COST AND DESIGN ANALYSIS OF NEONATAL INTENSIVE CARE UNITS: COMPARING SINGLE FAMILY ROOM, DOUBLE-OCCUPANCY, OPEN-BAY, AND COMBINATION SETTINGS FOR BEST DESIGN PRACTICES

By

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of the University of Florida in Partial Fulfillment of the
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Newborn intensive care is care for critically ill newborns requiring constant nursing, complicated surgical procedures, regular respiratory support, or other intensive interventions. Presently, the neonatal intensive care unit (NICU) population is increasing attributable to recent social and demographic trends such as teenage pregnancy, technological advances in neonatology, and fertility medicine techniques causing multiple births and low birth weight neonates. As a result of the increased use of NICUs, many hospitals are remodeling their facilities. Consequently, designers and hospital administrators are in need of information that will help generate knowledge-based guidelines. More specifically, designers and administrators are in need of information regarding the environmental and cost implications between various NICU types. This study examines the construction cost and design implications among four NICUs which offer different settings 1) single family room (SFR); 2) double-occupancy; 3) open-bay; and 4) combination layout.

The case study involved the comparison of four NICUs located in the United States that were built or remodeled since 1995. Construction costs and architectural floor plans were collected from each participant NICU. The floor plans were categorized by use 1) infant; 2) family; 3) staff; 4) systems; 5) unit circulation; 6) family space at bedside; 7) staff space at bedside; and 8) clear floor space. The NICU space allocations were compared across each facility to identify any design trends. The construction costs were adjusted to the year 2005 and normalized to the National City Average. From these results, the cost per square feet (SF) and cost per infant station were calculated and compared.

The primary results showed that the open-bay case had the highest construction cost in both cost categories (cost/SF and cost/infant station) and the combination case had the lowest cost in both cost categories. The SFR and double-occupancy cases offered the most family space bedside and the least family space outside the infant care area. In comparison, the open-bay case offered the least amount of family space bedside and the most amount of family space outside the infant care area. These results pose the questions: 1) is it preferable to have more family space at bedside in the infant care area or 2) is it preferable to have more family space outside the infant care area?

The study recognizes the limitations associated with case study research and that the results are not completely generalizable due to variables which cannot be controlled. Future research focusing on the environmental and cost implications associated with various NICU types is needed to provide the best setting for the patient, family, and healthcare staff.

CHAPTER 1
INTRODUCTION

Newborn intensive care is care for critically ill newborns requiring constant nursing, complicated surgical procedures, regular respiratory support, or other intensive interventions. An infant is considered premature if he or she is born before 37 weeks of gestation and weighs less than 2,500 grams (g). A very low birth weight (VLBW) infant is a child born weighing under 1,500 g (Feldman Reichman, Miller, Gordon, & Hendricks-Munoz, 2000).

There are three levels that define the Neonatal Intensive Care Unit (NICU). Level I (basic) care is a hospital nursery that can perform neonatal resuscitation, evaluate and provide care of healthy newborn infants and near-term infants (35 to 37 weeks' gestation), and stabilize newborn infants born before 35 weeks' gestational age until transfer to a facility that can provide the appropriate level of neonatal care. Level II (specialty) care is a hospital special care nursery that can provide care to infants born at more than 32 weeks' gestation and weighing more that 1500 g. These neonates are moderately ill with problems that are expected to resolve quickly and are not anticipated to need subspecialty services on an urgent basis. Level III (subspecialty) care is a hospital NICU that can provide continuous life support and comprehensive care for high-risk, critically ill newborn infants. Level III is subdivided into three levels differentiated by the capability to provide advanced medical and surgical care (Committee on Fetus and Newborn, 2004). This study focuses on Level III NICUs.

Technological advances in neonatology have resulted in an increase in the NICU population. Recent social and demographic trends including teenage pregnancies, pregnancies with drug abuse, and neglected perinatal care have increased the number of neonates needing special care. In addition, fertility medicine techniques have led to multiple births and low birth weight (LBW) neonates (Mathur, 2004). As a result of the increased use of NICUs, many hospitals are remodeling their facilities (Shepley, 2002). Consequently, designers and hospital administrators are in need of information that will help generate knowledge-based design guidelines.

Purpose

This research project explores the design and financial cost implications of single family room (SFR) NICU facilities. This work is part of a larger effort comparing SFR and multi-bed variation NICUs regarding 1) neonate outcomes; 2) family needs and preferences; 3) staff behaviors and preferences; 4) construction costs, and 5) administrative/operational costs. For the purpose of this study, the researcher compared the construction costs between a SFR, double-occupancy, open-bay, and combination layout NICU, as well as the environmental implications of each type of NICU.

Significance

An efficient and nurturing physical environment is critical for the support of premature infants, their families, and the healthcare staff that care for them. The advancements in neonatology, increasing NICU population, and need for updated facilities supports research in this area to provide designers with evidence-based guidelines to consult. In conjunction with successful environmental design, the costs of building, maintaining, and operating a NICU is equally important. Research based knowledge on the construction cost of SFR, double-occupancy, open-bay, and

combination layout NICUs is currently lacking and will aid in the decision-making process when designing and building new facilities. The findings will be represented as cost per square feet and cost per infant station, providing healthcare administrators and design professionals key information in determining the best practices for designing NICUs that support patients, families, and healthcare staff. Additionally, for each setting, circulation and space allocations for infant, family, and staff are compared to better understand how space is allocated for differing types of NICU facilities.

CHAPTER 2
LITERATURE REVIEW

Introduction

The design of the NICU is multifaceted because the environment affects the premature infant as well as the healthcare staff which, in turn, impacts the infants. NICU design is further complicated because alongside environmental impact concerns, one must be concerned with the obvious costs (construction and operational) and less obvious costs to family and staff such as environmental stress, preferences, and satisfaction.

This review of the literature focuses on recent trends and research of environmental factors in the NICU and their affect on the newborn infants, their family, and healthcare staff. Two nursing philosophies, family-centered care and developmental care are introduced. In addition, the limited research on construction cost, specifically construction costs for NICUs will be discussed. Finally, the literature on floor plan evaluations as a research instrument will be presented.

NICU Design and History

Traditional NICU designs have varied from open rooms supporting 10-50 incubators to smaller rooms with four-to-eight station pods, separated either by walls or cubicle curtains (Mathur, 2004; Shepley, 2002). In the 1980s, the benefits of family participation in the care of their babies were realized. This change in care philosophy influenced the design of the pin-wheel configuration where patient privacy was addressed. With the use of the pinwheel configuration (Figure 2-1), privacy (not necessarily lighting or acoustical privacy) can be afforded by partitions and headwalls in-

between the incubators, while allowing staff to observe several neonates at a time (Mathur, 2004).

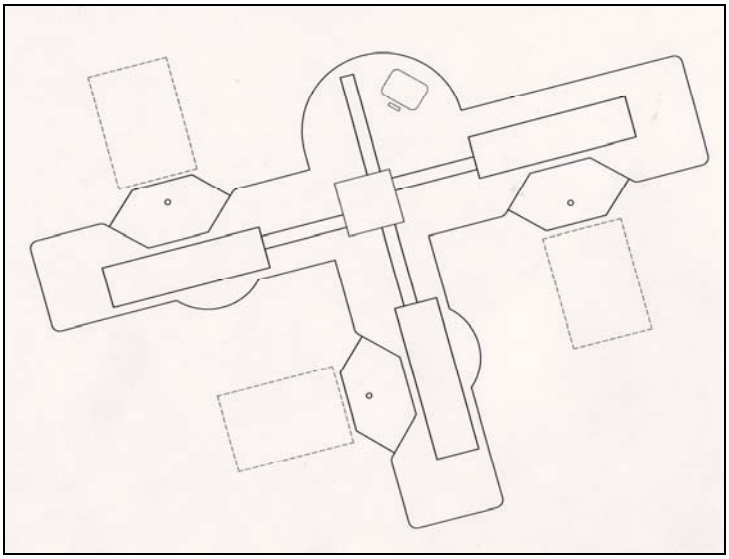

Figure 2-1: Example of Pin-wheel Configuration which is commonly used in open-bay layout NICUs

Recently, a trend in the design of NICUs has been to increase the number of private patient rooms for neonates and their families. Several factors have contributed to the recent popularity of SFRs 1) supportive data on infant outcomes; 2) increased understanding of the value of breastfeeding and kangaroo-care (Ferber & Makhoul, 2004); 3) the hospital-wide trend toward private rooms (Mader, 2002; Mathur, 2004); 4) the success of family-centered and developmental care (Cohen, Parsons, & Petersen, 2004; Robison, 2003); and 5) the success of innovative prototypes.

Some resistance to the SFR NICU is based on the perception that it would require more staff because all neonates can not be observed at all times if residing in single patient rooms. It is thought that an open floor plan reduces the need for staff to make frequent trips between unit bays and storage areas, thereby enabling them to spend time with infants (Shepley, 2002). In order to enable nurse's constant supervision of neonates in the SFR setting, it is essential that SFR units use communication technology to

mitigate the perceived need for more staff. Today's advanced monitoring, surveillance, and nurse locator systems can immediately notify staff of patient activities and allow access to patient information from remote locations (Mathur, 2004). Another perceived disadvantage to the SFR NICU is the notion that SFR design is more expensive than traditional designs because it requires more square footage (Moon, 2005). Unfortunately there is limited data to validate these assumed advantages and disadvantages of SFR, open-bay, and multi-bed variation NICUs.

NICU Environment and Its Effect on Neonates

Recent studies have shown that an environmentally sensitive NICU can enhance growth, shorten stay, and reduce hospital costs (Malkin, 1992; Mathur, 2004). Features of the NICU physical environment taken into design consideration often focus on environmental control: lighting control, acoustic control, temperature control, infection control, privacy and security. Other variables such as color and comfort are important environmental factors to be considered in the research, design and development of NICUs.

Light and Noise

The NICU requires a range of lighting levels to regulate neonates' biological rhythms, perform procedures, evaluate skin tone, and ensure the psychological well-being of staff and families. Unfortunately, these bright lights can be painful and stressful to premature infants. Constant light may disturb body rhythm interrupting their sleep cycles and bright light may not permit neonates to open their eyes and look around (Malkin, 1992; Mathur, 2004; Nair, Gupta, & Jatana, 2003; White, 2002). It has been shown that cycled light, instead of continuous light, can improve the growth rate of premature infants (Miller, White, Whitman, O'Callaghan, & Maxwell, 1995). Although covering isolettes

to minimize light exposure is practiced in many NICUs, isolette covers should not totally block an infant from view, because of the need to view the patient (Aucott, Donohue, Atkins, & Allen, 2002). It is recommended that light sources be balanced and free as possible of glare and veiling reflections (White, 2002).

The noise level in a functioning NICU impinges on the infants, staff, and family. The level of noise is a result of many things 1) the operational policies of the unit; 2) the equipment selected for the unit; and 3) the basic acoustic qualities of the unit's design and finishes (White, 2002). NICU sound levels can be compared to "light auto traffic" at 70 decibels; infants are often exposed to these continuous high decibel levels with no escape. The constant noise; besides being stressful, may lead to hearing loss for the infant (Levy, Woolston, & Browne, 2003; Malkin, 1992; Nair et al., 2003).

The effect of reducing light and noise between 7pm and 7am was examined in a randomized controlled trial. It was found that decreasing sound and light for 12 hours every night resulted in improved weight gain and increased time sleeping for neonates (Mann, Haddow, Stokes, Goodley, & Rutter, 1986). Levy et al. (2003) compared the mean noise amounts between Level II and Level III NICUs. It was found that mean noise amounts are significantly higher in Level III NICUs than in Level II NICUs. Considering the acuity of the patient, noise control is especially important in Level III NICUs.

Researchers have tried to develop systems to reduce noise in open-bay NICUs. It has been found that noise amounts can be decreased significantly by implementing regular quite hours and by modifying nursery layouts, especially placement of incubators (Strauch, Brandt, & Edwards-Beckett, 1993). Berens and Weigle (1996) proposed an

innovative NICU design that dramatically reduces noise by separating physically and acoustically, all of the NICU “noisemakers” into a control room. Other inexpensive strategies for noise reduction include 1) placing blankets over incubators to muffle sound (this technique limits visibility to neonates); 2) using padded plastic garbage cans instead of metal; 3) padding incubator doors; 4) rearranging incubators to reduce pockets of increased or focused noise; 5) removing water from ventilator tubing frequently to reduce bubbling noises; 6) placing noisy equipment such as telephones, radios, and centrifuges in a separate room adjoining the unit or in an isolated pod away from infants; 7) modifying heating and cooling systems to reduce noise; 8) talking quietly and closing doors and portholes gently; and 9) not dropping things on top of the incubator (Levy et al., 2003; Nair et al., 2003). The use of acoustical ceiling systems and carpet also assist in noise abatement, but must be selected and designed carefully for high performance results (White, 2002).

The design of health care facilities is governed by many regulations and technical requirements; it is also affected by many less defined needs and pressures. The implementation of the Health Insurance Portability and Accountability Act (HIPAA) has influenced hospital design, including NICU design, due to the need to provide patient privacy. These regulations put new emphasis on acoustic and visual privacy, and may affect the location and layout of workstations that handle medical records and other patient information, both paper and electronic, as well as patient accommodations (Carr, 2005). According to Mathur (2004), individual private rooms are the only reasonable way to meet the acoustical privacy requirements under HIPAA.

The control of light and noise is important and must be addressed in NICUs. The control of light levels may be more manageable in SFRs because the light requirements are only dictated by one patient and one family. As discussed, there are many strategies to limit noise and provide lighting strategies in open-bay layouts. However, personal control of noise and light for each neonate and family is desirable to suit their individual needs (Mathur, 2004).

Infection Control

Hospital acquired infections are common in very low birth weight (VLBW) infants; occurring in approximately 20% of VLBW infants (Gaynes, Edwards, Jarvis, Culver, Tolson, Martone, 1998; Sohn, Garrett, Sinkowitz-Cocran, Grohskopf, Levine, Stover, Siegel, Jarvis, Pediatric Prevention Network., 2001). Due to neonates' immature immune system, the NICU is a high risk area for developing infections. In open-bay NICUs, infection control may be complicated because particulate matter tends to move freely in an open space. According to Mathur (2004), isolating neonates from each other and from outside sources of infections is the most effective solution for infection control in NICUs; hence, according to Mathur a SFR NICU provides the best isolation for neonates. Many hospitals are moving towards private rooms to help with infection control (Mader, 2002). If the use of single rooms reduces communicable infections; the results may translate into financial savings (Price Waterhouse Coopers Web site, 2004) and less stress on the neonates.

NICU Environment and Its Effect on Family

The impact of family presence and visiting policy is commonly addressed in NICU research. For family members visiting their premature babies, privacy and comfort are important features to provide for them (Shepley, Fournier and McDougal, 1998). Parents

experience a high level of stress in the NICU due to confusing medical information, conflict with responsibilities at home, difficulty getting to distant facilities, loss of earnings, the high temperatures in a unit, and caring for a sick child (Callery, 1997; Goldson, 1992; Raeside, 1997). It has been noted that increased visitation with the baby in the NICU results in a better chance of recovery (Zeskind & Iacino, 1984). Based on Zeskind and Iacino's findings pertaining to the positive effects of increased family visitation; providing a NICU environment that is comfortable for visiting families is optimal.

Research on family stress and needs in the NICU is important; presently research concerning family issues regarding the diverse NICU arrangements would be beneficial. Are there differences in parent-child interaction in the four settings (e.g., number of visits, time spent at bedside)? Which type of unit is most preferred by families? These parent-child issues will be investigated in the larger NICU research project. The family needs and preferences will be studied by data collection from medical charts relating to parent participation. Plus, a family survey will concentrate on the family-centered care philosophy and how the facility supports the parents, siblings, and other family members.

