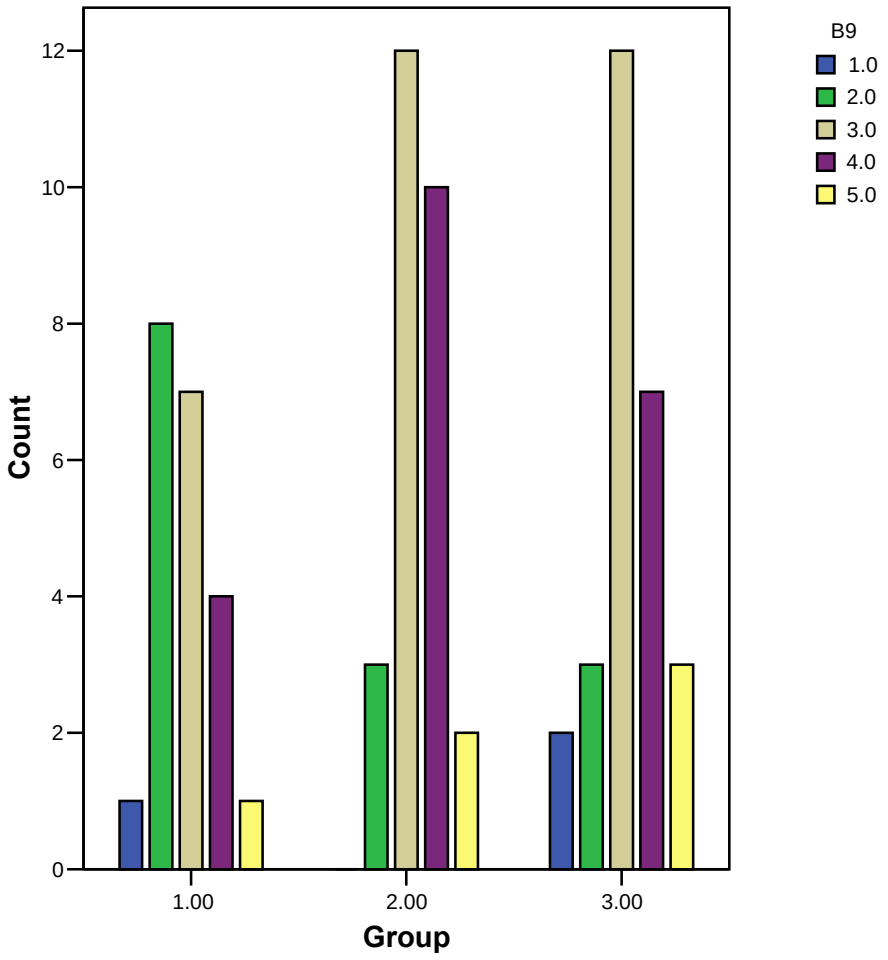
Quiet, private space in or near the unit for family members to be alone



