Recommended Standards for Newborn ICU Design

Preface

The Recommended Standards for Newborn ICU Design that follow are the result of an ongoing effort by many people. The participants in the 7th consensus conference who developed these standards are listed in the pages that follow, but we wanted to also recognize members of our International Advisory Committee who provided input during the consensus process, including Anne Augustin, Carlo Bellieni, Michael Dunn, Linda Franck, Maureen Gilmore, Carl Kuschel, and Kaye Spence. We also wish to acknowledge the professional advice of Jack Evans, Brian Kubicki, and Edward Logsdon on Standard 23, and to thank Christa Plott for her technical support in preparing this document.

These standards have now been disseminated to more than 25 countries and several hundred newborn ICU's, architectural firms, state planning agencies, and medical professionals. Because upgrading these standards is a continuing process, we are anxious to get your feedback regarding any changes or additions you think are important for these standards so that we can incorporate these into our discussions. In addition, we would like to know the impact these standards are having on neonatal unit design and care. Please contact us to let us know how you are using these standards.

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Introduction

The creation of formal planning guidelines for newborn intensive care units (NICUs) first occurred when *Toward Improving the Outcome of Pregnancy* was published in 1976[1]. This landmark publication, written by a multidisciplinary committee and published by the March of Dimes, provided a rationale for planning and policy for regionalized perinatal care, as well as details of roles and facility design. Since then, the American Academy of Pediatrics (AAP) and American College of Obstetricians and Gynecologists (ACOG) have published several editions of their comprehensive *Guidelines for Perinatal Care*[2], and The American Institute of Architects has likewise published several editions of their *Guidelines for Construction of Hospital and Healthcare Facilities*[3]. In 1993, *Toward Improving the Outcome of Pregnancy* was revised[4]. The second TIOP reviewed medical and societal changes since the original document and formulated new recommendations in recognition of these developments, particularly the ascendance of managed care.

The purpose of this committee is to complement the above documents by providing health care professionals, architects, interior designers, state health care facility regulators, and others involved in the planning of NICUs with a comprehensive set of standards based on clinical experience and an evolving scientific database.

With the support of Ross Products Division / Abbott Laboratories, a multidisciplinary team of physicians, nurses, state health planning officials, consultants, and architects reached consensus on the first edition of these recommendations in January 1992. The document was then sent to all members of the American Academy of Pediatrics Section on Perinatal Pediatrics to solicit their comments, and we also sought input from participants at the 1993 Parent Care Conference and at an open, multidisciplinary conference on newborn ICU design held in Orlando in 1993. Subsequent editions of these recommended standards were then developed by consensus committees in 1993, 1996, 1999, 2002, and 2006 under the auspices of the Physical and Developmental Environment of the High-Risk Infant Project.

Various portions of these recommended standards have now been adopted by the American Institute of Architects' *Guidelines*[3], the AAP/ACOG *Guidelines*[2], and by standards documents in several other countries. In the future, we will continue to update these recommendations on a regular basis, incorporating new research findings, experiences, and suggestions.

It is our hope this document will continue to provide the basis for a consistent set of standards that can be used by all states and endorsed by appropriate national organizations, and that it will also continue to be useful in the international arena.

While many of these standards are minimums, the intent is to optimize design within the constraints of available resources, and to facilitate excellent health care for the infant in a setting that supports the central role of the family and the needs of the staff. Decision makers may find these standards do not go far enough, and resources may be available to push further toward the ideal.

Application of These Standards

Unless specified otherwise, the following recommendations apply to the newborn intensive care built environment, although most have broader application for the care of ill infants and their families.

Where the word *shall* is used, it is the consensus of the committee participants that the standard is appropriate for future NICU constructions. We recognize that it may not be reasonable to apply these standards to existing NICUs or those undergoing limited renovation.

We also recognize the need to avoid statements requiring mandatory compliance unless a clear scientific basis or consensus exists. The standards presented in this document address only those areas where we believe such data or consensus are available.

Individuals and organizations applying these standards should understand that this document is not meant to be all-encompassing. It is intended to provide guidance for the planning team to apply the functional aspects of operations with sensitivity to the needs of infants, family and staff. The program planning and design process should include research, evidence based recommendations and materials, with objective input of experts in the field in addition to the internal interdisciplinary team. The design should creatively reflect the vision and spirit of the infants, families and staff of the unit. The program and design process should include:

- Review of articles on practice, teambuilding, and planning
- Education in the change process
- Visits to new and renovated units
- Vendor Fairs
- Vision and Goals
- Program Planning
- Space planning, including methods to visualize 3-D space
- Operations planning, including traffic patterns, functional locations, and relationship to ancillary services
- Interior planning
- Surface materials selection
- Review of blueprints, specifications, other documents and mock-ups
- Building and construction
- Post-construction verification and remediation.