NICU Environment and Its Effect on Healthcare Staff

The NICU environment can be highly stressful for the healthcare staff, suggesting that, to reduce stress, the facility layout must support their activities (Shepley, 2002). It is thought that SFRs may increase the amount of time nurses spend walking in the NICU. In a longitudinal case study performed by Shepley (2002), nurse time spent walking in an open-bay NICU was compared to the original closed bays. The hypothesis that the total amount of time spent walking from activity to activity would be reduced was not supported. Hence, an open-bay layout does not necessarily produce less walking distance

for nurses compared to closed bay units, and may not minimize walking distances in single family room units.

Within the context of the parent study, staff behaviors and preferences will be compared in both the private and open setting. This data will be extracted from anonymous hospital records (medical errors, staff turnover, staffing numbers) and collected by administering a survey targeted to the healthcare staff.

Nursing Models: Family-Centered Care and Developmental Care

Family-Centered Care

A move toward family-centered care and a consumer-focused orientation have resulted in the widespread use of individual private rooms for obstetrical services and universal patient rooms (Mathur, 2004). Family-centered care is the philosophy that the healthcare providers and family are partners, working together to best meet the needs of the patient by promoting communication, respecting diversity, and empowering families. Full parent participation in care requires unrestricted access to the neonatal intensive care unit which may increase the potential infection risk (Moore, Coker, DuBuisson, Swett, & Edwards, 2003). The literature suggests that the family-centered care delivery model improves satisfaction with the hospital experience and that parents who are informed and involved are more confident and competent caring for their sick children (Cohen et. al, 2004). Single family room NICUs may provide the best setting for family-centered care by affording an area for each family adjacent to the neonate; as well as providing a setting that may help with infection control.

Developmental Care

Developmental care consists of four standards in the NICU 1) caregiving is flexible, individualized, and responsive to vulnerabilities of every infant; 2) parent-infant

relationships are supported from birth; 3) all caregivers practice collaboratively; and 4) a developmentally appropriate environment is provided (Robison, 2003).

Als, Buehler, Duffy, Liederman, & McAnulty (1995) assessed the effectiveness of individualized developmental care in the NICU for low-risk pre-term infants. The control group received standard care and the experimental group received individualized care at the same facility. Results showed that individualized care supports neurobehavioral functioning and appears to prevent frontal lobe and attentional difficulties in the newborn period, the possible causes of behavioral and scholastic disabilities often seen in low-risk pre-term infants in later ages .

The Journal of the American Medical Association (1994) reported that infants who were provided with developmentally supportive care through control of the environment and individualized attention were found to benefit from a reduced dependence on respiratory support, earlier oral feeding, reduced incidence of complications, improved weight gain, shorter hospital stays, and reduced costs of care, compared with infants not provided this type of care in the control group (Als, Lawhon, Duffy, McAnulty, Gibes-Grossman, & Blickman, 1994; Robison, 2003).

A NICU that provides more control over environmental features may better support developmental care since developmental care focuses on uninterrupted sleep, self regulation, and decreasing both light and noise in the NICU environment (Robison, 2003).

Recommended Standards for NICU Design

The Guidelines for Design and Construction of Hospital and Health Care Facilities (2003) serves as a standard for American hospital and medical facilities. In a multi-bedroom unit, every bed position shall be within 20 feet of a hands-free hand washing

station. Where an individual room concept is used, a hands-free hand washing station shall be provided within each infant care room. In the interest of noise control, sound attenuation shall be a design factor. Provisions shall be made for indirect lighting and high-intensity lighting in all nurseries. Controls shall be provided to enable lighting to be adjusted over individual patient care spaces. Each patient space shall contain a minimum of 120 square feet (SF) per bassinet excluding sinks and aisles. There shall be an aisle for circulation adjacent to each patient care space with a minimum width of three feet. Each infant care space shall be designed to allow privacy for the baby and family. The NICU shall be designed as part of an overall safety program to protect the physical security of infants, parents, and staff to minimize the risk of infant abduction (The American Institute of Architects Academy of Architecture for Health, 2003). These recommendations are the benchmark for design standards. Many municipalities adopt these standards, in effect; making the guidelines required minimum standards. Often, hospitals require the design team to follow these guidelines, even when they are not required by law.

Construction Cost

Controlling costs is essential for hospital administrators in today's tough economic environment. The costs to the healthcare system are many and complex, including upfront cost associated with the construction of the facility. Construction costs can vary depending upon a number of factors such as 1) local, state, and national regulations; 2) type of contract (negotiated, hard bid, guaranteed bid max); 3) season of year; 4) contractor management; 5) weather conditions; 6) local union restrictions; 7) building code requirements; 8) availability of adequate energy, skilled labor, and building

materials; 9) owners special requirements/restrictions; 10) safety requirements; 11) size of project; and 12) location of project (Waier, 2005).

The type of project also has great influence on construction cost: new construction or remodel. In the case of a remodel, the extent to which the existing building impedes 1) construction activity; 2) the extent of demolition required; and 3) utilities that may have to be relocated affect costs. Decisions affecting cost of new construction can include: 1) selection of the site; 2) selection of the basic structural system, mechanical and electrical system types; and 3) exterior envelope criteria (Bobrow & Thomas, 2000).

Healthcare construction costs vary by region, with a premium for construction in seismically active areas (Bobrow & Thomas, 2000). When making cost comparisons from city to city and region to region, the Means City Cost Indexes (CCI) is a valuable tool, since hospitals in urban areas tend to have higher costs due to a higher cost of living than do hospitals in rural areas. The publication contains 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 one-million dollars and up. The costs are primarily for new construction or major renovation of buildings. A city cost can be adjusted to the national average or to a specific city. The 30 City Average Index is the average of 30 major U.S. cities and serves as a national average (Waier, 2005).

When comparing construction costs between different years, the costs should be normalized to the same year. The Means Historical Cost Index can be used to convert building costs at a particular time to the approximate building costs for some other time (Waier, 2005).

Floor Plan Analysis

Archival data collection and/or post-occupancy evaluations (POE) can offer useful cost-saving knowledge. Each project, no matter how well executed, has both successes and failures; designers can learn from POEs and improve the design of future facilities (Wang, 2002). Preiser, Rabinowitz, and White (1988) divide POEs into three levels of involvedness: indicative POE, investigative POE, and diagnostic POE. An indicative POE is one that analyzes as-built drawings and lists them into topics; and interviews are conducted with building occupants to better understanding 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 multi-methodological approach (surveys, observations, physical measurements, etc.) conducted in comparison to other facilities.

The research method of floor plan analysis for this endeavor is a combination of the three types of POEs as written by Preiser et al. (1988). The floor plan analyses involved examination of as-built drawings, comparison with comparable facilities, and measurements categorized into topics.

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. The floor plan evaluations will help clarify the suggestion that SFR NICUs require more space and potentially a higher cost than open-bay or multi-bed variation units.

CHAPTER 3
METHODOLOGY

Research Design

The objectives of this study were two-fold 1) to compare the construction cost of four NICU types and 2) to analyze the floor plans of each case to identify any design trends within each setting. The research method used for this project is a multiple comparison case study. The dependent variables are Level III NICUs built or remodeled since 1995. The independent variables are single family room (SFR), double-occupancy, open-bay, and combination layout NICUs. Four cases that offer contrasting situations were compared and analyzed. The project incorporated three phases 1) data collection; 2) data analysis; and 3) comparison of case study results. The research project took place at the University of Florida in Gainesville, Florida.

Sampling Procedures

Hospitals were selected for this study by a sample of convenience. The hospitals are located in the United States and meet the criteria for nursing model and unit design (SFR, double-occupancy, open-bay, or combination). Thirty-one Level III NICUs built or remodeled since 1995 were identified as meeting the inclusion criteria and asked to participate. The hospitals were sent a letter explaining the research project and asked to voluntarily participate in the study and those who agreed to participate were included in the study (see Appendix A).

Participants

Eleven hospitals across the United States formally agreed to participate in the study. From the eleven participants, a comparison based on plan evaluation, photographs, and printed documentation from four hospitals was completed (Figure 3-1).

Figure 3-1: Geographic Location of Participants

Because of design variation, four categories have been developed 1) single family room; 2) double-occupancy; 3) open-bay; and 4) combination (a mixture of SFR, open-bay and double-occupancy).

Inclusion criteria requires the NICU must be Level III, built since 1995, hold 16 beds or greater, and have an average census of twelve patients per day or greater. Participation is voluntary and based on informed consent (see Appendix B).

Ethics

There are limited ethical concerns to be aware of with this research project as there are no human participants or patient records to alter. Furthermore, the participating hospital's names will remain anonymous. However, the researcher is aware of the Belmont Report on ethical principles and guidelines for the protection of human subjects

of research. This research project does not require Institutional Review Board (IRB) approval; nevertheless it falls under the larger project's IRB approval. The researcher completed and received the certificate of completion for HIPAA for researchers at the University of Florida on September 28, 2004 (see Appendix C). Hence, the researcher understands the importance of providing privacy for participants and documents that may be involved in this research endeavor.

Hospital participation in this study is voluntary and no monetary benefit or coercion to participate was used. Explicit authorization was obtained before any hospital records were investigated. The incentive to participate in this study is to help add to the knowledge base of NICU design to provide the best environment for the patient, family, and staff.

The compilation of data to compare and conclude outcomes must be an ethical process. The researcher is aware of the unethical practice of slanting or changing data to produce a significant or specific outcome. For this research project, any significant data serves a positive purpose for future NICU design.

Data Collection

Information specific to the NICUs participating in the study was collected with the approval of the healthcare facilities administration. Data collection involved collecting archival data associated with the reviewed plans for construction costs. The floor plans were requested to be sent as AutoCAD files, AutoCAD is a computer aided drawing program commonly used by architects and interior designers. The construction costs gathered from the hospital's facilities department were primarily sent electronically or by mail. The construction costs are limited to the cost of the Level III NICU, which in some cases required extraction from a larger project. Photos and marketing materials were also

requested with permission to publish to help further identify various design features in each NICU (see Appendix D and Appendix E).

The AutoCAD drawings requested from each participant consist of 1) floor plan with labels; 2) furniture plan and equipment plan; 3) finish schedule; 4) reflected ceiling plan; 5) lighting power and systems plan; 6) sections; 7) elevations; 8) headwall elevations; and 9) door schedule (see Appendix F). The plans that were most beneficial were the floor plans and the furniture, fixture, and equipment plans.

Data Analysis

Floor Plans

Following the collection of floor plans and architectural documents from the four NICU facilities and performing an initial literature review, a system was developed to effectively organize and analyze the floor plans. The purpose of the plan evaluations was to examine NICU design issues and identify trends in design layout. The main focus of the four plan evaluations was on the allocation of space for the staff, patient, and family; as well as the amount of space allocated to unit circulation.

The first step of the plan analysis phase involved assessing each NICU by categorizing every room into one of twelve categories: patient, family, public shared, staff medical, staff communal, staff office, staff, storage, service medical, service facility, circulation vertical, and unit circulation. Next, the twelve categories were assigned to one of six general categories: patient, family, staff, public, systems, and unit circulation. This step helped to clearly identify the allocation of space within each unit for the six main area categories.

The square feet (SF) total of every space was measured and listed in a Microsoft Excel spreadsheet. The amounts of family and staff space at each baby station were

identified. This was accomplished by measuring midpoint at each isollette to divide the room or space into half, not including the actual baby station. The amount of family space at bedside and staff space at bedside was listed in a Microsoft Excel spreadsheet. Last of all, the amount of clear floor space for each infant area was measured and calculated. This step was completed by totaling the family and staff space in each infant area and then subtracting any permanent fixtures such as sinks and/or counters.

After the floor plans were assessed and measured, three sets of diagrams were prepared for each setting 1) circulation diagram; 2) allocation of space diagram; and 3) infant care area diagram. The diagrams overlaid the AutoCAD floor plans to precisely illustrate the allotment of spaces each case provides. The diagrams helped to identify the circulation patterns and user zones for each setting (see Appendices J-M and Appendices N-Q).

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. Once all of the plans were measured and calculated, the net to gross factor for each facility was calculated (the amount of space taken up by walls and unusable space).

Construction Cost

The breakdown of cost topics requested from each participant was 1) land acquisition; 2) construction cost; 3) design and engineering fees; 4) owner construction administration; 5) development and soft cost; 6) equipment; 7) furnishings and fixtures; and 8) financing (see Appendix F). From this information, only the construction costs were extracted for comparison. Once the costs were collected and organized, the cost needed to be adjusted to the year 2005 and normalized 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 (see Formula 3-1). After the costs were adjusted to 2005, the Means City Cost Indexes were used to compare cost from city to city, with the end result normalized to the National City cost average (see Formula 3-2).

- Formula 3-1

$$\frac{Index\ \ for\ Year\ X}{Index\ \ for\ Year\ 2005} \times Cost\ in\ 2005 = Cost\ in\ Year\ X$$

Using formula 3-1, the Historical Cost Index for a specific year *X* was divided by the Cost Index for year 2005; the decimal value was then divided into the particular hospital construction cost, giving the approximate cost if that facility was built in 2005.

- Formula 3-2

$$\frac{Specific\ City\ Cost}{National\ \ Average\ Cost} \times 100 = City\ Cost\ \ Index$$

Using formula 3-2, to obtain the National Average Cost, the particular construction cost (Specific City Cost) was multiplied by 100 (the National Average Index) and then divided by the specific city cost index, giving the adjusted cost of that facility in comparison to the National Average.

Once the NICU construction costs were adjusted to be comparable in year and region, the costs were divided by the total square feet of the unit to give the cost per square foot for each case (see Formula 3-3).

- Formula 3-3

$$\frac{Adjusted\ Construction\ Cost}{NICU\ \ Square\ Feet} = Cost\ \ per\ Square\ Foot$$

Additionally, the construction costs were divided by the number of beds in each unit to provide the cost per infant care area (see Formula 3-4). The results should serve

as a general guide for the cost of building SFR, double-occupancy, open-bay, and combination layout NICUs.

- Formula 3-4

$$\frac{Ajusted\ Construction\ Cost}{\#\ of\ \ Beds} = Cost\ \ per\ InfantStation\,.$$

CHAPTER 4
RESULTS OF THE STUDY

Demographic Descriptive Information

Single Family Room NICU Description

The SFR NICU is located in the Midwest. In a typical year, the unit cares for 350 to 400 high-risk infants. The facility was built (new-construction) in 2001, is located on the 2nd floor, and has 22 Level III licensed infant stations. Included in the 22-bed total is 1 designated isolation room with an ante room adjoining. Each infant room has a daybed, recliner, and phones that flash, not ring. The family lounge has seating, TV/VCR, a kitchenette, and washer and dryer. Adjacent to the family lounge are three sleep rooms with double beds. The NICU patient area has 4 nurse substations as well as 4 breast milk areas equally dispersed. The facility practices family-centered care and kangaroo care.

Double-occupancy NICU Description

The double-occupancy NICU is located in the West. Approximately 1,200 newborns are cared for in the NICU each year. The facility was remodeled in 1998 and has 48 Level III licensed infant stations. Included in the 48-bed total is 1 isolation room. All of the patient rooms are semi-private with the majority (94%) of the rooms being double-occupancy. The infant stations are set-up one of two ways: two beds along the same wall or two beds cattycorner to one another on opposing walls. The family lounge has seating, lockers, laundry facility, shower room, breast feeding room, and 2 sleep over rooms. The NICU patient area has 5 nurse stations equally dispersed. The facility has billowing clouds and fiber optic “stars” which decorate the ceiling.