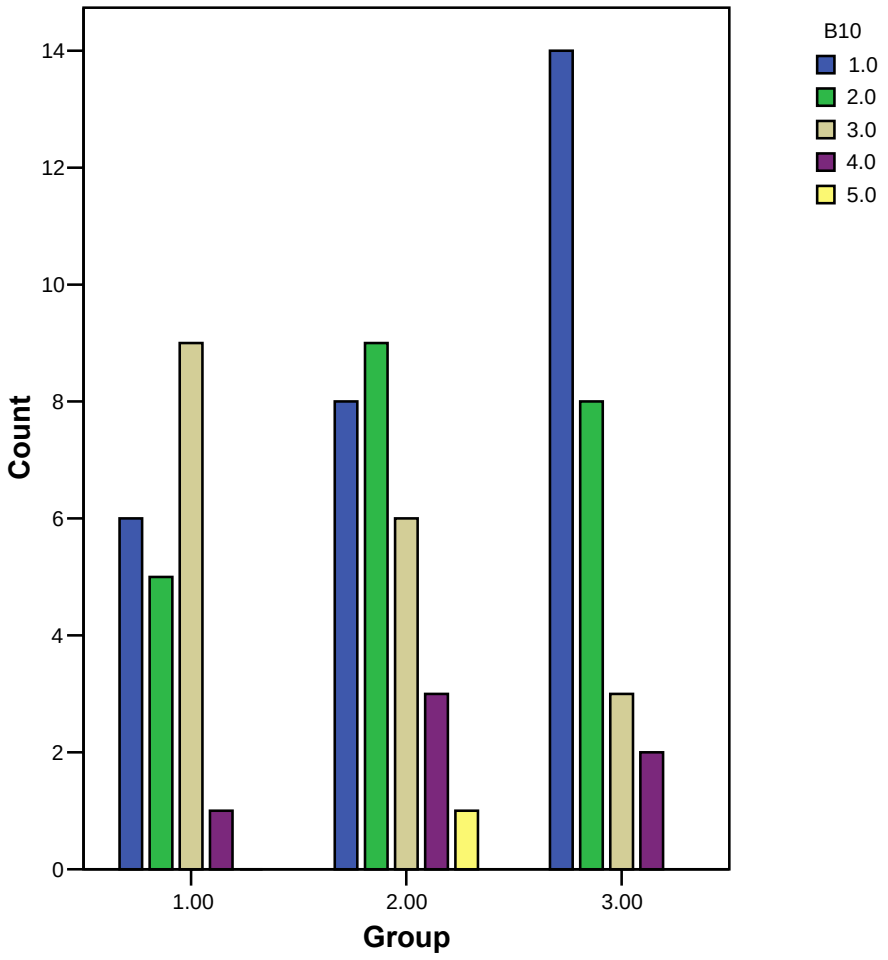
Importance of families to interact with each other



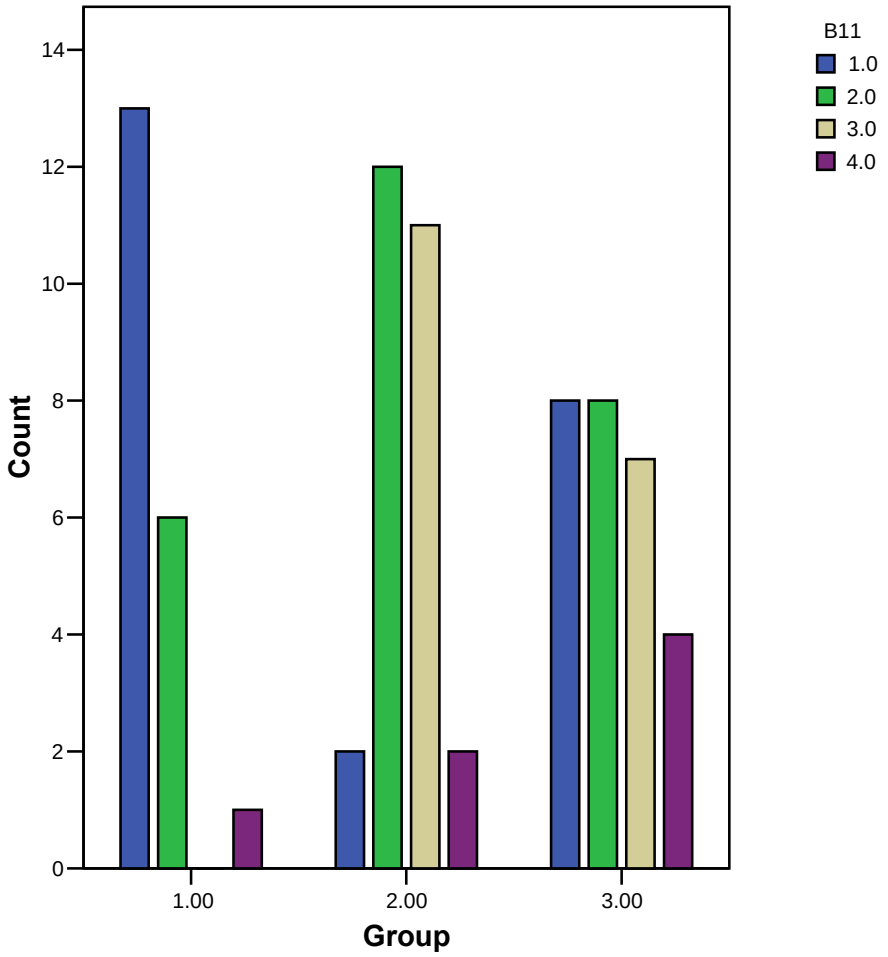
Layout facilitates interaction between parents