Substantive Changes - 7th Edition

For the first time, the Consensus Committee ventured outside the NICU proper to write a recommended standard for the delivery room, where the care of high-risk infants nearly always begins. We also acknowledged the increasing use of private (single-family) rooms and operating facilities within the NICU by writing recommended standards that begin to address those practices. Finally, we continued to address the acoustical characteristics of the NICU in an ongoing effort to provide an optimal environment both for infants who are in a crucial stage of auditory development and for their caregivers.

Delivery Room Standard - The minimum size and structural content of infant resuscitation areas in operative delivery rooms and labor/delivery rooms is specified.

Standard 23: Acoustic Environment – We reduced the maximum allowable Noise Criterion rating to 25 for building mechanical systems and permanent equipment in infant care rooms and adult sleep rooms, and to NC-30 for rooms in open communication with these areas in order to better achieve the already-established standard for ambient noise level of Leq 45 dB to promote sleep, communication, and learning.

Standard 26: Operating Rooms Intended for use by Newborn ICU Patients - Specifications both for general operating rooms intended for use by NICU patients, as well as specialized procedure rooms within the NICU are identified in order to meet the special sensory needs of newborns.

Standard 27: Private (Single-Family) Rooms – We designated increased space needs in a private room setting compared to beds in a multiple-bed room and identified specific structural needs for these rooms, including a clarification that an outside window is not required.

We made a few other less substantive changes in the Recommended Standards that are not summarized here as they are not likely to have a significant impact on the design process, but were part of our effort to be sure the standards are as useful and contemporary as possible.

The Newborn Intensive Care Unit

No consensus national standard of what constitutes a NICU exists. Some states have defined levels of care, while other states have informal or no systems for classification. The American Academy of Pediatrics has defined NICU levels and sub-levels of care based primarily on availability of specialized equipment and staff[2], but many NICUs often encompass both intensive and step-down or intermediate care. The recommended minimum standards we have written encompass Level III subspecialty care in general, rather than distinguish criteria for each sub-level.

For the purposes of this document, *newborn intensive care* is defined as care for medically unstable or critically ill newborns requiring constant nursing, complicated surgical procedures, continual respiratory support, or other intensive interventions.

Intermediate care includes care of ill infants requiring less constant nursing, but does not exclude respiratory support. When an intensive care nursery is available, the intermediate nursery serves as a "step down" unit from the intensive care area. When hospitals mix infants of varying acuity, requiring different levels of care in the same area, intensive care design standards shall be followed to provide maximum clinical flexibility.

Standards

Delivery Room Standard

Infant Resuscitation/Stabilization Areas

Space for infant resuscitation/stabilization shall be provided within operative delivery rooms and within Labor/Delivery/Recovery (LDR), Labor/Delivery/Recovery/Post-partum (LDRP) rooms, or other non-operative delivery rooms. Delivery rooms may directly connect to nursery or Newborn ICU (NICU) space via pass-through windows or doors. The ventilation system for each delivery and resuscitation room shall be designed to control the ambient temperature between 72-78 degrees Fahrenheit (22-26 degrees Centigrade) during the delivery, resuscitation, and stabilization of a newborn.

Specific recommendations for each location where infant resuscitation or stabilization occurs are as follows:

Operative Delivery Rooms

Recommendations for operating rooms intended for use by NICU patients (Standard 26) shall be followed with these exceptions:

- **A minimum clear floor area of 80 square feet (7.5 square meters) for the infant shall be provided in addition to the area required for other functions.**
- **3 oxygen, 3 air, 3 vacuum and 12 simultaneously-accessible electrical outlets shall be provided for the infant and shall comply with all specifications for these outlets described in NICU Standard 4.**
- **The infant space may not be omitted from the operative delivery room(s) when a separate infant resuscitation/stabilization room is provided.**

LDR, LDRP or other Non-operative Delivery Rooms

- **A minimum clear floor area of 40 square feet (3.7 square meters) shall be provided for infant space. This space may be used for multiple purposes including resuscitation, stabilization, observation, exam, sleep or other infant needs.**
- **1 oxygen, 1 air, 1 vacuum and 6 simultaneously-accessible electrical outlets shall be provided for the infant in addition to the facilities required for the mother.**
- **The infant space may not be omitted from the LDR, LDRP or non-operative delivery room when a separate infant resuscitation/stabilization room is provided.**

Pass-Through Windows and Doors

- **Windows and doors shall be designed for visual and acoustical privacy and shall allow easy exchange of an infant between personnel.**
- **When an operative delivery room is equipped with a pass-through window or door, it shall have positive pressure so that air flows out to the infant room when the window or door is opened.**

Interpretation: Today's delivery rooms (operative and non-operative) are required to have separate resuscitation space and outlets for infants. This space includes an acceptable environment for most uncomplicated term infants, but may not support the optimal management of infants who will become NICU patients.