Open-bay NICU Description

The open-bay NICU is located in the Southeast. The facility was expanded and remodeled in 2004 and has 20 Level III licensed infant stations. Included in the 20-bed total are 2 isolation rooms and 2 ECMO rooms (cardiac bypass for babies). Additionally, the unit has 2 exam areas. The infant stations are set-up two ways: 1) the pin-wheel configuration and 2) open spaces along the perimeter walls. The family lounge has seating, TV/VCR, lockers, restrooms, more breastfeeding space, and a sky light. The NICU patient area has 2 nurse stations.

Combination NICU Description

The combination NICU is located in the South. The facility was remodeled in 2004 and has 45 licensed Level III infant stations. The unit supports a combination layout with three semi-private double-occupancy rooms, six pods of pin-wheel configuration infant stations, open-bays along perimeter walls, and 1 isolation room. Each infant area has a recliner bedside and a sink within close proximity. The family lounge has seating, lockers, a child play area, restroom, family office, and pump room. Eight small nurse areas are spread throughout the NICU patient areas. Both family-centered care and developmental care are practiced by the healthcare staff.

Floor Plan Analysis Results

The floor plans for each NICU were separated into five categories of spaces: infants, family, staff, unit circulation, and miscellaneous. The infant space includes all of the patient rooms together including isolation, ECMO, and ante rooms. The family spaces include the following areas 1) family lounge (restroom, kitchenette, and laundry); 2) sleep-over rooms; 3) breastfeeding and pump rooms; 4) conference and consultation; 5) family scrub; 6) family transition; 7) vending and nourishment; and 8) parent quiet

rooms. Staff space consists of 1) nurse stations and reception; 2) pharmacy; 3) alcoves; 4) staff lounge and lockers; 5) staff restrooms; 6) clean and soiled utility; 7) supply; 8) offices (social service, nurse practitioner, dictation, and physician); 8) labs; 9) procedure areas; 10) medication preparation and formula/breast milk; 11) respiratory therapy; 12) equipment; 13) x-ray; and 14) on-call rooms. Unit circulation includes all lateral circulation throughout the unit. Vertical circulation such as stairs and elevators were excluded from the unit circulation category because external factors such as fire exits and building location influence vertical circulation requirements. Lastly, a category to encapsulate universal building features was developed and designated “miscellaneous”. This category includes 1) public space; 2) systems; and 3) vertical circulation. The systems sub-category includes 1) housekeeping; 2) general storage; and 3) mechanical, data, and electrical rooms.

Single Family Room Floor Plan

The SFR unit is 18,130 square feet (SF). Of the 6 key allocations of space categories, unit circulation comprises the highest percentage of the unit at 28% (Figure 4-1). The average infant station area is 171 SF. The average family space at bedside is 88 SF. The average staff space at bedside is 64 SF. The infant station is 19 SF (Figure 4-2). The average clear floor space is 137 SF, which is 80 % of the room (see Appendix H and Appendix I).

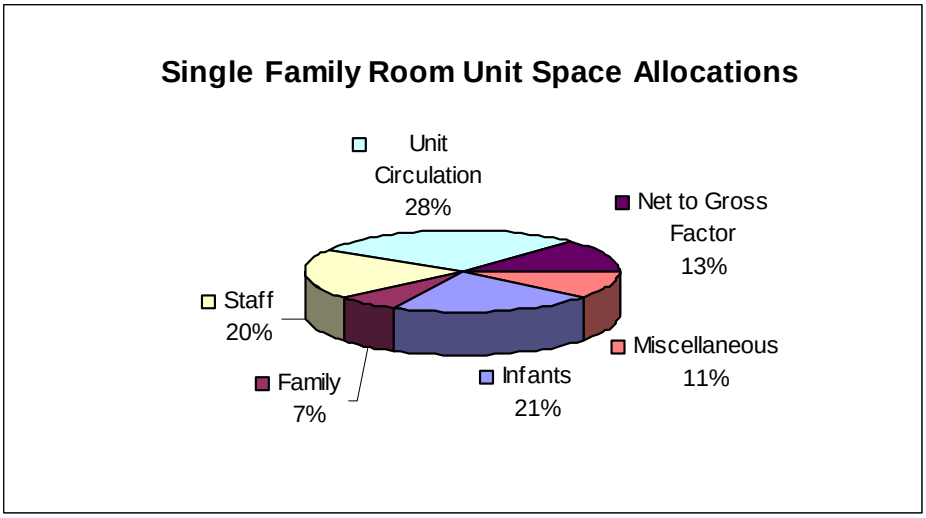

Figure 4-1: SFR Unit Space Allocations

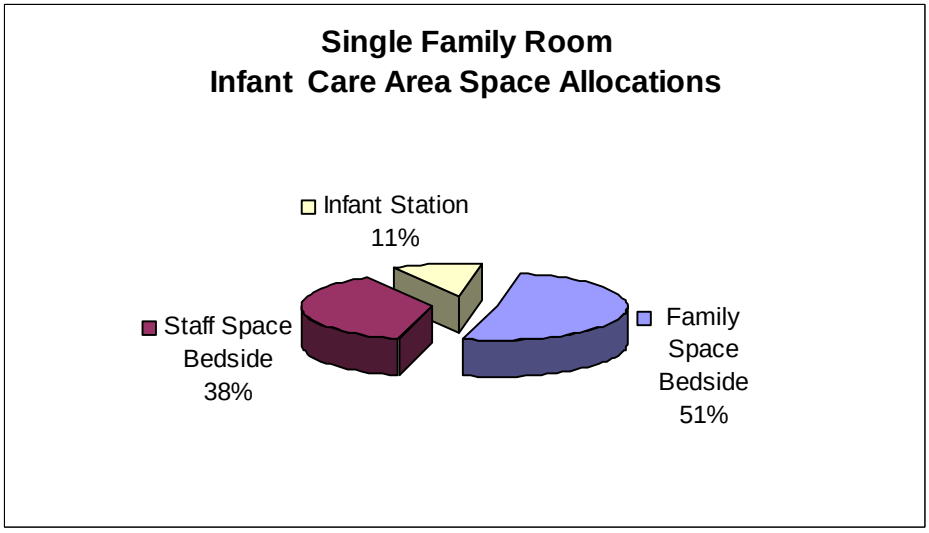

Figure 4-2: SFR Infant Care Area Space Allocations

Double-occupancy Floor Plan

The double occupancy unit is 16,337 SF. Of the 6 key allocations of space categories, infant space comprises the highest percentage of the unit at 33% (Figure 4-3). The average infant station area is 111 SF. The average family space at bedside is 52 SF. The average staff space at bedside is 39 SF. The infant station is 20 SF (Figure 4-4). The average clear floor space is 82 SF, which is 74 % of the room (see Appendix H and Appendix I).

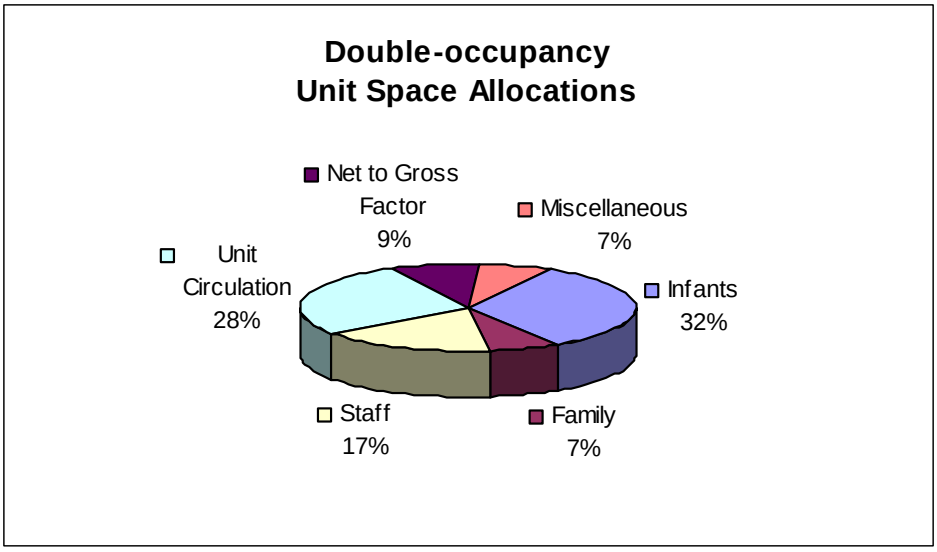

Figure 4-3: Double-occupancy Unit Space Allocations

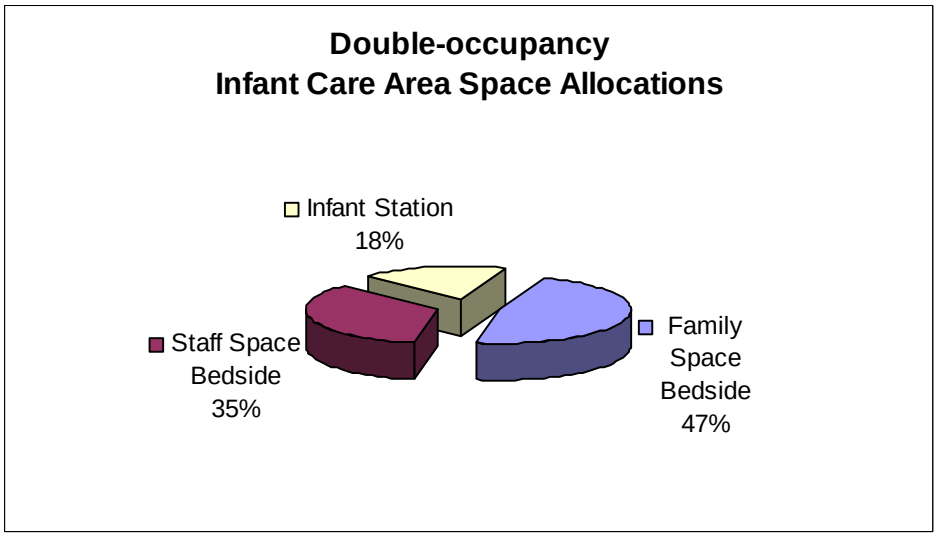

Figure 4-4: Double-occupancy Infant Care Area Space Allocations

Open-bay Floor Plan

The open-bay unit is 10,871 SF. Of the 6 key allocations of space categories, staff space comprises the highest percentage of the unit at 33% (Figure 4-5). The average infant station area is 115 SF. The average family space at bedside is 40 SF. The average staff space at bedside is 48 SF. The infant station is 27 SF (Figure 4-6). The average clear floor space is 85 SF, which is 74 % of the room (see Appendix H and Appendix I).

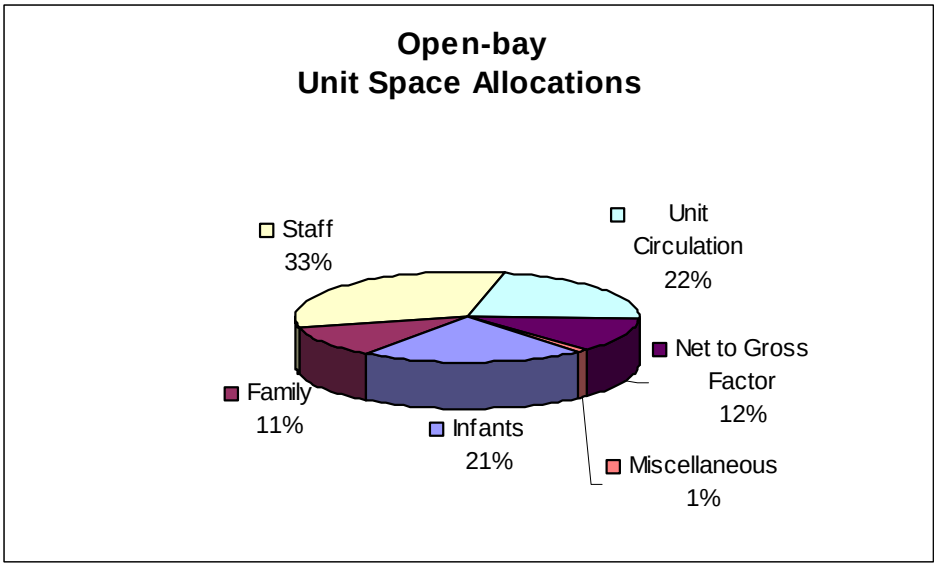

Figure 4-5: Open-bay Unit Space Allocations

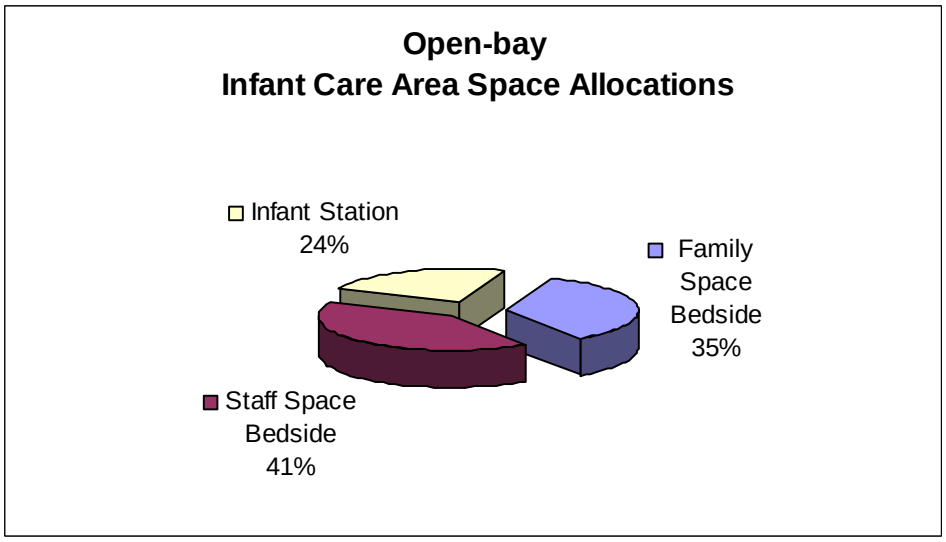

Figure 4-6: Open-bay Infant Care Area Space Allocations

Combination Floor Plan

The combination unit is 20,519 SF. Of the 6 key allocations of space categories, unit circulation comprises the highest percentage of the unit at 30% (Figure 4-7). The average infant station area is 111 square feet. The average family space at bedside is 41 SF. The average staff space at bedside is 42 SF. The infant station is 29 SF (Figure 4-8).

The average clear floor space is 80 SF, which is 72% of the room (see Appendix H and Appendix I).