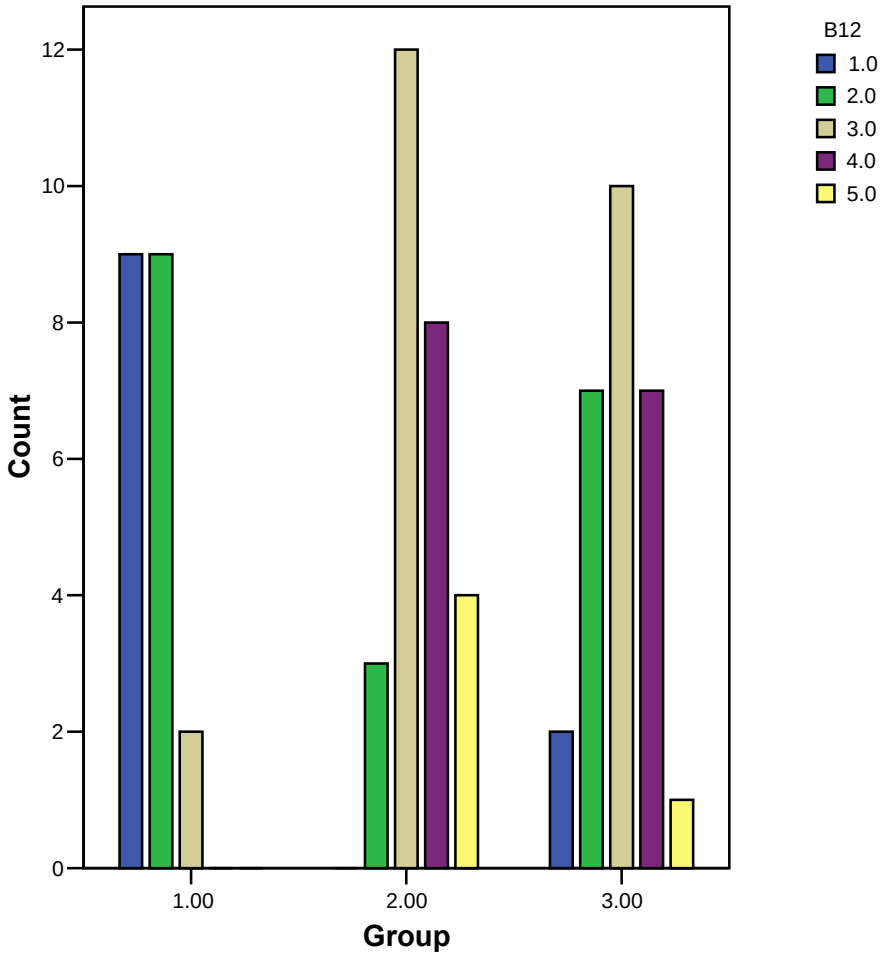
Equipment should be hidden so families do not feel uncomfortable