Some term infants and most preterm infants are at greater thermal risk and often require additional personnel, equipment and time to optimize resuscitation. They are essentially NICU patients from the time of delivery and would therefore be optimally managed in space designed to NICU standards. The appropriate resuscitation/stabilization environment should be provided. Providing it in each delivery room allows parents to be aware of staff's efforts to revive and care for their infant before transport to the NICU. Providing it in the nursery or NICU via pass-through windows or doors offers efficiencies for staff, an environment designed for infants, and obviates the need for transport from the delivery room. Infectious concerns for an opening into an operative room from a non-sterile (NICU) area are addressed by designing airflow out of the sterile room when windows and doors are opened. Only the infant crosses this barrier and receiving NICU personnel can be required to wear sterile gowns and gloves to avoid contamination of the operative room personnel passing the infant.

Provision of appropriate temperature for delivery room resuscitation of high-risk preterm infants is vital to their stabilization. While lower temperatures are often more comfortable for gowned attendants, the needs of the high-risk infant must take priority. It is also essential that these appropriate ambient temperatures can be achieved within a short time frame, since many high-risk deliveries occur with little warning.

Since many of the higher risk patients are delivered in operative delivery rooms, the operative room minimums should be greater than the minimum standards for LDRs or LDRPs. If a hospital serves a predominantly high risk perinatal population, the hospital is encouraged to exceed the minimum standards.

Equipment storage may be best provided by a wall-hung board or other technique to allow ready visibility and access to all needed resuscitation equipment.

Newborn ICU Standards

Standard 1: Unit Configuration

The NICU design shall be driven by systematically developed program goals and objectives that define the purpose of the unit, service provision, space utilization, projected bed space demand, staffing requirements and other basic information related to the mission of the unit. Design strategies to achieve program goals and objectives shall address the medical, developmental, educational, emotional, and social needs of infants, families and staff. The design shall allow for flexibility and creativity to achieve the stated objectives.

The NICU shall be configured to individualize the caregiving environment and services for each infant and family.

Interpretation: Program goals and objectives congruent with the philosophy of care and the unit's definition of quality should be developed by a planning team. This team should include, among others, health care professionals, families whose primary experience with the hospital is as consumers of health care, administrators and design professionals.

The program goals and objectives should include a description of those services necessary for the complete operation of the unit and address the potential need to expand services to accommodate increased demand.

The specific approaches to achieve individualized environments are addressed in subsequent sections.

Standard 2: NICU Location Within the Hospital

The NICU shall be a distinct area within the health care facility, with controlled access and a controlled environment.

The NICU shall be located within space designed for that purpose. It shall provide effective circulation of staff, family, and equipment. Traffic to other services shall not pass through the unit.

The NICU shall be in close and controlled proximity to the area of the hospital where births occur. When obstetric and neonatal services must be on separate floors of the Hospital, an elevator located adjacent to the units with priority call and controlled access by keyed operation shall be provided for service between the birthing unit and the NICU.

Units receiving infants from other facilities shall have ready access to the hospital's transport receiving area.

Interpretation: The purpose of this standard is to provide safe and efficient transport of infants while respecting their privacy. Accordingly, the NICU should be a distinct, controlled area immediately adjacent to other perinatal services, except in those local situations (e.g., free-standing children's hospitals) where exceptions can be justified. Transport of infants within the hospital should be possible without using public corridors.

Standard 3: Minimum Space, Clearance, and Privacy Requirements for the Infant Space

Each infant space shall contain a minimum of 120 square feet (11.2 square meters) of clear floor space, excluding handwashing stations, columns, and aisles (see Glossary). There shall be an aisle adjacent to each infant space with a minimum width of 4 feet (1.2 meters) in multiple bed rooms. When single infant rooms or fixed cubicle partitions are utilized in the design, there shall be an adjacent aisle of not less than 8 feet (2.4 meters) in clear and unobstructed width to permit passage of equipment and personnel.

Multiple bed rooms shall have a minimum of 8 feet (2.4 meters) between infant beds. There shall be provision for visual privacy[Error! Reference source not found.] for each bed, and the design shall support speech privacy at a distance of 12 feet (3.6 meters).

Interpretation: These numbers are minimums and often need to be increased to reflect the complexity of care rendered, bedside space needed for parenting and family involvement in care, and privacy for families (see Standard 27: Private [Single-Family] Rooms).

Infant space for intensive care infant beds situated in a single infant room should be at least 150 net square feet (14 square meters) per infant to provide adequate space for equipment and families. The width of aisles in multiple bed rooms should allow for easy movement of all equipment that might be brought to the infant's bedside, as well as easy access for a maternal bed. The width of the corridors or aisles outside single infant rooms or infant spaces designed with permanent cubicle partitions should allow for simultaneous passage of two such items as mandated by state and federal architectural and fire codes.

The need for privacy for infants and families should be addressed not only in design of each bed space, but also in the overall unit design - for example, by minimizing traffic flow past each bed.