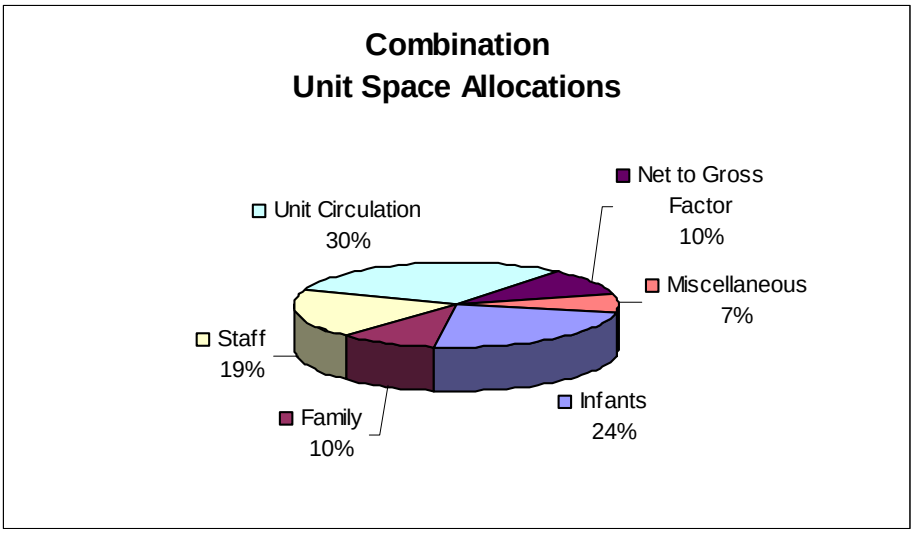

Figure 4-7: Combination Unit Space Allocations

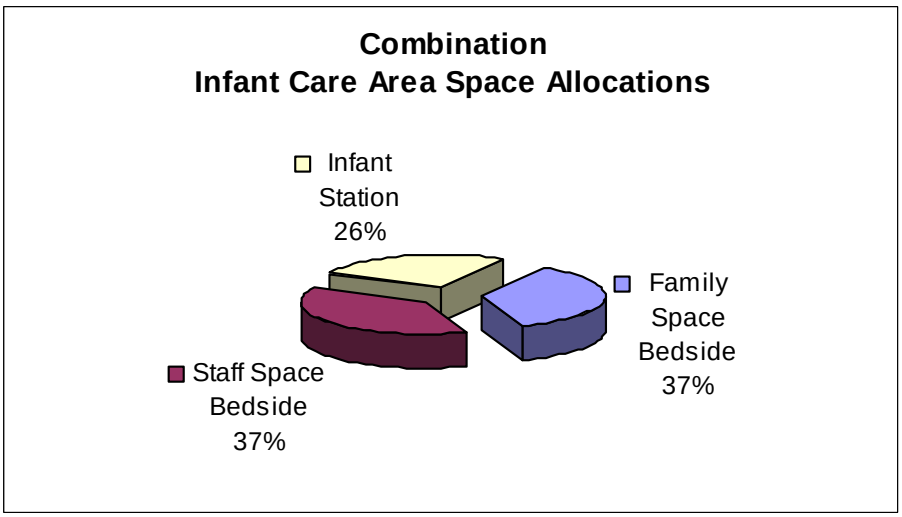

Figure 4-8: Combination Infant Care Area Space Allocations

Construction Cost Results

Single Family Room Costs

The adjusted construction cost for the SFR NICU is $4, 680, 707.00. The cost per square foot is $258.00 and the cost per infant station is $212,759.00 (Table 4-1 and Appendix G).

Table 4-1: Comparison of Construction Cost Data

NICU Type	Adjusted Construction Cost	NICU Square Feet	Cost per Square Feet	Cost per Infant Station
SFR	$ 4,680,707	18,130 SF	$258	$212,759
Double-occupancy	$ 5,399,950	16,337 SF	$331	$112,499
Open-bay	$ 4,387,062	10,871 SF	$404	$219,353
Combination	$ 3,956,015	20,519 SF	$193	$87,911

Double-occupancy Costs

The adjusted construction cost for the double-occupancy NICU is $5,399,950.00. The cost per square foot is $331.00 and the cost per infant station is $112,499.00 (Table 4-1 and Appendix G).

Open-bay Costs

The adjusted construction cost for the open-bay NICU is $4,387,062.00. The cost per square foot is $404.00 and the cost per infant station is $219,353.00 (Table 4-1 and Appendix G).

Combination Costs

The adjusted construction cost for the combination NICU is $3,956,015.00. The cost per square foot is $193.00 and the cost per infant station is $87,911.00 (Table 4-1 and Appendix G).

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CHAPTER 5
DISCUSSION AND CONCLUSSIONS

Findings

The purpose of this research project was to compare four different NICU settings in regards to their construction costs and space allocation features. Present literature has focused mainly on SFR and open-bay NICU settings, though combination and double-occupancy settings are common as well. Each NICU type may have benefits and drawbacks; and there are various techniques to limit the weaknesses in each setting. The review of literature focusing on construction costs reflects the lack of research in this particular area, especially relating to NICUs.

Construction Cost

The NICU construction costs were compared on two levels 1) cost per SF and 2) cost per infant station. The open-bay setting has the highest cost per SF at $404. The combination setting has the lowest cost per SF at $193. Similarly, the open-bay has the highest cost per infant station at $219,353. The combination has the lowest cost per infant station at $87,911. It should be noted that SFR setting was the second lowest for cost per square feet and double-occupancy was second lowest in cost per infant station (Figure 5-1). Figure 5-1 shows the cost results for both cost categories (cost/SF and cost/infant station) for each NICU.

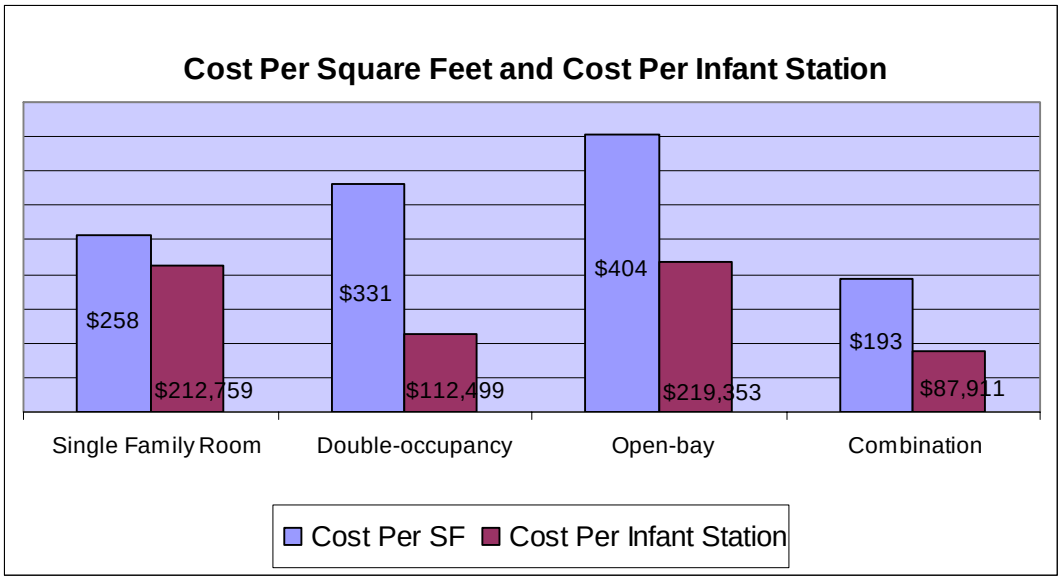

Figure 5-1: Cost per Square Feet and Cost per Infant Station

Floor Plan Space Allocation

The NICU floor plans were evaluated and compared in terms of user and systems space 1) infant; 2) family; 3) staff; 4) unit circulation; 5) net to gross factor; and 6) miscellaneous. The double occupancy setting has the most unit space allocated to patient area at 33%. The remaining NICUs all have similar amounts of space allocated to patient area at approximately 22%. The open-bay setting has the most unit space allocated to family space at 11%. Note that the SFR and double-occupancy settings both allocate the least amount of space to family. The open arrangement has the most unit space allocated to staff at 33%. The combination setting has the most unit space allocated to unit circulation at 30% (Table 5-1).

The infant care areas were analyzed and compared in terms of 1) average infant care area; 2) average family space at bedside; 3) average staff space at bedside; and 4) average clear floor space in infant care area. The SFR setting has the largest average infant care area at 171 SF with the highest amount of clear floor space at 80 %. Also, the

SFR has the highest percentage of family space at bedside at 51% (Figure 5-2). The open-bay setting has the highest percentage of staff space at bedside (42%) (Table 5-2).

Table 5-1: Comparison of NICU Space Allocations: Percentage of Unit

NICU Type	**Infant Space**	**Family Space**	**Staff Space**	**Unit Circulation**	**Net to Gross Factor**	**Miscellaneous**
SFR	21.1%	6.5%	20.3%	28.2%	13.0%	10.9%
Double-occupancy	32.7%	6.7%	17.3%	27.5%	8.5%	7.3%
Open-bay	21.2%	10.9%	32.7%	22.2%	12.0%	1.0%
Combination	24.4%	9.9%	18.8%	29.9%	10.3%	6.7%

Table 5-2: Comparison of Infant Care Area Space Allocations

		Percentage of Infant Care Area		
NICU Type	**Average Infant Care Area**	**Family Space Bedside**	**Staff Space Bedside**	**Clear Floor Space**
SFR	171 SF	51%	38%	80%
Double-occupancy	111 SF	47%	35%	74%
Open-bay	115 SF	35%	42%	74%
Combination	111 SF	37%	37%	72%

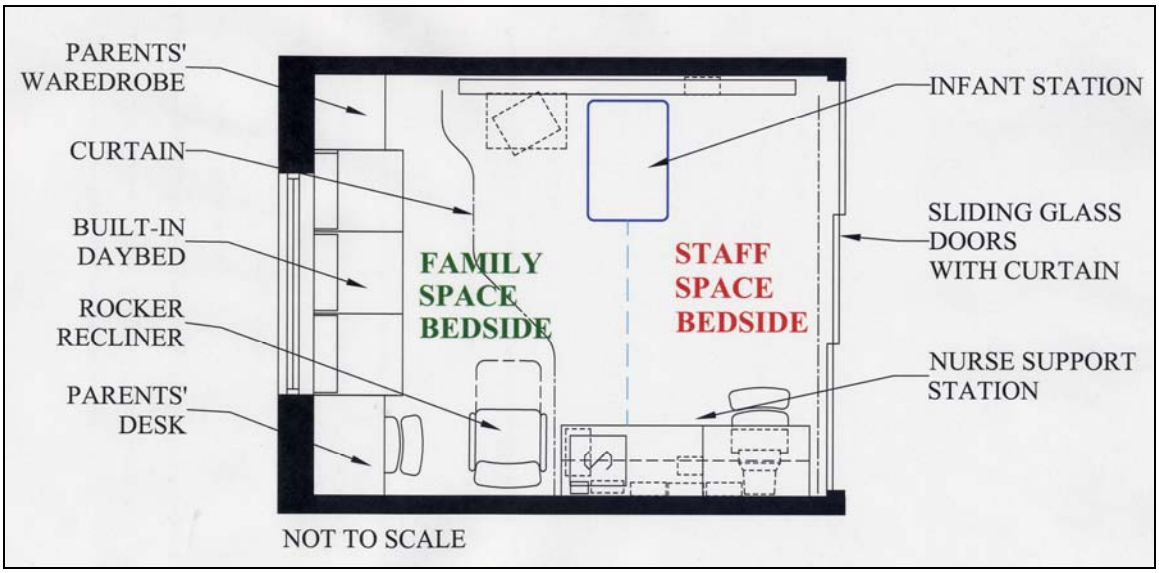

Figure 5-2: SFR Infant Care Area. This diagram shows the typical layout of a private room in the SFR NICU case.

Implications for Research Findings

Single Family Room

According to Mathur (2004), the increased area for SFRs is offset by the elimination of parent sleep rooms within the unit. In comparison to the other NICU cases, the SFR unit allocates the least amount of space to family, which is space outside of the infant care area (lounge, sleep rooms, etc). However, the SFR has the highest percentage of space for the family at bedside (Figure 5-2 and Figure 5-3). These results pose the questions: 1) is it preferable to have more family space at bedside in the infant care area or 2) is it preferable to have more family space outside the infant care area? These results also support Mathur's suggestion that the increased area for SFRs is offset by the lesser amounts of allocated family space in the SFR unit.

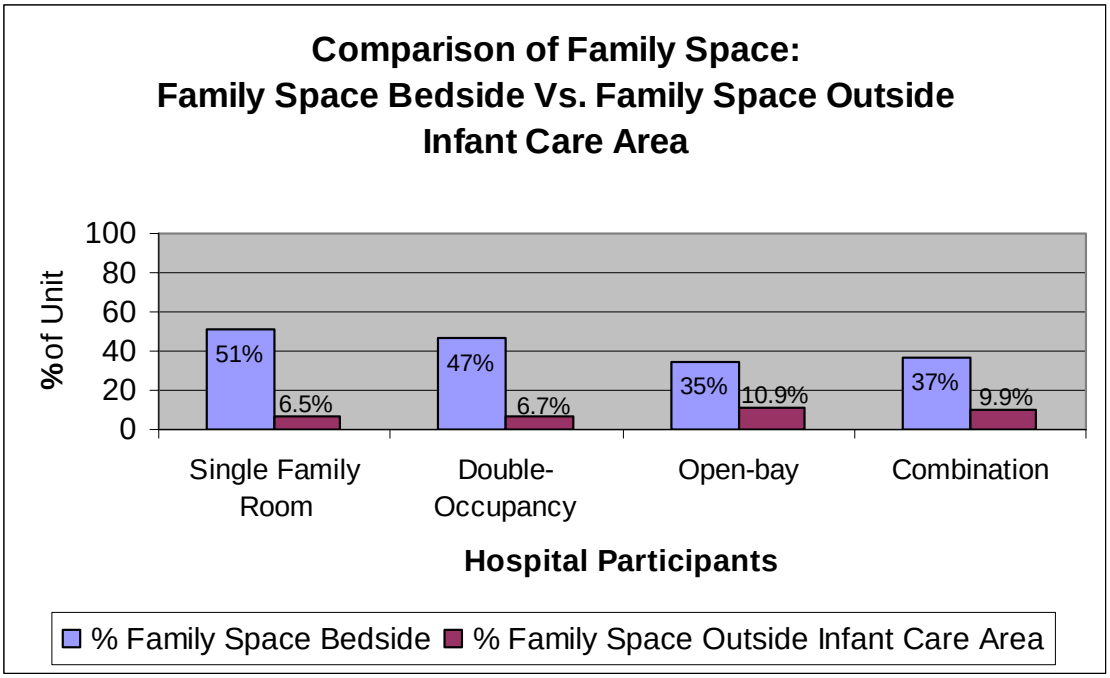

Figure 5-3: Comparison of Family Space Bedside vs. Family Space outside Infant Care Area

According to Moon (2005), providing private rooms (in general) may result in higher costs due to more square footage. The results of this study do not support Moon's position, since the SFR unit was second lowest in the cost per SF category and third lowest in the cost per infant station category (Figure 5-1). Furthermore, the total amount of space offset by the decreased amount of family space outside the infant care area conflicts with Moon's suggestion that private units require more total square footage (Table 5-1).

The assumption that SFRs have a higher net to gross factor is to some extent supported by this study. The SFR unit has the highest net to gross factor at 13%, however the open-bay has the second highest net to gross factor at 12%. The 1% difference may be a result of more family space in the open-bay, which would mean more walls in the family space, increasing the open-bay's net to gross factor (Figure 5-4).