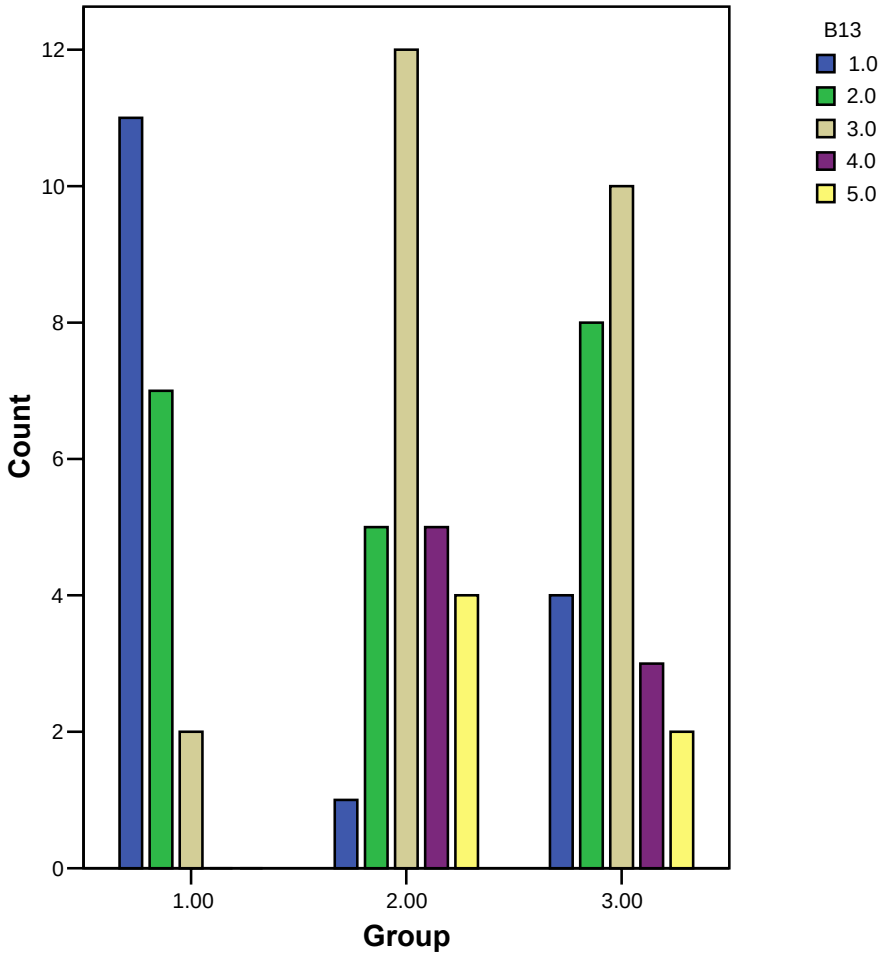
Environment is depressing

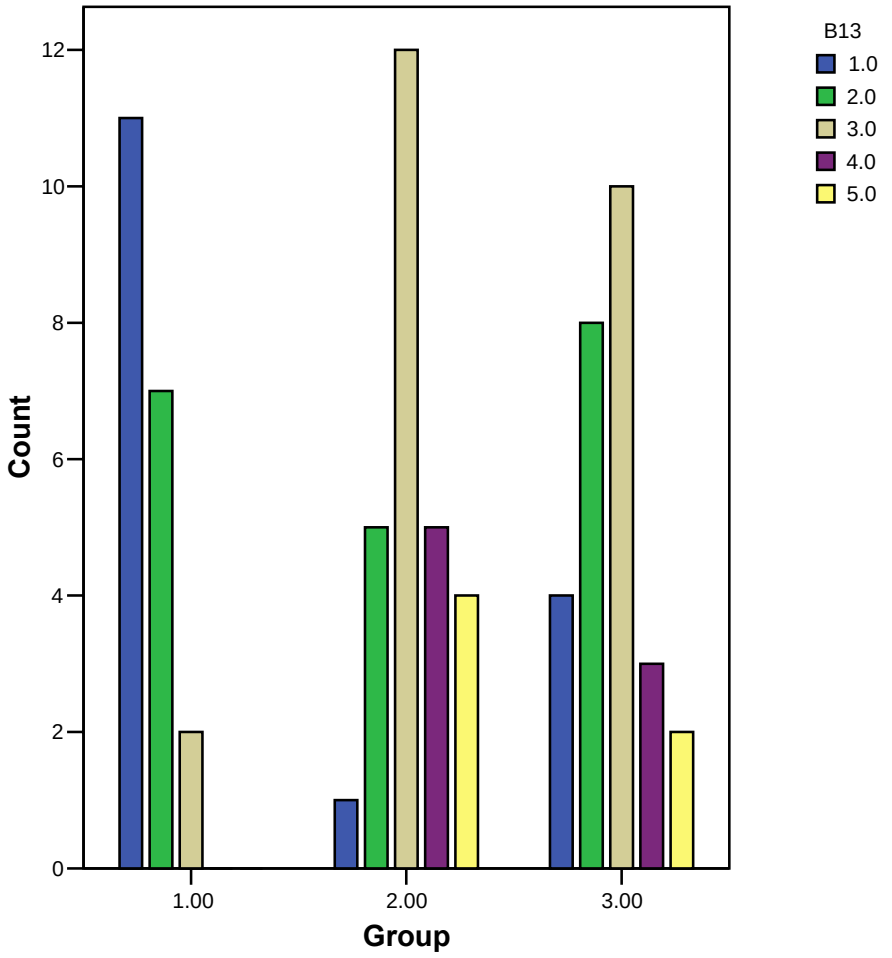


Atmosphere is tense and stressful for family members



Atmosphere is tense and stressful for staff

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CHER NICU POWERPOINT PRESENTATION
CEU Questions

The following are a list of questions. Correct answers are at the end.