Standard 4: Electrical, Gas Supply, and Mechanical Needs

Mechanical requirements at each infant bed, such as electrical and gas outlets, shall be organized to ensure safety, easy access and maintenance.

There shall be a minimum of 20 simultaneously accessible electrical outlets. The minimum number of simultaneously accessible gas outlets is:

Air 3,
Oxygen 3, and
Vacuum 3.

There shall be a mixture of emergency and normal power for all electrical outlets per current National Fire Protection Association recommendations[6].

There shall be provision at each bedside to allow data transmission to a remote location.

Interpretation: A system that includes easily accessible raceways for electrical conduit and gas piping, work space, and equipment placement is recommended because it permits flexibility to modify or upgrade mechanical features. All outlets should be positioned to maximize access and flexibility. Standard duplex electrical outlets may not be suitable, since each outlet may not be simultaneously accessible for oversized equipment plugs. The number of electrical, gas, and suction outlets specified is a minimum; access to more may be necessary for critically ill infants. This area should also include communication devices, supply storage, and charting space, resulting in an efficient, organized, and self-contained workstation around the infant.

Standard 5: Airborne Infection Isolation Room(s)

An airborne infection isolation room shall be available for NICU infants, and shall provide a minimum of 150 square feet (14 square meters) of clear floor space, excluding the entry work area. A hands-free handwashing station for hand hygiene and areas for gowning and storage of clean and soiled materials shall be provided near the entrance to the room. Ventilation systems for isolation rooms shall be engineered to have negative air pressure with air 100% exhausted to the outside, and shall meet acoustic standards for infant rooms (Standard 23). Airborne infection isolation room perimeter walls, ceilings, and floors, including penetrations, shall be sealed tightly so that air does not infiltrate the environment from the outside or from other airspaces.

Airborne infection isolation rooms shall have self-closing devices on all room exit doors. An emergency communication system and remote patient

monitoring capability shall be provided within the airborne infection isolation room.

Airborne infection isolation rooms shall have observation windows with internal blinds or switchable privacy (opaquing) glass for privacy. Placement of windows and other structural items shall allow for ease of operation and cleaning.

Airborne infection isolation rooms shall have a permanently installed visual mechanism to constantly monitor the pressure status of the room when occupied by a patient with an airborne infectious disease. The mechanism shall continuously monitor the direction of the airflow.

Interpretation: An airborne infection isolation room adequately designed to care for ill newborns should be available in any hospital with an NICU. In most cases, this is ideally situated within the NICU, but in some circumstances, utilization of an airborne infection isolation room elsewhere in the hospital (e.g., in a pediatric ICU) would be suitable.

At least one single-occupancy isolation room should be available for any infant with a suspected airborne infection. A space within the NICU should also be available to safely cohort a group of infants infected with or exposed to a common airborne pathogen.

When not used for isolation, these rooms may be used for care of non-infectious infants and other clinical purposes.

Turbulence attendant to high air-exchange rates can result in unacceptable levels of background noise in airborne infection isolation rooms. Such levels result in speech interference, annoyance, and physiologic responses typical of noise exposure for adults and infants. Specific attention is required, therefore, to the design of noise-attenuating devices in the heating/ventilation/air-conditioning (HVAC) ductwork and to washable acoustic surfaces on the walls and ceilings to ensure that sound levels meet the Standard in these rooms. Glass partitions should be limited to that which is actually necessary for safe visualization. Proportional amounts of acoustically absorptive and acoustically reflective surfaces should be appropriate to achieve greater than 25% sound absorption.

Standard 6: Family Entry and Reception Area

The NICU shall have a clearly identified entrance and reception area for families. Families shall have immediate and direct contact with staff when they arrive at this entrance and reception area.

Interpretation: The design of this area should contribute to positive first impressions for families and foster the concept that families are important

members of their infant's health care team, not visitors. Facilitating contact with staff will also enhance security for infants in the NICU.

This area should have lockable storage facilities for families' personal belongings (unless provided elsewhere), and may also include a handwashing and gowning area.

Standard 7: Handwashing Stations

Where a single infant room concept is used, a hands-free handwashing station shall be provided within each infant room. In a multiple bed room, every infant bed shall be within 20 feet (6 meters) of a hands-free handwashing station. Handwashing stations shall be no closer than 3 feet (0.9 meter) from an infant bed or clean supply storage.

Handwashing sinks shall be large enough to control splashing and designed to avoid standing or retained water. Minimum dimensions for a handwashing sink are 24 inches wide x 16 inches front to back x 10 inches deep (61 cm x 41 cm x 25 cm) from the bottom of the sink to the top of its rim. Space for pictorial handwashing instructions shall be provided above all sinks. There shall be no aerator on the faucet. Walls adjacent to handwashing sinks shall be constructed of non-porous material. Space shall also be provided for soap and towel dispensers and for appropriate trash receptacles. Towel dispensers shall operate so that only the towel itself need be touched in the process of dispensing, and constructed in such a fashion as to be consistent with Standard 23.