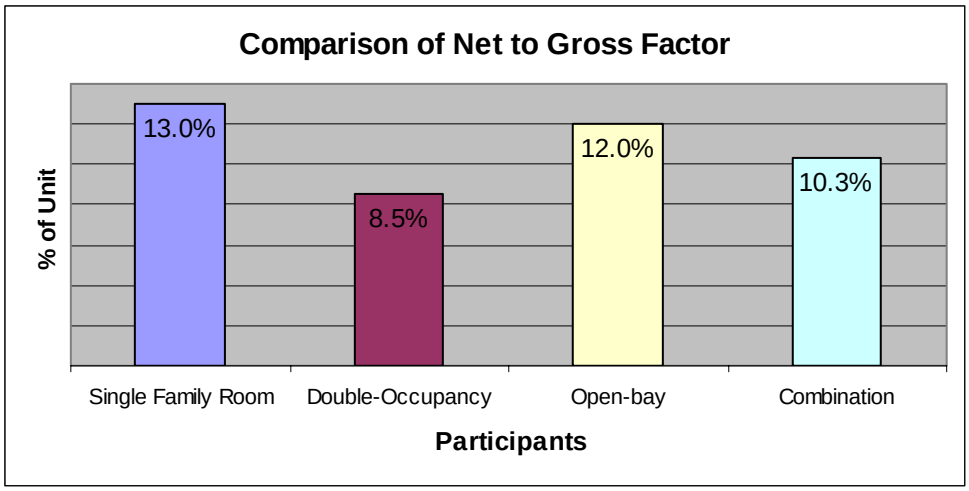

Figure 5-4: Comparison of Net to Gross Factor among Settings

The infant rooms in this particular SFR unit exceed the recommended guidelines for minimum square footage, which is 120 SF. Even so, with the average infant care area at 171 SF and the clear floor space at 80%, this is only approximately 5% more than the double-occupancy and open-bay average clear floor space percentages. Meaning, the extra SF in the SFR setting is not necessarily going to average clear floor space, but to fixed design features such as: sinks, counters, couches, and lockers.

Double-occupancy

The double-occupancy case has similarities with the SFR case. The main difference in the infant care areas between the SFR and double-occupancy is the number of beds in the room. As one might expect, the double-occupancy has the second highest amount of average family space at bedside and second lowest amount of unit space allocated for family (Figure 5-3). Both the SFR and double-occupancy cases have family space outside the patient area, just at a lower percentage. The double-occupancy's cost per SF was in-between SFR and open-bay, but the cost per infant station was significantly lower than the SFR and open-bay (Figure 5-1).

The double-occupancy case was the most efficient from a functionality standpoint; the net to gross factor was the lowest at 8.5% (Figure 5-4). This may be a result of fewer walls used for infant space (2 beds per room instead of 1 bed per room) and fewer walls in family space outside the infant care area.

Open-bay

The open-bay unit has the highest amount of family space outside of the infant care area and the least amount of family space bedside (Figure 5-3). This indicates a priority for family space, though not especially at bedside. The open-bay unit has the highest amount of staff space bedside as well as the highest amount of staff space outside the infant care area. This indicates a priority for staff space throughout the entire unit.

The open-bay unit has the highest costs in both categories (Figure 5-1), a surprising outcome given the assumptions from the literature (Moon, 2005). It should be noted that the open-bay project was a remodel as well as an expansion project. The expansion involved capturing part of the roof space not on the first floor. The expansion of the facility may have increased the construction cost because of additional cost associated with expansion, hence, these factors should be considered when comparing the high construction cost for the open-bay to the other NICU settings.

Combination

The combination setting has the lowest cost per SF and cost per infant station (Figure 5-1). Within the infant care area, the family and staff space bedside are nearly equal to one another (Figure 5-5).

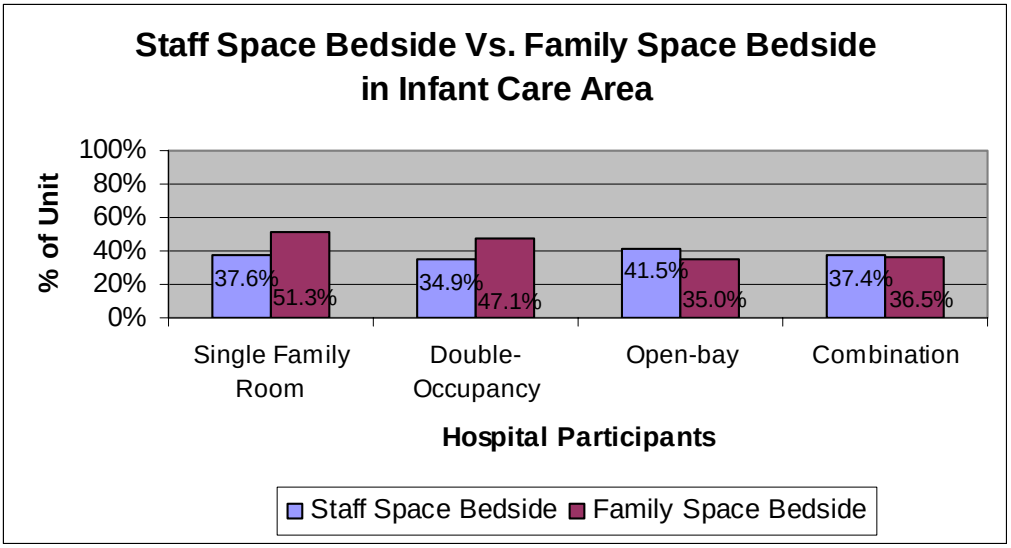

Figure 5-5: Staff Space Bedside vs. Family Space Bedside

The combination unit allocated the most space to unit circulation and the open-bay unit allocated the lowest amount of space to circulation (Figure 5-6 and Figure 5-7). Both of these units make use of the pin-wheel configuration for some of their baby stations. The combination unit has six pin-wheel stations; the use of pin-wheels may be a factor in the combination unit's high amount of unit circulation.

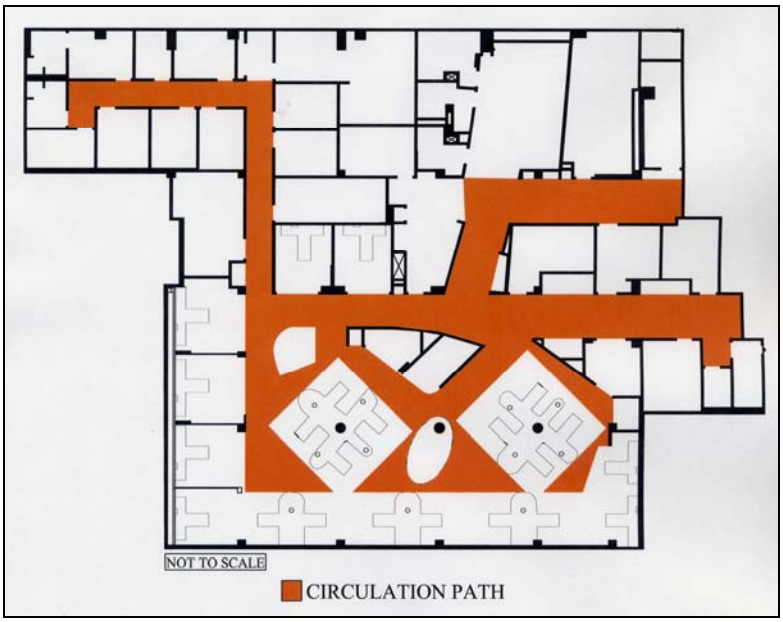

Figure 5-6: Open-bay Layout Circulation Diagram

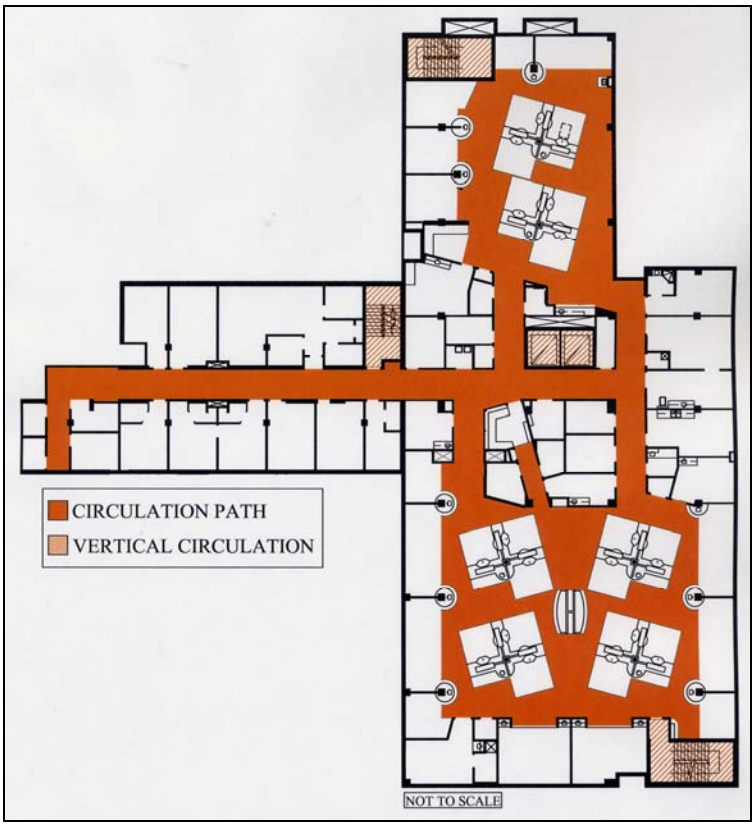

Figure 5-7: Combination Layout Circulation Diagram

Limitations of the Research

Several factors may have impacted the results of this study. A sample size of four hospitals, one of each type, is a small sample size to produce generalizable results. Case studies are thought to not be generalizable due to multiple variables which may not be controlled (Yin, 2003).

Due to the extraction of construction cost data from larger projects, data errors could have been made. Plus, the project relied on participants to send data (construction cost) to be analyzed, providing for possible human error. As discussed in Chapter 2, many factors can impinge on construction costs that are specific to each case. For example, the budget for one hospital may have been substantially higher than the budget for another, in turn, having one NICU that is more *high-end* than another. Factors such as weather and type of project (new construction or remodel) can also have an effect on

cost. The construction cost which were adjusted to the year 2005 and normalized to the National Average are approximations based on historical cost and city cost indexes.

The researcher made certain assumptions during the plan analysis phase about the way certain areas are most likely used. For example, when calculating space at bedside, dividing the infant area in half at midpoint infant station and assigning sides to family and staff based on furniture placement (recliner or stool placement in most cases) is purely an assumption on how the space is used. In actuality, during daily activities in the NICU, carts and multiple chairs may be moved in and out of patient areas depending on the circumstance.

In the process of assigning specific rooms to family and/or staff, assumptions were made on what user group uses the room more frequently. Telephone calls were made to NICU contacts to verify room usage, but in some cases, rooms are shared by family and staff. For example, consultation rooms are shared areas, in most cases consultation rooms were assigned to family space if they were adjacent to family lounges. Similarly, when calculating unit circulation in the open-bay and combination layout NICUs, assumptions were made in the open areas to calculate circulation based on guidelines for aisle widths in NICUs.

Future Directions

As seen from this research study, there are a range of NICU settings: single family room, double-occupancy, open-bay, and combination. Further empirical research on the implications of these various settings is needed, in particular the costs of building, maintaining, and operating these facilities. Research on family preference and behaviors is needed, particularly to help determine whether more family space should be allocated

bedside or outside of the infant care area. Future NICU studies should compare more than one case of each setting to produce results that are more generalizable.

Conclusions

Each NICU setting has its strengths and weaknesses. Depending on the NICU operations and nursing model, one type may be more supportive than another. For example, in a family-centered care environment, family participation is encouraged; hence the facility that provides more space for family at bedside may be preferred, rather than more family space outside the infant care area.

The literature suggests that environmental control is important for neonates' growth 1) acoustical control; 2) lighting control; 3) infection control; 4) temperature control; 5) privacy; and 6) security. Single family rooms may be the best setting to afford privacy and environmental control for the benefit to infants. From the results of this study, the SFR setting did not have the highest construction cost. Therefore, if assuming SFR units provide the most control of the environment, the single family room unit may be the preferred layout for future NICU projects.

APPENDIX A
LETTER TO PARTICIPATE

UNIVERSITY OF FLORIDA

College of Design, Construction, & Planning
Department of Interior Design

PO Box 115705
Gainesville, FL. 32611-5705
(352) 392-0252x457
Fax (352) 392-7266
Email: debraharris@dcp.ufl.edu

January 7, 2005

<Address>
<Address>
<Address>

Dear <insert name>,

We are conducting a study to identify best design practices for Neonatal Intensive Care Units (NICU) that support infants, their families, and the healthcare staff. A recent trend in the design of NICU facilities has been to increase the number of private patient rooms for neonates and their families. This study will compare private patient room units, open bay units, and combination units in two steps. One step includes data for health outcomes, perceptions, and quality of experience for staff and parents of neonates. The second step is the purpose of this inquiry.

Your Level III NICU was identified to participate in the study. Participation is voluntary and involves providing electronic documents that assist in assessing the impact of design on: 1) quality of the indoor environment; 2) impact on direct care systems; and 3) differences in construction, operation, and administrative costs. We are asking that you provide three types of electronic data for this study:

1. Plans of the NICU (see detailed list on permission form)
2. A limited list of hospital records data
3. Costs for construction, operation, and administration of the NICU.

Based on the plan analysis, a limited number of facilities will be asked to allow a 2-day site visit to their NICU.

We appreciate your participation and expect that the study will provide important information that will inform and provide design guidelines for Neonatal Intensive Care Units. The attached Agreement Form provides an opportunity to designate participation. Please complete the form and **return by January 18, 2005** by mail using the self-addressed stamped envelope or fax to Debra D. Harris at 352/392-7266. If you have any questions, please contact Debra D. Harris, Ph.D. at 352/392-0252 x457 (or cell at 352/262-4458). An email with directions for sending the data will be forthcoming upon the receipt of the agreement form.

Sincerely,

Debra D. Harris, Ph.D.

APPENDIX B
AGREEMENT TO PARTICIPATE

UNIVERSITY OF FLORIDA

College of Design, Construction, & Planning
Department of Interior Design
PO Box 115705, Gainesville, FL. 32611-5705

(352) 392-0252x457
Fax (352) 392-7266
Email: debraharris@dcp.ufl.edu

Neonatal intensive care unit environmental design research:
A comparison between open bay and single family rooms
AGREEMENT TO PARTICIPATE

Please initial on the line for agreement to participate:

_____ *Initial here*

1. **Hospital records (as available)**
   a. Number of infant stations
   b. Average census
   c. Admissions per year
   d. Average number of skilled NICU staff required for unit per shift
   e. Average number of support staff required for unit per shift
   f. Staff turnover
   g. Patient transfers
   h. Medical errors reported
   i. Nosocomial infection rates

_____ *Initial here*

2. **ACAD drawings and photo documentation (as available)**
   a. Floor plan
   b. Furniture plan
   c. Finish plan
   d. Reflected ceiling plan
   e. Lighting power and systems plan
   f. Sections
   g. Elevations
   h. Headwall elevations and details
   i. Door and frame elevations and details
   j. Photos and marketing materials

_____ *Initial here*

3. **First costs - total project costs (as available)**
   a. Land acquisition
   b. Construction costs
   c. Design and engineering
   d. Owner construction administration
   e. Development and soft costs
   f. Equipment
   g. Furnishings and fixtures
   h. Financing costs

_____ *Initial here*

4. **Operational costs (as available)**
   a. Initial investment cost
   b. Operations cost
   c. Maintenance and repair cost
   d. Replacement cost
   e. Residual value

_____ *Initial here*

5. **Administrative costs (as available)**
   a. Staffing direct care
   b. Staffing support
   c. Supplies

We agree to participate in the study by providing the requested information initialed above for the NICU study comparing NICU unit design and the impact on users, costs, and planning.

Name/Contact: _____

Telephone: _____

Email: _____

Hospital Name: _____

Address: _____

_____

Signature for approval : _____ Date _____

We appreciate the time and effort to participate in our study. Please FAX to Debra D. Harris, Ph.D. at 352/392-7266 ***OR*** use the enclosed return envelope by January 11, 2005.

THANK YOU!

APPENDIX C
CERTIFICATION OF COMPLETION FOR HIPAA

Congratulations!! http://privacy.health.ufl.edu/training/research/certificate.asp?id=969...