1. Research methodologies used in this study included all except:
    a. Questionnaires
    b. Behavior mapping
    c. Plan review
    d. Structures interviews

2. Positive aspects of single family rooms (SFR) include all of the following, except:
    a. Increased interaction between sets of parents
    b. Control of light
    c. Privacy
    d. Larger areas at infant station to accommodate families

3. According to the literature review, families list the following as important amenities or factors, except:
    a. A place to rest
    b. Access to food
    c. Access to doctor's offices
    d. Protection for their infants from lighting and noise

4. According to the literature review, in the US the estimated cost of neonatal care in the first year of life exceeds:
    a. $2-4 billion US dollars
    b. $5-6 million US dollars
    c. $2-4 hundred thousand US dollars
    d. $5-6 hundred thousand US dollars

\

5. According to the literature review, nosocomial infections increase length of stay for the infant up to 24 days with an increased cost of up to _____ per patient.
    a. 25%
    b. 20%
    c. 15%
    d. 10%

6. Single family room design is gaining popularity because of the following factors, except for:
    a. Data on the positive impact of developmentally appropriate care
    b. Increased understanding of the value of breast feeding and kangaroo care
    c. The hospital-wide trend towards single patient rooms
    d. Estimated savings on construction costs

7. In the literature review, it is discussed that existing single family room research:
    a. Provides extensive data on patient outcomes
    b. Outlines comprehensive evidence-based programs for successful design
    c. Is limited, justifying the need for further research
    d. Provides a case for administrative cost savings

8. Three configuration types of neonatal intensive care units were identified in addition to Single Family Room (SFR), except one of the following:
    a. Open-bay unit
    b. Congregate unit
    c. Combination unit
    d. Double occupancy unit
    e.
9. The analysis methodology for construction costs was:
    a. Adjust to the year 2005; normalize to the national average cost
    b. Adjust to the year 1995; normalize to the regional average cost
    c. Adjust to the year 2000; normalize to the regional average cost
    d. Adjust to the year 1995; normalize to the national average cost

10. The objectives of the staff survey included all except one of the following. Select the objective that was not part of this survey:
    a. Document staff preferences
    b. Document staff satisfaction levels
    c. Document perceived stress levels
    d. Document staff attrition

11. Unit space allocation for NICU design in this study considers which of the following:
    a. Circulation, family space, infant care area, staff work space
    b. Non-usable square feet, circulation, public area, family space
    c. Medical systems, infant care area, vertical circulation, family space
    d. Circulation, staff work space, infant care area, public space

12. The average space allocated to circulation across all NICU configurations was:
    a. 28%
    b. 26%
    c. 15%
    d. 21%

13. The unit configuration which allocated the most square feet to the family within the infant station area was:
    a. Open-bay unit
    b. Double occupancy unit
    c. Single Family Room unit
    d. Combination unit

14. The unit configuration which allocated the most square feet to the care giver staff within the infant station area was:
    a. Open-bay unit
    b. Double occupancy unit
    c. Single Family Room unit
    d. Combination unit

15. In the findings about the post-occupancy evaluations, which of the following is not controlled by choices made in the design of the environment?
    a. Privacy
    b. Individual control of space (lighting, acoustics, temperature, etc)
    c. Monitoring of infants
    d. Staff development

16. When moving into the new units, hospital records indicated that:
    a. The average daily census increased for all configuration types
    b. The average daily census decreased for all configuration types
    c. The average daily census increased for only single family room configuration
    d. The average daily census decreased for only single family room configuration

17. Staff members in which configuration type were more satisfied with the physical environment?
    a. Open-bay unit
    b. Single Family Room unit
    c. Double occupancy
    d. Combination unit

18. In the staff survey, staff located in the single family room unit were all but one of the following:
    a. More satisfied with their job
    b. Dissatisfaction with work load
    c. More stressed
    d. Preferred the single family room physical environment

19. Recommendations for the design of neonatal intensive care units include all but one of the following:
    a. Increase usable space allocated to families
    b. Rethink the role of the nursing station and charting areas and define needs based on the work patterns and culture of the nursing staff
    c. Centralize clean supply and support spaces to minimize square feet allocation for healthcare staff
    d. Address visual and auditory privacy for patient and their families