Handwashing facilities located at a level where they can be used by people in wheelchairs shall be available in the NICU.

Separate receptacles for biohazardous and non-biohazardous waste shall be available.

Interpretation: Sinks for handwashing should not be built into counters. Sink location, construction material and related hardware (paper towel and soap dispensers) should be chosen with durability, ease of operation, ease of cleaning, and noise control in mind. Non-absorbent wall material should be used around sinks to prevent the growth of mold on cellulose material.

Local, state, and federal regulatory agencies dictate what healthcare-generated waste is biohazardous or non-biohazardous and appropriate disposal methods that are dependent on the type of waste. Depending upon the jurisdiction, biohazard signage may need to be affixed.

Standard 8: General Support Space

Distinct facilities shall be provided for clean and soiled utilities, medical equipment storage, and unit management services.

Clean Utility/Holding Area(s): **For storage of supplies frequently used in the care of newborns.**

Soiled Utility/Holding Room: **Essential for storing used and contaminated material before its removal from the care area. Unless used only as a holding room, this room shall contain a counter and a hands-free handwashing station separate from any utility sinks. The handwashing station shall have hot and cold running water that is turned on and off by hands-free controls, soap and paper towel dispensers, and a covered waste receptacle with foot control.**

The ventilation system in the soiled utility/holding room shall be engineered to have negative air pressure with air 100% exhausted to the outside. The soiled utility/holding room shall be situated to allow removal of soiled materials without passing through the infant care area.

A designated area for collection of recyclable materials used in the NICU shall be established[7]. This area shall measure at least one square foot per patient bed and be located outside the patient care area.

Charting/Staff Work Areas: **Provision for charting space at each bedside shall be provided. An additional separate area or desk for tasks such as compiling more detailed records, completing requisitions, and telephone communication shall be provided in an area acoustically separated from the infant and family areas. Dedicated space shall be allocated as necessary for electronic medical record keeping within infant care areas.**

Interpretation: *Storage Areas:* A three-zone storage system is desirable. The first storage area should be the central supply department of the hospital.

The second storage zone is the clean utility area described in the standard; it should be adjacent to and acoustically separated from the infant care area. Routinely used supplies such as diapers, formula, linen, cover gowns, charts, and information booklets may be stored in this space. There should be at least 8 cubic feet (0.22 cubic meters) for each infant for secondary storage of syringes, needles, intravenous infusion sets, and sterile trays.

There should also be at least 18 square feet (1.7 square meters) of floor space allocated for equipment storage per infant in intermediate care, and 30 square

feet (2.8 square meters) for each infant bed in intensive care. Total storage space may vary by unit size and storage system.

Easily accessible electrical outlets are desirable in this area for recharging equipment.

The third storage zone is for items frequently used at the infant's bedside. Bedside cabinet storage should be at least 16 cubic feet (0.45 cubic meters) for each infant in the intermediate care area and 24 cubic feet (0.67 cubic meters) for each infant in the intensive care area. Bedside storage should be designed for quiet operation.

Hospitals contribute significant waste each year to incinerators and landfills. This creates not only an environmental hazard, but also conditions that are harmful to human health. Providing a designated collection area enables staff to separate and store for collection waste such as paper, newsprint, corrugated cardboard, plastics, metals, batteries, fluorescent lamps, and glass to either facilitate existing hospital procedures for recycling or initiate a recycling system. Space within the designated collection area also may be used for collection of medical supplies for distribution to hospitals or clinics in need of such materials.

Charting/Staff Work Areas: A clerical area should be located near the entrance to the NICU so personnel can supervise traffic into the unit. In addition, there should be one or more staff work areas, each serving 8 to 16 beds. These areas will allow groups of 3-6 caregivers to congregate immediately adjacent to the infant care area for report, collaboration, and socialization without impinging on infant or family privacy. Infants' charts, computer terminals, and hospital forms may be located in this space.

Design of the NICU must anticipate use of electronic medical record devices so that their introduction doe not require major disruption of the function of the unit or impinge on space designed for other purposes. Design considerations include ease of access for staff, patient confidentiality, infection control and noise control, both with respect to that generated by the devices and by the traffic around them.

Laundry Room: If laundry facilities for infant materials are provided, a separate laundry room can serve the functions of laundry and toy cleaning within the NICU. Infant clothing and the cloth covers of positioning aids should be laundered on a regular schedule and as needed. In addition, toys utilized by infants or siblings are required to be cleaned on a regular schedule for each infant and between infants. Space for a commercial-grade washer and dryer should be accommodated. The dryer should be vented through an outside wall. The placement of a commercial-grade dishwasher could promote the efficiency and effectiveness of the aseptic cleaning process for toys.