UF Health Science Center

Certificate of Completion

This is to certify that

Natalie Hardy

has successfully completed the

HIPAA for Researchers
at the University of Florida

on 9/28/2004

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APPENDIX D
PUBLIC RELATIONS FORM

NEONATAL INTENSIVE CARE UNIT ENVIRONMENTAL DESIGN RESEARCH
INSTRUCTIONS FOR DATA COLLECTION OF THE LEVEL III NEONATAL INTENSIVE CARE UNIT

PUBLIC RELATIONS
Send Electronic Submission of Data and questions to debraharris@dcp.ufl.edu

Provide photographs and materials for current NICU Level III. If available, please provide archival records of previous NICU Level III.

Please provide the following digital documents. The documents may be sent electronically to debraharris@dcp.ufl.edu as attachments or attached as a zip file. On the email subject line, please name the hospital and "Public Relations Data." The permission to publish forms may be faxed to Debra Harris at 352.392.7266.

The following documents are included?	YES	NO
1. NICU III Photographs	_____	_____
2. NICU Marketing Materials	_____	_____
3. Form Permission to Publish complete and fax to Debra Harris at 352.392.7266 for each image submitted to research study	_____	_____

Thank you for your time and participation!
Thank you for your time and effort in providing the requested data. If you have any questions or concerns please call Debra D. Harris, Ph.D. at 352.392.0252x457 or email at debraharris@dcp.ufl.edu

APPENDIX E
PERMISSION TO PUBLISH

PERMISSION TO PUBLISH

To: Debra D. Harris
NICU III Environmental Design Research Study
College of Design, Construction & Planning
PO Box 115705
Gainesville, Florida 32611-5705

From:

Date:

Please fill out the following form and mail or fax to Debra Harris at 352.392.7266. Thank you for your help.

_____ gives permission for the reproduction of the following images that may appear in peer-reviewed journals

The following credit information will be provided in association with this image:

Image # ___: (describe image) _____

Hospital: _____ (please provide name)

Architect: _____ (please provide name)

Photographer: _____ (please provide name)

_____ _____
Signature of Hospital Representative Date

_____
Printed Name

_____
Title

APPENDIX F
FACILITIES PLANNING FORM

This is a two-part form pertaining to architectural drawings and NICU construction costs. The total project costs were simplified into seven topics; only the construction cost were analyzed and compared for this project.

NEONATAL INTENSIVE CARE UNIT ENVIRONMENTAL DESIGN RESEARCH
INSTRUCTIONS FOR DATA COLLECTION OF THE LEVEL III NEONATAL INTENSIVE CARE UNIT

Facilities Planning
Send Electronic Submission of Data to debraharris@dcp.ufl.edu

The drawing documents may be sent electronically as attachments or attached as a zip file. On the email subject line, list the hospital and "Facilities Data."

The following drawings are included?	YES	NO
▪ Floor plans with labels	_____	_____
▪ Furniture plan	_____	_____
▪ Equipment plan	_____	_____
▪ Finish schedule	_____	_____
▪ Reflected ceiling plan	_____	_____
▪ Lighting / power plan	_____	_____
▪ Systems plan	_____	_____
▪ Sections & Elevations	_____	_____
▪ Headwall elevations and details	_____	_____
▪ Door schedule	_____	_____
▪ Do the drawings indicate support spaces dedicated to the NICU that may be in close proximity to the unit?	_____	_____
▪ Date of Occupation MM/DD/YR: _____		

First Costs (Total Project Costs) Indicate whether you have provided data for the categories listed below. Submit in Excel format. Do not use abbreviations or acronyms unless definitions are provided. On the email subject line, list the hospital and "Facilities First Cost Data."

The following data is included?	YES	NO	N/A
▪ Land acquisition (if applicable)	_____	_____	_____
▪ Construction	_____	_____	
▪ Design and engineering	_____	_____	
▪ Owner construction and administration	_____	_____	
▪ Development and soft costs	_____	_____	
▪ Furnishings, fixtures and equipment	_____	_____	
▪ Financing	_____	_____	

Thank you for your time and participation!
Thank you for your time and effort in providing the requested data. If you have any questions or concerns please call Debra D. Harris, Ph.D. at 352.392.0252x457 or email at debraharris@dcp.ufl.edu

APPENDIX G
CONSTRUCTION COST DATA

This table lists the construction cost figures before they were adjusted to be comparable in year and region with the end result being the adjusted cost national average.

Table G-1: Construction Cost Data

NICU	Geographic Region	Construction Date	Un-adjusted Construction Cost	Adjusted Cost 2005	Adjusted Cost National Average
SFR	Midwest	2001	$3,644,287	$4,282,847	$4,680,707
Double-occupancy	West	1998	$4,842,500	$6,247,742	$5,399,950
Open-bay	Southeast	2004	$3,442,880	$3,557,907	$4,387,062
Combination	South	2004	$3,284,524	$3,394,261	$3,956,015

APPENDIX H
NICU SPACE ALLOCATION DATA

Table H-1: Unit Space Allocation Square Feet Amounts

NICU	Total Project Square Feet	Infant Space	Family Space	Public Space	Staff Space	Systems Space	Unit Circulation	Vertical Circulation	Net to Gross Factor
SFR	18130 SF	3832 SF	1182 SF	706 SF	3680 SF	493 SF	5107 SF	779 SF	2351 SF
Double Occupancy	16337 SF	5336 SF	1090 SF	208 SF	2833 SF	130 SF	4496 SF	852 SF	1391 SF
Open-bay	10871 SF	2299 SF	1184 SF	0 SF	3555 SF	110 SF	2418 SF	0 SF	1305 SF
Combination	20519 SF	4998 SF	2038 SF	105 SF	3864 SF	395 SF	6142 SF	855 SF	2120 SF

Table H-2: Unit Space Allocation Percentage of Unit

NICU	Infant Space	Family Space	Public Space	Staff Space	Systems Space	Unit Circulation	Vertical Circulation	Net to Gross Factor
SFR	21.1%	6.5%	3.9%	20.3%	2.7%	28.2%	4.3%	13.0%
Double-Occupancy	32.7%	6.7%	1.3%	17.3%	0.8%	27.5%	5.2%	8.5%
Open-bay	21.2%	10.9%	0.0%	32.7%	1.0%	22.2%	0.0%	12.0%
Combination	24.4%	9.9%	0.5%	18.8%	1.9%	29.9%	4.3%	10.3%

APPENDIX I
INFANT CARE AREA SPACE ALLOCATION DATA

Table I-1: Average Infant Care Area Space Allocation Square Feet Amounts

NICU	Infant Care Area	Clear Floor Space	Family Space Bedside	Staff Space Bedside	Infant Station
SFR	171 SF	137 SF	88 SF	64 SF	19 SF
Double-occupancy	111 SF	82 SF	52 SF	39 SF	20 SF
Open-bay	115 SF	85 SF	40 SF	48 SF	27 SF
Combination	111 SF	80 SF	41 SF	42 SF	29 SF

Table I-2: Average Infant Care Area Percentages of Space

NICU	Clear Floor Space	Family Space Bedside	Staff Space Bedside	Infant Station
SFR	79.9%	51.3%	37.6%	11.1%
Double-occupancy	74.1%	47.1%	34.9%	18.0%
Open-bay	74.1%	35.0%	41.5%	23.5%
Combination	72.0%	36.5%	37.4%	26.1%

APPENDIX J
SINGLE FAMILY ROOM ALLOCATION OF SPACE DIAGRAM

The SFR unit allocated the least amount of family space outside the infant care area, which was 6.5% of the unit, while allocation the most amount of family space at bedside.

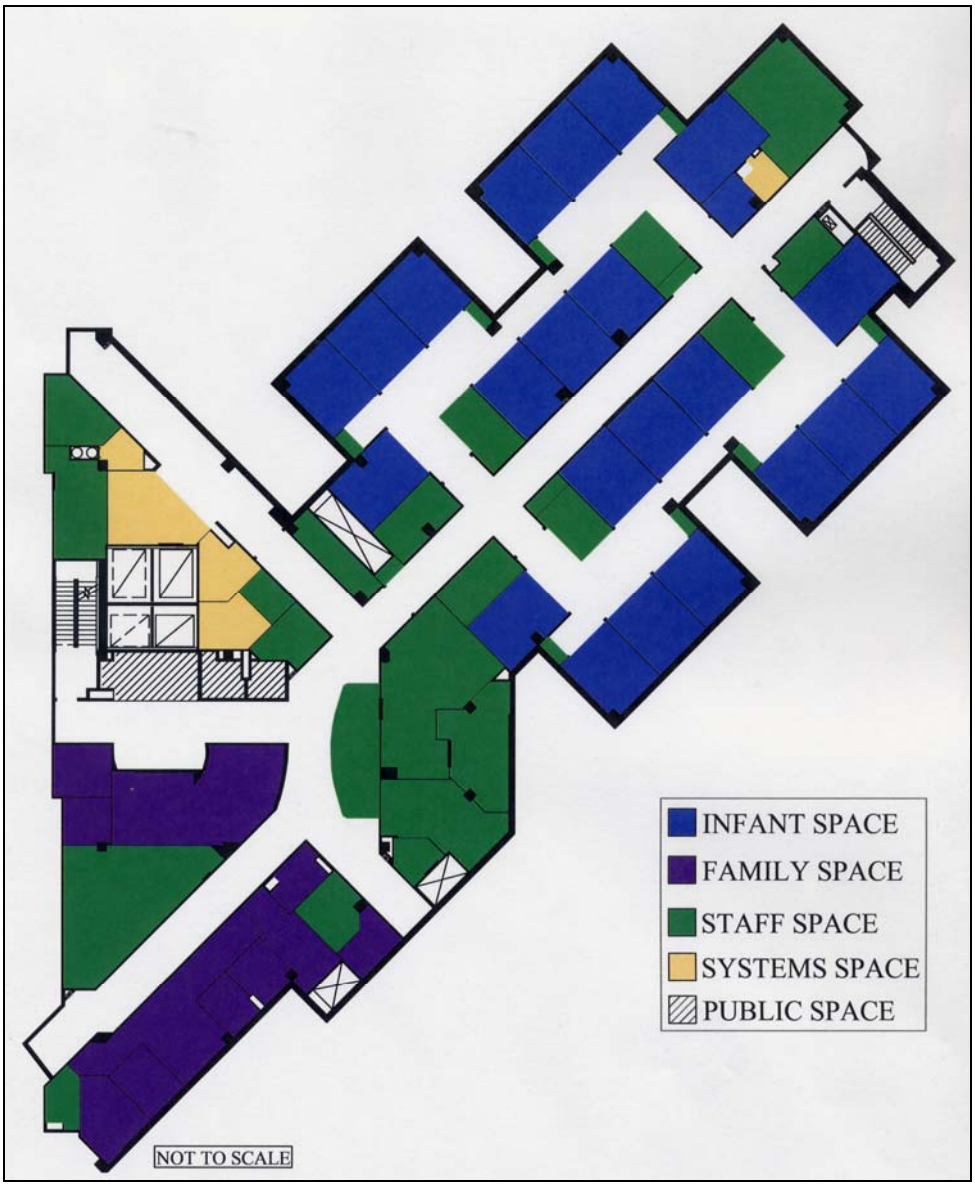

Figure J-1: Single Family Room Allocation of Space Diagram

APPENDIX K
DOUBLE-OCCUPANCY ALLOCATION OF SPACE DIAGRAM

The double-occupancy unit allocated the highest amount of space to infant space at 32.7% of the unit. Similar to the SFR unit, within the infant care area, the family space at bedside was second highest and the family space outside the infant care area is second lowest at 6.7% of the unit.

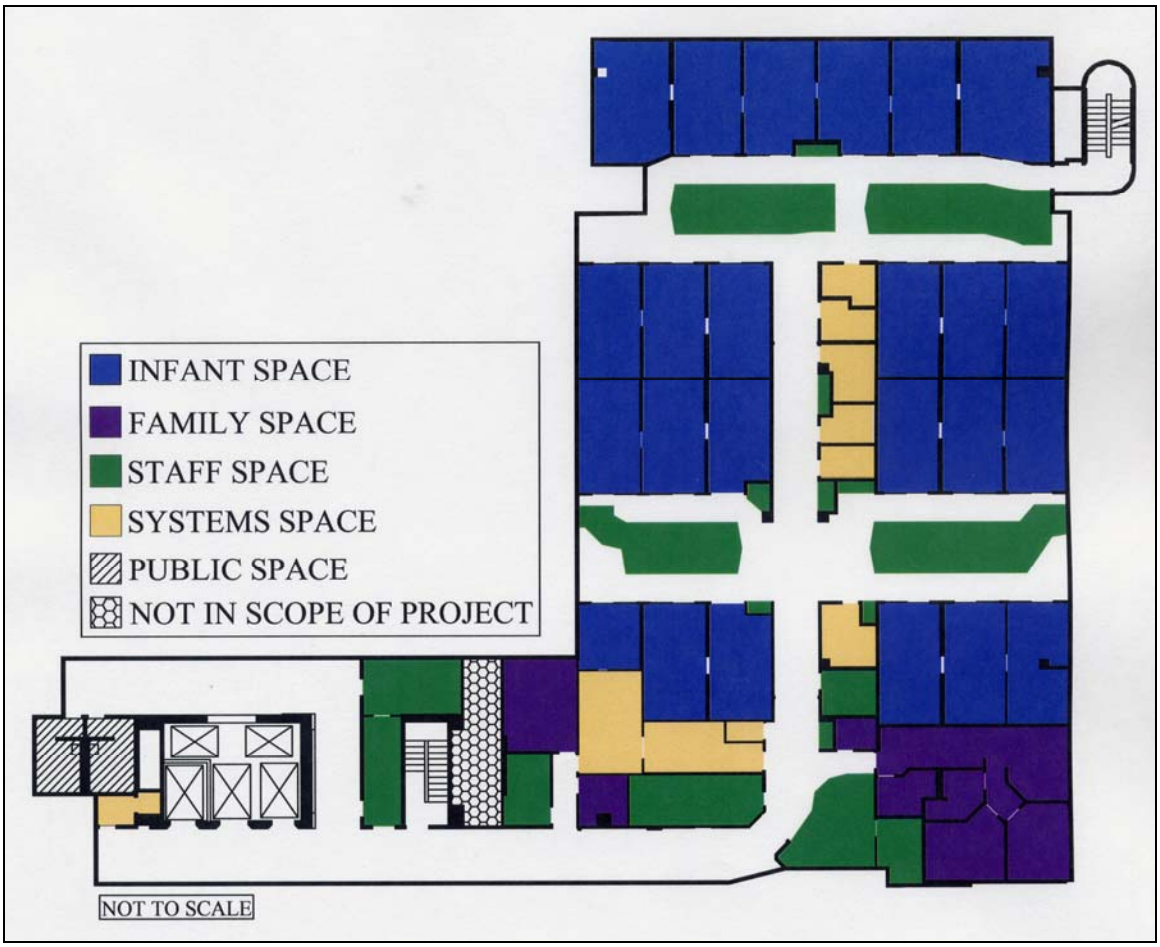

Figure K-1: Double-Occupancy Allocation of Space Diagram

APPENDIX L
OPEN-BAY ALLOCATION OF SPACE DIAGRAM

The open-bay unit allocated the most amount of family space outside the infant care area at 11% and the least amount of family space bedside at 35%. The open-bay unit allocated the highest amount of staff space bedside within the infant care area at 42%.