20. Recommendations specific to the design of single family room units suggest:
    a. Universal control of the environmental conditions
    b. Minimize non-usable space by limiting congregate spaces in the program
    c. Place handwashing sinks primarily in the corridor of the patient unit
    d. Provide enough space for families who wish to stay with their infants by providing sitting/sleeping furniture, a work surface, and secure storage for personal belongings

Correct Answers

1. Correct answer: d
2. Correct answer: a
3. Correct answer: c
4. Correct answer: a
5. Correct answer: b
6. Correct answer: d
7. Correct answer: c
8. Correct answer: b
9. Correct answer: a
10. Correct answer: d
11. Correct answer: a
12. Correct answer: b
13. Correct answer: c
14. Correct answer: c
15. Correct answer: d
16. Correct answer: a
17. Correct answer: b
18. Correct answer: c
19. Correct answer: c
20. Correct answer: d

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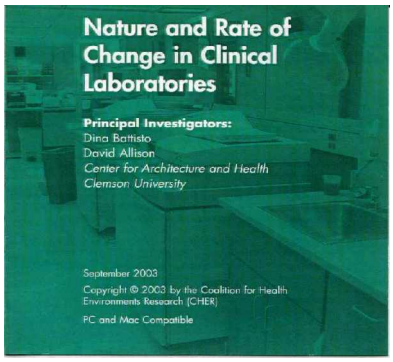


Nature and Rate of Change in Clinical Laboratories

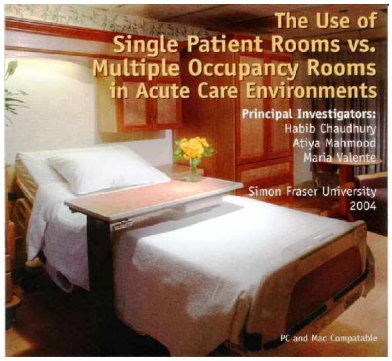
Dina Battisto and David Allison, Architecture + Health, Clemson University

Clinical laboratories in the U.S. are experiencing a tremendous amount of change. Advances in information and automation systems, as well as services and point- of-care testing are influencing laboratory workplaces nationwide. Based on data collected from 240 clinical laboratory staff in community-based hospitals, this 56-page report is a must-read for those who want to know how these changes are affecting the need for flexible building designs and furnishings.

COLOR In Healthcare Environments

Ruth Brent Tofle, Benyamin Schwartz, So-Yeon Yoon, Andrea Max-Royale

Many healthcare providers, designers and practitioners in the field have questioned the relationship between people and color in the environment and searched for empirical reasoning for the various color guidelines in healthcare settings. The evidence-based knowledge, however, for making informed decisions regarding color application in the designed environment has been sporadic, fragmented, conflicting, anecdotal, and loosely tested. This monograph attempts to separate the common myths and realities in color studies and promises to play a stimulating role in the advances of color studies for the built environment, and more specifically in the design of healthcare settings.



The Use of Single Patient Rooms vs. Multiple Occupancy Rooms in Acute Care Environments

Habib Chaudhury, Atiya Mahmood, Maria Valente

This study is a multi-faceted approach to the issues surrounding single occupancy rooms vs. multi-occupancy patient rooms in acute care environments. It consists of a literature review, first cost analysis, and an assessment of operational costs and patient care issues. Overall this valuable study addresses a vital area of interest for hospitals faced with budget constraints and a need to replace existing beds. It combines objective evaluation of first cost with a more subjective survey of nurses, administrators and others to gather their experience with these different room configurations.

The Impact of Single Family NICU Rooms

Debra D. Harris, Mardelle McCuskey Shepley, Robert White, M.D.

A recent trend in the design of neonatal intensive care facilities has been to increase the number of private patient rooms for neonates and their families. Several factors have contributed to the popularity of single family rooms including supportive data on infant outcomes; increased understanding of the value of breastfeeding and kangaroo care; the hospital-wide trend toward private rooms; and the success of innovative prototypes. The implementation of the Health Insurance Portability and Accountability Act (HIPAA) has also influenced the design of NICUs due to the need to provide patient privacy. The purpose of this study is to explore the implications of single family rooms (SFRs) relative to open-bay arrangements in neonatal intensive care units (NICUs).

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