Standard 9: Staff Support Space

Space shall be provided within the NICU to meet the professional, personal, and administrative needs of the staff. Rooms shall be sized and located to provide privacy and to satisfy their intended function. Locker, lounge, private toilet facilities and on-call rooms are required at a minimum.

Interpretation: Support elements can be defined as those that facilitate the provision of infant care and the well being of the staff; they may account for at least one third of the floor space of the entire unit.

Staffing areas are defined as space limited to use by staff members to meet personal, professional, and administrative needs. These areas include lockers, lounges, counseling, education and conference space, and on-call rooms that provide privacy and satisfy their intended function.

Standard 10: Family Transition Room(s)

Family-infant room(s) shall be provided within or immediately adjacent to the NICU that allow(s) families and infants extended private time together.

The room(s) shall have direct, private access to sink and toilet facilities, emergency call and telephone or intercom linkage with the NICU staff, sleeping facilities for at least one parent, and sufficient space for the infant's bed and equipment.

The room(s) can be used for other family support, educational, counseling, or demonstration purposes when unoccupied.

Interpretation: Access to family-infant room(s) encourages overnight stays by parents and the infant in the NICU. The room(s) should be sufficiently equipped and sized to accommodate the parents, with additional space for a physician, nurse, social worker, chaplain, or other individuals who may need to meet with the parents and baby in private.

For security reasons, transition room(s) should be situated within an area of controlled public access.

The number of electrical, medical gas, and suction outlets specified will be dependent on the function(s) intended for this area.

Sufficient family-infant rooms should be provided to allow those families who wish to room in with their infants the opportunity to do so. The appropriate number of rooms will depend on each hospital's practice pattern, the number of

single infant rooms with parent sleeping facilities, the availability of other rooms nearby, the size of the region served, and other variables.

Standard 11: Family Support Space

Space shall be provided in or immediately adjacent to the NICU for the following functions: family lounge area, lockable storage, telephone(s), and toilet facilities. Separate, dedicated rooms shall also be provided for lactation support and consultation in or immediately adjacent to the NICU. A family library or education area shall be provided within the hospital. Access to the Internet and educational materials shall be provided via a computer station in the family lounge or at the infant's bedside.

Interpretation: *Family Lounge Area:* This should include comfortable and moveable seating, as well as a play area stocked with entertainment materials for children. A nourishment area should also be considered, as well as external windows or skylights.

Lockable Storage: Secure storage for personal items should be provided at each infant space.

Lactation Support: Comfortable seating, a handwashing sink, and a means of communication to the NICU should be provided.

Family Education Area: This should include publications, audiovisual resources, and Internet access so that families can learn about health conditions, child development, parenting issues, and parent-to-parent support. This area might also include space and supplies to learn about and practice caregiving techniques.

Telephones: Telephones should be provided that offer privacy and that enable an individual to sit down while talking.

Consultation Room: This should include comfortable seating and allow complete visual and acoustic privacy.

Standard 12: Support Space for Ancillary Services

Distinct support space shall be provided for all clinical services that are routinely performed in the NICU.

Interpretation: Ancillary services such as (but not necessarily limited to) respiratory therapy, laboratory, pharmacy, radiology, developmental therapy, and specialized feeding preparation are common in the NICU. Distance, size, and access are important considerations when designing space for each of these

functions. Satellite facilities may be required to provide these services in a timely manner.

Unless performed elsewhere in the hospital, a specialized feedings preparation area or room should be provided in the NICU, away from the bedside, to permit mixing of additives to breast milk or formula. This area should be equipped with a hands-free handwashing station, counter work space, and storage areas for supplies, formula, and both refrigerated and frozen breast milk[8].

Standard 13: Administrative Space

Administrative space shall be provided in the NICU for activities directly related to infant care, family support, or other activities routinely performed within the NICU.

Interpretation: A wide range of personnel are assigned to the NICU, many of whom require office or administrative space. When planning the NICU, administrative space should be considered for each discipline that provides service to the unit on a daily basis and needs a distinct area for carrying out their responsibilities, even if that individual has additional office space elsewhere.

Standard 14: Ambient Lighting in Infant Care Areas

Ambient lighting levels in infant spaces shall be adjustable through a range of at least 10 to no more than 600 lux (approximately 1 to 60 foot candles), as measured at each bedside. Both natural and electric light sources shall have controls that allow immediate darkening of any bed position sufficient for transillumination when necessary.

Electric light sources shall have a color rendering index (CRI)[9] of no less than 80, a full-spectrum color index (FSCI)[10] of no less than 55, and a gamut area (GA)[10] of no less than 65 and no greater than 100. The sources shall avoid unnecessary ultraviolet or infrared radiation by the use of appropriate lamps, lens, or filters[11].

No direct view of the electric light source or sun shall be permitted in the infant space (as described in Standard 3): this does not exclude direct procedure lighting, as described in Standard 15. Any lighting used outside the infant care area shall be located so as to avoid any infant's direct line of sight to the fixture.