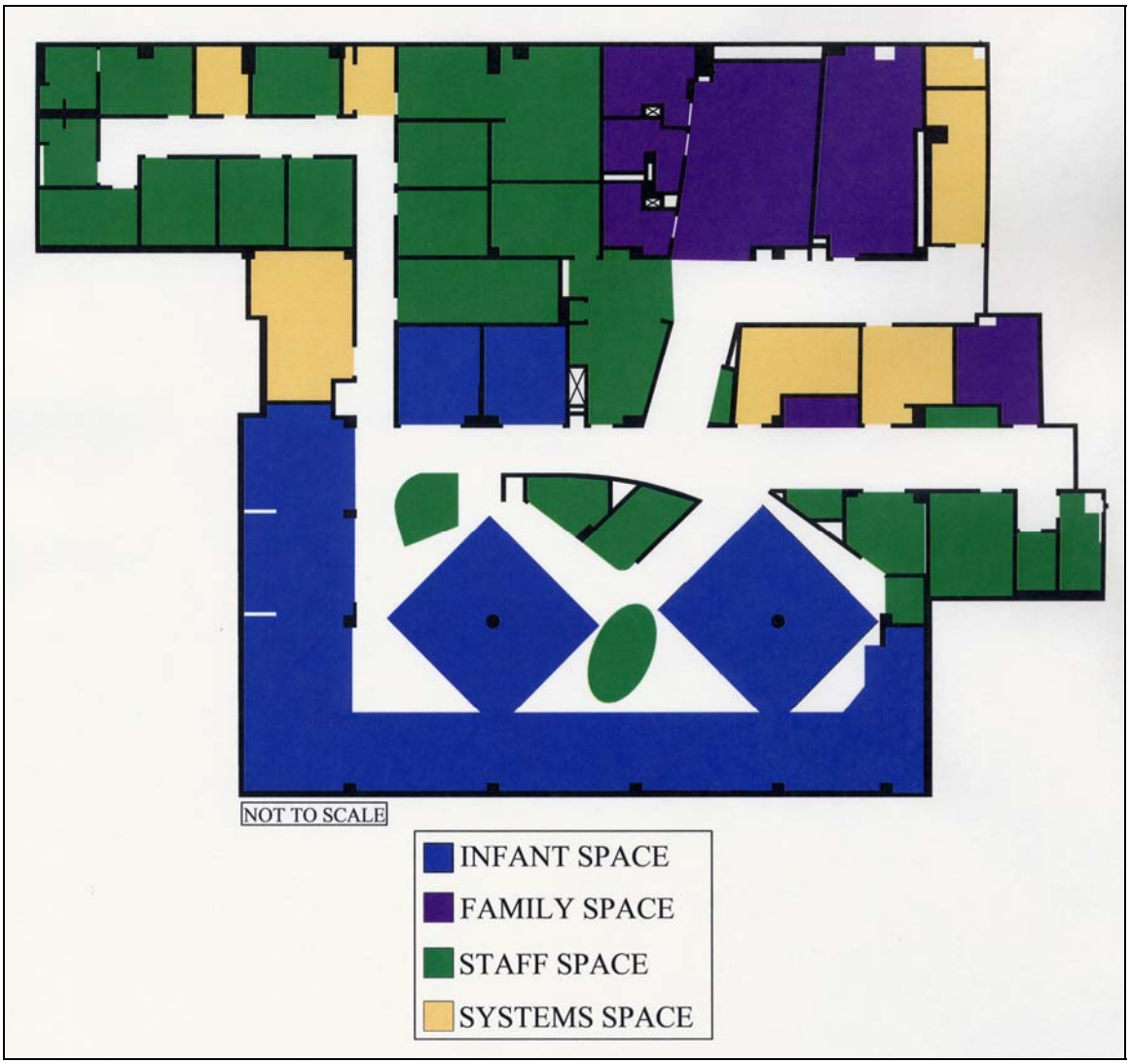

Figure L-1: Open-Bay Allocation of Space Diagram

APPENDIX M
COMBINATION UNIT ALLOCATION OF SPACE DIAGRAM

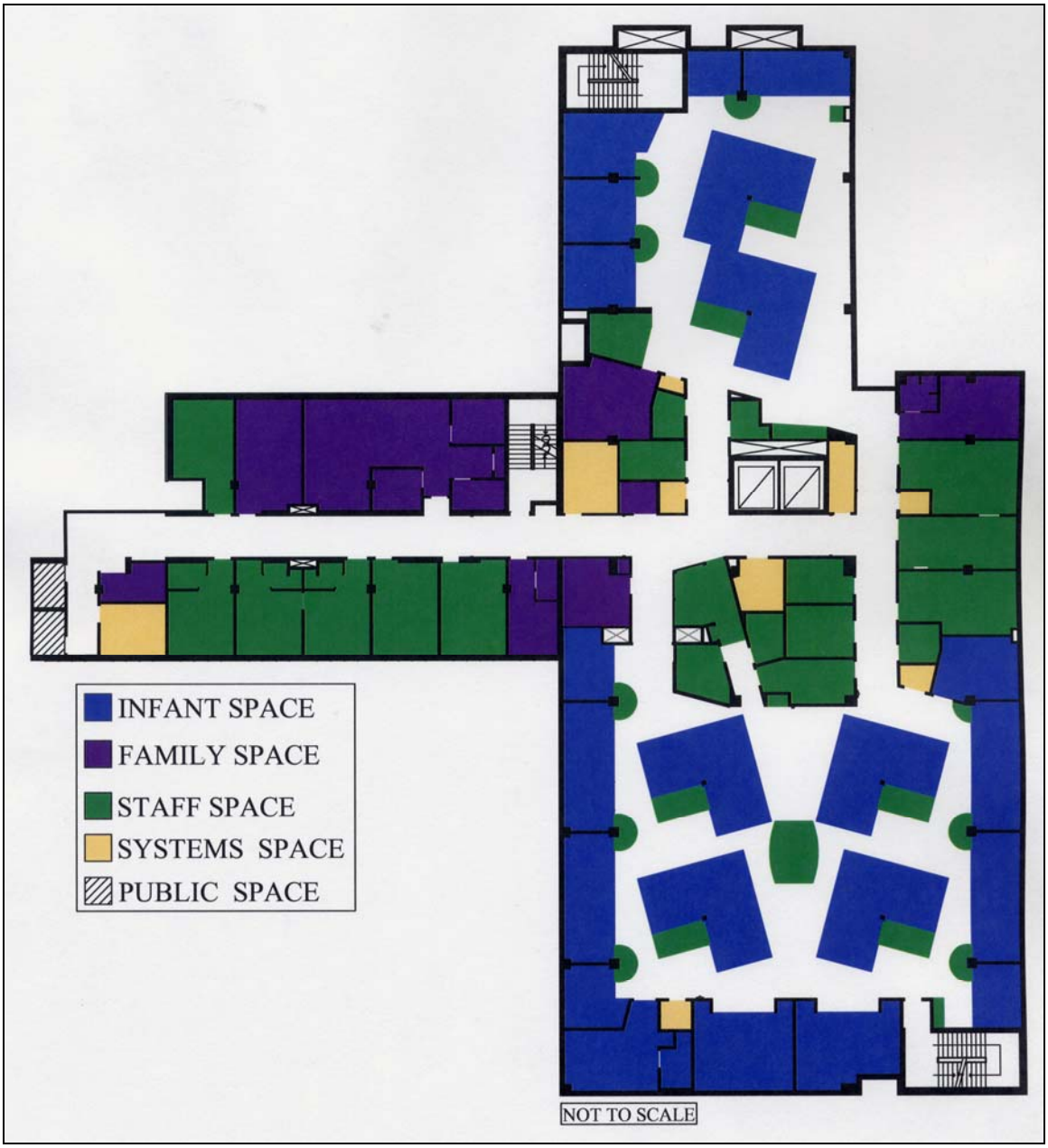

Figure M-1: Combination Unit Allocation of Space Diagram

APPENDIX N
CIRCULATION DIAGRAM FOR SINGLE FAMILY ROOM UNIT

This diagram represents the unit circulation in the SFR NICU which was 28.2% of the unit. The SFR and double-occupancy unit's allocated similar amounts of unit space to circulation, with a 1% difference (see Appendix O).

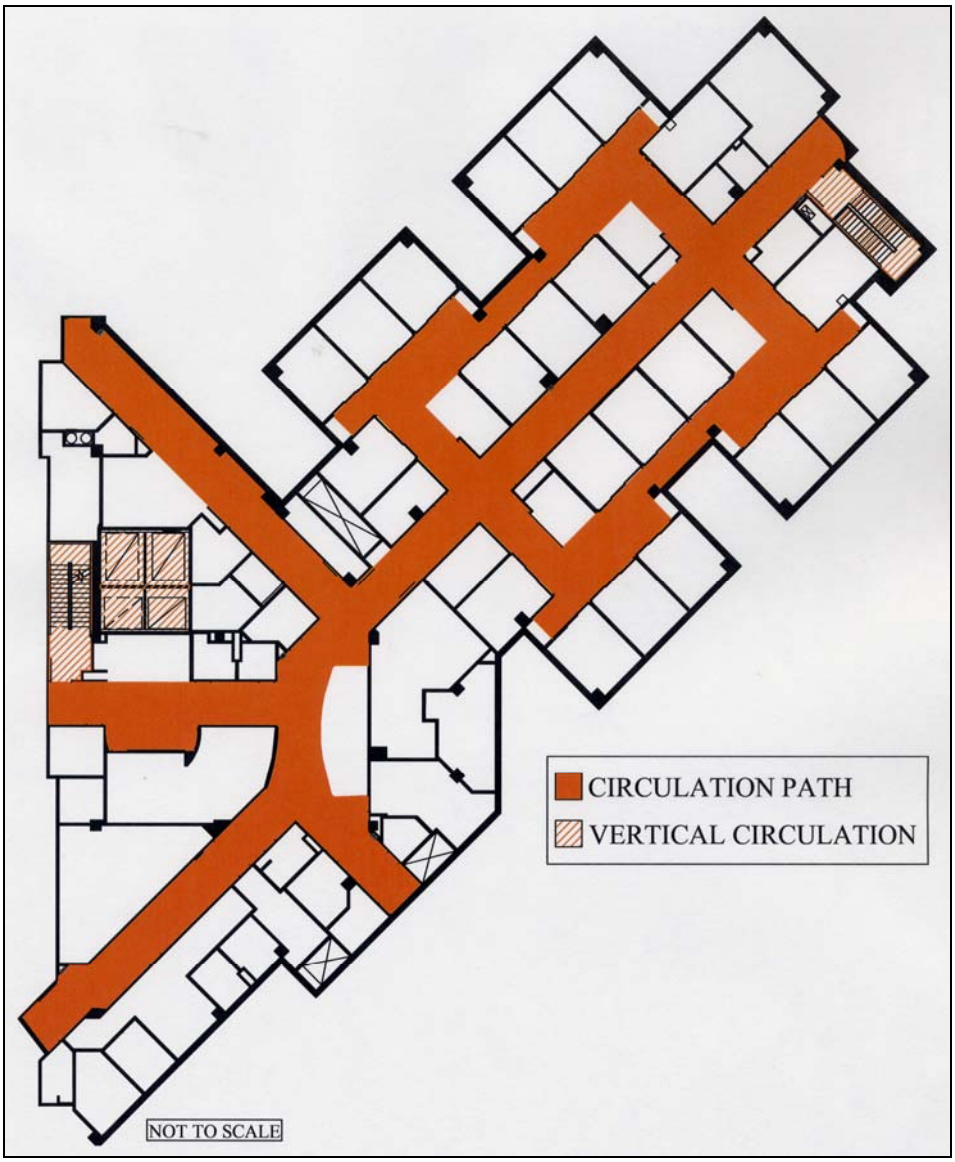

Figure N-1: Circulation Diagram for Single Family Room NICU

APPENDIX O
CIRCULATION DIAGRAM FOR DOUBLE-OCCUPANCY UNIT

This diagram represents the unit circulation in the double-occupancy layout which was 27.5% of the unit. The double-occupancy and SFR unit's allocated similar amounts of unit space to circulation, with a 1% difference (see Appendix N).

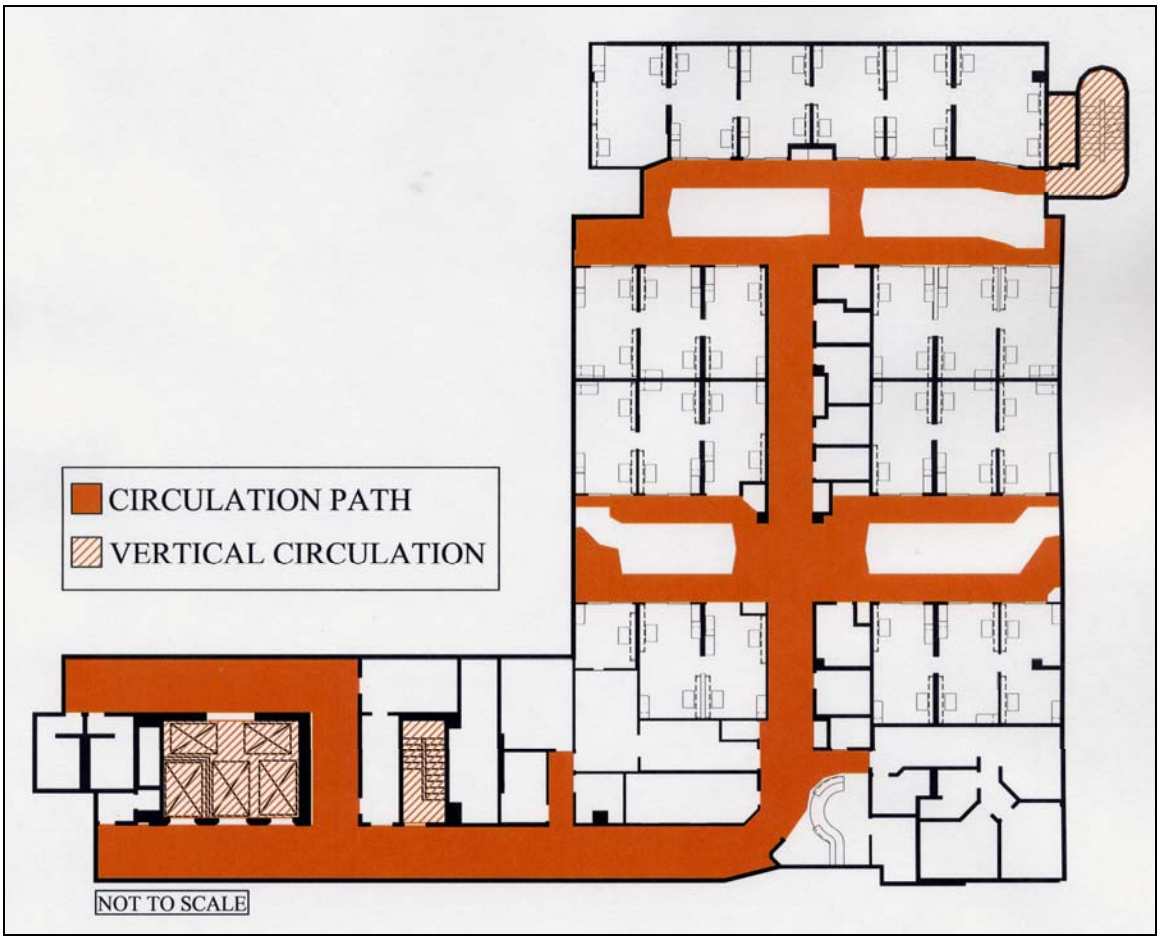

Figure O-1: Circulation Diagram for Double-occupancy NICU

APPENDIX P
CIRCULATION DIAGRAM FOR OPEN-BAY UNIT

This diagram represents the unit circulation in the open-bay layout NICU. The circulation comprised 22% of the unit, which was the lowest circulation amount in comparison to the other three NICUs.