Lighting fixtures shall be easily cleaned.

Interpretation: Substantial flexibility in lighting levels is required by this standard so that the disparate needs of infants at various stages of development and at various times of day can be accommodated, as well as the needs of caregivers. In very preterm infants, there has been no demonstrable benefit to exposure to light. After 28 weeks gestation, there is some evidence that diurnally-cycled lighting has potential benefit to the infant[12]. Caregivers benefit from moderate levels of ambient light in order to perform tasks and maintain wakefulness.

Control of illumination should be accessible to staff and families, and capable of adjustment across the recommended range of lighting levels. Use of multiple light switches to allow different levels of illumination is one method helpful in this regard, but can pose serious difficulties when rapid darkening of the room is required to permit transillumination, so a master switch should also be provided.

Perception of skin tones is critical in the NICU; light sources that meet the CRI, FSCI, and GA values identified above provide accurate skin-tone recognition. Light sources should be as free as possible of glare or veiling reflections. When the light sources to be used are linear fluorescent lamps, these color criteria can be met by using lamps that carry the color designation “RE80”.

Standard 15: Procedure Lighting in Infant Care Areas

Separate procedure lighting shall be available to each infant bed. The luminaire shall be capable of providing no less than 2000 lux at the plane of the infant bed, and must be framed so that no more than 2% of the light output of the luminaire extends beyond its illumination field. This lighting shall be adjustable so that lighting at less than maximal levels can be provided whenever possible.

Interpretation: Temporary increases in illumination necessary to evaluate a baby or to perform a procedure should be possible without increasing lighting levels for other babies in the same room.

Since intense light may be unpleasant and harmful to the developing retina, every effort should be made to prevent direct light from reaching the infant’s eyes. Procedure lights with adjustable intensity, field size, and direction will help protect the infant’s eyes from direct exposure and provide the best visual support to staff.

Standard 16: Illumination of Support Areas

Illumination of support areas within the NICU, including the charting areas, medication preparation area, the reception desk, and handwashing areas, shall conform to IESNA specifications[11].

Interpretation: Illumination should be adequate in areas of the NICU where staff perform important or critical tasks; the IESNA specifications in these areas are similar to but somewhat more specific than the general guidelines recommended by AAP/ACOG[2].

In locations where these functions overlap with infant care areas (e.g., close proximity of the staff charting area to infant beds), the design should nevertheless permit separate light sources with independent controls so the very different needs of sleeping infants and working staff can be accommodated to the greatest possible extent. Care must be taken, however, to insure that bright light from these locations does not reach the infants' eyes (see Standard 14).

Consideration should be given to providing a space easily accessible to all staff that will provide an opportunity for exposure to higher-intensity light levels for at least 15 minutes a shift in order to ameliorate the effects of working at night and Seasonal Affective Disorder[13]. This space can be illuminated with white light to produce 300-500 lux at the eye, which is produced by approximately 1500-2500 lux at the work plane. If a blue local lighting system is used, the illumination should be from a spectrally narrowband source - such as a blue LED – with a peak wavelength at or near 470 nanometers, and should produce at least 30 lux at the eye[14].

Standard 17: Daylighting

At least one source of daylight shall be visible from infant care areas, either from each infant room itself or from an adjacent staff work area. When provided, external windows in infant care rooms shall be glazed with insulating glass to minimize heat gain or loss, and shall be situated at least 2 feet (0.6 meter) away from any part of an infant's bed to minimize radiant heat loss. All external windows shall be equipped with shading devices that are neutral color or opaque to minimize color distortion from transmitted light.

Interpretation: Windows provide an important psychological benefit to staff and families in the NICU[9,15]. Properly designed daylighting is the most desirable illumination for nearly all caregiving tasks, including charting and evaluation of infant skin tone.

However, placing infants too close to external windows can cause serious problems with radiant heat loss or gain and glare, so provision of windows in the NICU requires careful planning and design.

Shading devices should be easily controlled to allow flexibility at various times of day, and should either be contained within the window or easily cleanable. These should be designed to avoid direct sunlight from striking the infant, IV fluids, or monitor screens.

Standard 18: Floor Surfaces

Floor surfaces shall be easily cleanable and shall minimize the growth of microorganisms.

Flooring material with a reflectance of no greater than 40%[9] and a gloss value of no greater than 30 gloss units shall be used[16,17], to minimize the possibility that glare reflected from a bright procedure or work-area light will impinge on the eyes of infants or caregivers.

Floors shall be highly durable to withstand frequent cleaning and heavy traffic.

Flooring materials shall be free of substances known to be teratogenic, mutagenic, carcinogenic, or otherwise harmful to human health.

Interpretation: While ease of cleaning and durability of NICU surfaces are of primary importance, consideration should also be given to their glossiness (the mirror-like reflectivity of a surface)[18], their acoustical properties, and the density of the materials used. Reduced glossiness will reduce the risks from bright reflected glare; acoustic and density properties will directly affect noise and comfort.