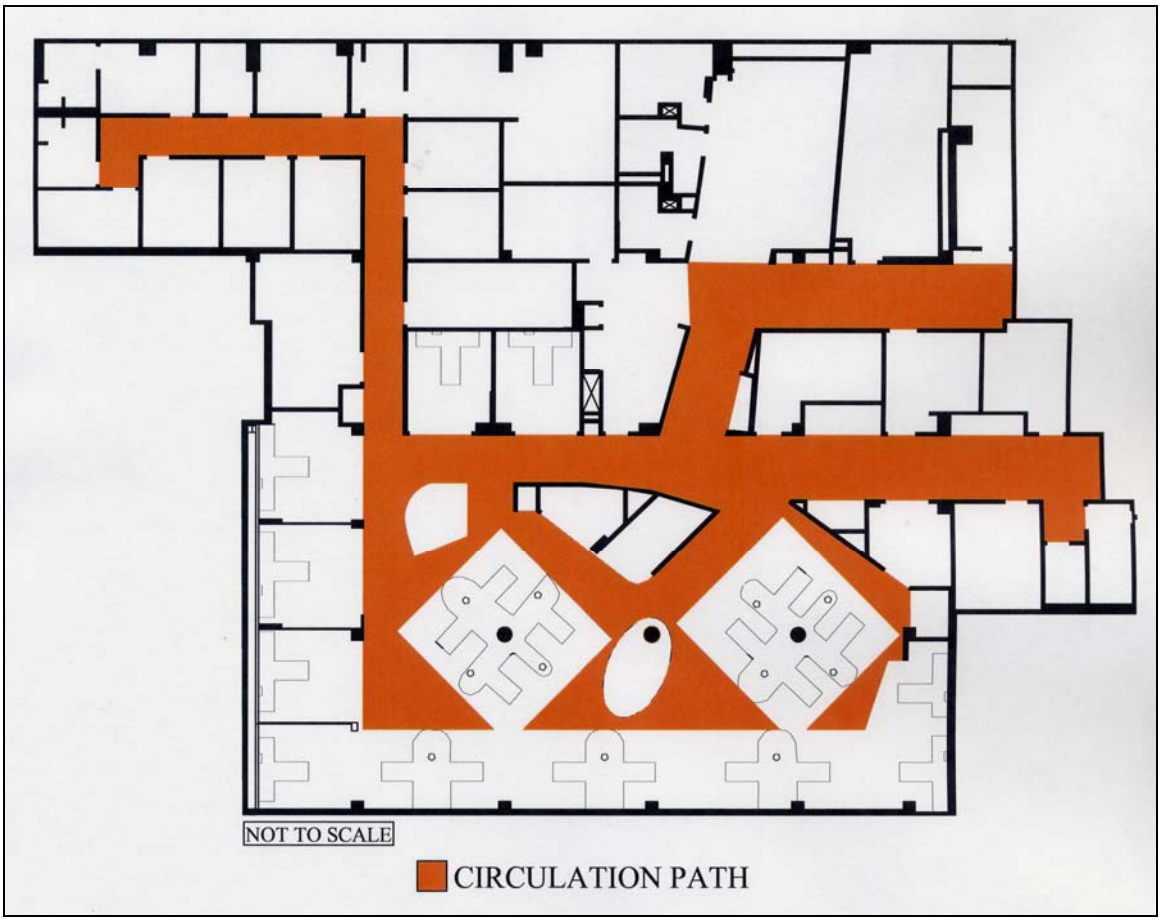

Figure P-1: Circulation Diagram for Open-bay NICU

APPENDIX Q
CIRCULATION DIAGRAM FOR COMBINATION LAYOUT UNIT

This diagram represents the unit circulation in the combination layout NICU. The circulation comprised 30% of the unit, which was the highest circulation amount in comparison to the other three NICUs.

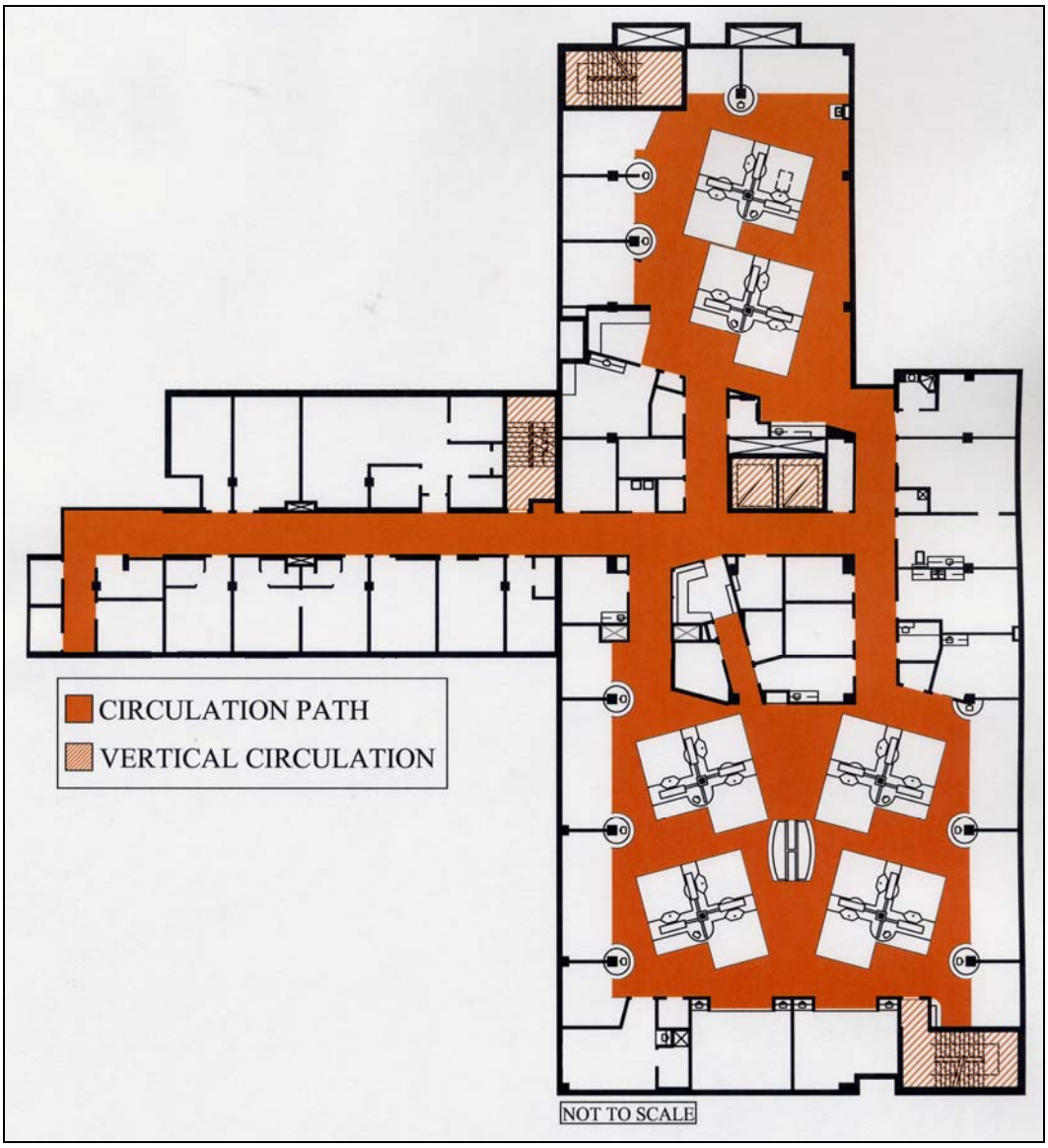

Figure Q-1: Circulation Diagram for Combination layout NICU

LIST OF REFERENCES

Als, H., Buehler, D.M., Duffy, F.H., Liederman, J., & McAnulty, G.B. (1995). Effectiveness of individualized developmental care for low-risk pre-term infants: Behavioral and elecrophysiologic evidence. *The American Academy of Pediatrics, 96(5),* 923-932.

Als, H., Lawhon, G., Duffy, F., McAnulty, G., Gibes-Grossman, R., & Blickman, J. (1994). Individualized developmental care for the very low birth-weight preterm infant–medical and neurofunctional effects. *Journal of the American Medical Association, 272,* 853-858.

The American Institute of Architects Academy of Architecture for Health. (2003). *Guidelines for Design and Construction of Hospital and Healthcare Facilities,* Washington, D.C. The Facilities Guidelines Institute, with assistance from the U.S. Department of Health and Human Services.

Aucott, S., Donohue, P.K., Atkins, E., & Allen, M.C. (2002). Neurodevelopmental care in the NICU. *Mental Retardation and Developmental Disabilities Research Reviews, 8,* 298-308.

Berens, R.J. & Weigle, C.G.M. (1996). Cost analysis of ceiling tile replacement for noise abatement. *Journal of Perinatology, 16(3),* 199-201.

Bobrow, M. & Thomas, J. (2000). Inpatient care facilities. In S.A. Kilment (Ed.), *Building type basics for healthcare facilities* (pp. 131-191). NY: John Wiley and Sons.

Callery, P. (1997). Paying to participate: Financial, social, and personal costs to parents of involvement in their children's care in hospital. *Journal of Advanced Nursing, 25,* 746-752.

Carr, R.F. (2005). *Health Care Facilities.* Retrieved from the WBDG Web site on March 2, 2005, from http://www.wbdg.org/design/health_care.php.

Cohen, J., Parsons, V., & Petersen, M.F. (2004). Family-centered care: Do we practice what we preach? *JOGNN, 33,* 421-427.

Committee on Fetus and Newborn. (2004). Levels of neonatal care. *Pediatrics, 114(5),* 1341-1347.

Feldman Reichman, S.R., Miller, A.C., Gordon, R.M., & Hendricks-Munoz, K.D. (2000). Stress appraisal and coping in mothers of NICU infants. *Children's Health Care, 29 (4),* 279-293

Ferber, S.G. & Makhoul, I.R. (2004). The effect of skin-to-skin contact (kangaroo care) shortly after birth on the neurobehavioral responses of the term newborn: A randomized controlled trial. *Pediatrics, 113(4),* 858-865.

Gaynes, R.P., Edwards, J.R., Jarvis, W.R., Culver, D.H., Tolson, J.S., & Martone, W.J. (1998). Nosocomial infections among neonates in high-risk nurseries in the United States. National nosocomial infections surveillance system. *Pediatrics*, (3), 357-361.

Goldson, E. (1992). The neonatal intensive care unit: Premature infants and parents. *Infants and Young Children, 4(3),* 31-42.

Levy, G.D., Woolston, D.J., & Browne, J.V. (2003). Mean noise amounts in level II vs. level III neonatal intensive care units. *Neonatal Network, 22(2),* 33-38.

Mader, B. (2002). Private hospital rooms the new norm [Electronic Version]. *The Business Journal of Milwaukee.* Retrieved April 30, 2005, from http://www.bizjournals.com/milwaukee/stories/2002/11/11/focus2.html?GP=OTC -MJ1752087487

Malkin, J. (1992). Birth centers: Freestanding and acute care settings. In V.N. Reinhold (Ed.), *Hospital interior architecture: Creating healing environments for special patient populations* (pp. 235-266). NY: John Wiley and Sons.

Mann, N.P., Haddow, R., Stokes, L., Goodley, S., & Rutter, N. (1986). Effect of night and day on preterm infants in a newborn nursery: Randomized trial. *British Medical Journal, 293(6557),* 1265-1267.

Mathur, N.S. (2004). A single-room NICU – The next generation evolution in the design of neonatal intensive care units. Retrieved from the AIA Web site on November l2, 2004, from http://www.aia.org/aah_a_jrnl_0401_article3

Miller, C.L., White, R., Whitman, T.L., O'Callaghan, M.F., & Maxwell, S.E. (1995). The effects of cycled verses noncycled lighting on growth and development in preterm infants. *Infant Behavior and Development, 18(1), 87-95.*

Moon, S. (2005). Construction – and costs – Going Up. *Modern Healthcare, 35(10),* 30-42.

Moore, K.A.C., Coker, K., DuBuisson, A.B., Swett, B., & Edwards, W.H. (2003). Implementing potentially better practices for improving family-centered care in neonatal intensive care units: Successes and challenges. *Pediatrics, 111, 4,* 450-460.

Nair, C., Gupta, S.C.G., & Jatana, L. (2003). NICU environment: Can we be ignorant? *MJAFI, 59,* 93-99.

Preiser, W.F.E., Rabinowitz, H.Z., & White, E.T. (1988). *Post-occupancy evaluation.* New York: Van Nostrand Reinhold.

Price Waterhouse Coopers LLP. (2004). The role of hospital design in the recruitment, retention, and performance of NHS nurses in England. Retrieved May 20, 2005, from http://www.healthyhospitals.org.uk/diagnosis/HH_Full_report_Appendices.pdf

Raeside, L. (1997). Perceptions of environmental stressors in the neonatal unit. *British Journal of Nursing, 6,* 914-916.

Robison, L.D. (2003). An organizational guide for an effective developmental program in the NICU. *JOGNN, 32,* 379-386.

Shepley, M.M. (2002). Predesign and postoccupancy analysis of staff behavior in a neonatal intensive care unit. *Children's Health Care, 31(3),* 237-253.

Shepley, M.M., Fournier, M.A., & McDougal, K. (Eds.). (1998). *Healthcare environments for children & their families*. Dubuque, IA: Kendall Hunt.

Sohn, A.H., Garrett, D.O., Sinkowitz-Cocran, R.L., Grohskopf, L.A., Levine, G.L., Stover, B.H., Siegel, J.D., Jarvis, W.R., Pediatric Prevention Network. (2001). Prevalence of nosocomial infections in neonatal intensive care unit patients: Results from the first national point-prevalence survey. *Journal of Pediatrics, 139(6),* 821-827.

Strauch, C., Brandt, S., & Edwards-Beckett, J. (1993). Implementation of a quiet hour: Effect on noise levels and infant sleep states. *Neonatal Network, 12(2),* 31–35.

Waier, P.R. (Ed.). (2005) *R.S. Means Building Construction Cost Data*. Kingston, MA: Reed Construction Data, Inc.

Wang, D. (2002). Design in relation to research. In L. Groat & D. Wang (Eds.), *Architectural Research Methods* (pp. 99-132). John Wiley & Sons, Inc.

White, R.D. (2002). Recommended Standards for Newborn ICU Design. *Report of the Fifth Consensus Conference on Newborn ICU Design.* Retrieved on May 10, 2005, from http://www.nd.edu/~kkolberg/DesignStandards.htm

Yin, R.K. (2003). *Case Study Research – Design and Methods*, Thousand Oaks, CA.: Sage Publications.

Zeskind, P.S. & Iacino, R. (1984). Effects of maternal visitation to pre-term infants in the neonatal intensive care unit. *Child Development, 55,* 1887-1893.

BIOGRAPHICAL SKETCH

Paige was born in Jacksonville, Florida, and has an older sister. Throughout grade school she enjoyed gymnastics, piano, and creative activities. Paige went to Riverview High School in Sarasota, Florida, and graduated in 1994. She was a cheerleader for the Riverview Rams for two years.

During her undergraduate years at the University of Florida, Paige studied anthropology, with a focus on cultural anthropology. She graduated in May of 1999 with a Bachelor of Arts in anthropology. After graduation, Paige worked for Delta Airlines for three years.

Paige returned to the University of Florida in August of 2002 and started the Master of Interior Design program. Paige developed many interests in interior design, including universal design, specifically designing for the aging population; as a result she completed a graduate minor in gerontology. She enjoys all aspects of the design process: research, space planning, 3-dimensional design and furniture design, and presentation rendering.

Following graduation, Paige plans to continue living in Florida and work at a design firm.