Materials should permit cleaning without the use of chemicals that may be hazardous, since it may not be possible to vacate the space during cleaning.

Transition surfaces that do not obstruct mobility, are durable, and minimize noise and jarring of equipment should be provided at the intersection of different flooring materials.

Materials suitable to these criteria include resilient sheet flooring (medical grade rubber or linoleum) and carpeting with an impermeable backing, heat- or chemically-welded seams, and antimicrobial and antistatic properties. Carpeting has been shown to be an acceptable floor covering in the hospital[19] and the NICU[20] and has obvious aesthetic and noise reduction appeal, but it is not suitable in all areas (e.g., around sinks or in isolation or soiling utility/holding areas). Small floor tiles (e.g., 12 inch squares) have myriad seams and areas of non-adherence to the sub-floor. These harbor dirt and fluids and are a potential source of bacterial and fungal growth.

Much is known[21] regarding the effects of chemicals such as mercury on human health and development. Additional efforts should be made to exclude persistent, bioaccumulative toxic chemicals (PBTs) such as polyvinyl chloride (PVC) from healthcare environments. PVC or vinyl is common in flooring materials including sheet goods, tiles, and carpet. The production of PVC generates dioxin, a potent carcinogen, and fumes emitted from vinyl degrade indoor air quality. Dioxin

releases are not associated with materials such as polyolefin, rubber (latex), or linoleum.

Volatile organic compounds (VOCs) such as formaldehyde and chlorinated compounds such as neoprene also should be avoided when selecting adhesives or sealants for floor coverings. Specify low- or no-VOC and non-toxic and non-carcinogenic materials. Flooring containing natural rubber (latex) should be certified non-allergenic by the manufacturer.

Infants should not be moved into an area of newly installed flooring for a minimum of two weeks to permit complete off-gassing of adhesives and flooring materials.

Standard 19: Wall Surfaces

Wall surfaces shall be easily cleanable and provide protection at points where contact with movable equipment is likely to occur. Surfaces shall be free of substances known to be teratogenic, mutagenic, carcinogenic, or otherwise harmful to human health.

Interpretation: As with floors, the ease of cleaning, durability, and acoustical properties of wall surfaces must be considered. Although commonly used, vinyl wall covering contains PVC and will degrade indoor air quality, and thus should be avoided. VOCs and PBTs such as cadmium often are found in paints, wall-coverings, acoustical wall panels, and wood paneling systems and also should be avoided. Specify low- or no-VOC paints and coatings.

Standard 20: Furnishings

Built-in and freestanding furnishings such as cabinets and carts, especially those in the infant care areas, shall be easily cleanable with the fewest possible seams in the integral construction. Exposed surface seams shall be sealed. Furnishings shall be of durable construction to withstand impact by movable equipment without significant damage.

Furnishings and materials shall be free of substances known to be teratogenic, mutagenic, carcinogenic, or otherwise harmful to human health.

Interpretation: Countertops should have the fewest possible seams. Edges exposed to impact should be "soft" (i.e., bull-nosed). Corners created at wall or backsplash intersections should be coved. Intersections with sinks or other devices should be sealed or made integral with the top. Casework construction

should not chip or flake when struck by objects in the normal routine of infant care, and should be of sufficient moisture resistance to prevent deterioration**.**

Furnishings in the NICU are often composite pieces made of various parts and layers of materials that are assembled with glue or adhesives. Materials and substances typically used in these furnishings often contain volatile organic compounds (VOCs) such as formaldehyde, which is frequently found in pressed wood products including plywood and particle board. Vinyl-based laminates, which often are applied to the surface of pressed wood products, also contain VOCs such as polyvinyl chloride (PVC). Specify low- or no-VOC materials, including urea-formaldehyde-free adhesives, for all furnishings in the NICU.

Specifying furnishings and materials from regional sources (within a 300 – 500 mile radius) not only provides support for the local community, but also reduces the amounts of fossil fuels necessary for transport.

Standard 21: Ceiling Finishes

Ceilings shall be easily cleanable and constructed in a manner to prohibit the passage of particles from the cavity above the ceiling plane into the clinical environment.

The ceiling construction in infant rooms and adult sleep areas and the spaces opening onto them shall not be friable and shall have a noise reduction coefficient (NRC) of at least 0.95 for 80% of the entire surface area or an average NRC of 0.85 for the whole ceiling including solid and acoustically absorptive surfaces. To ensure protection from noise intrusion, ceilings in infant rooms and adult sleep areas shall be specified with a ceiling articulation class (CAC)-29.

Finishes shall be free of substances known to be teratogenic, mutagenic, carcinogenic, or otherwise harmful to human health.

Interpretation: Since sound abatement is a high priority in the NICU, acoustical ceiling systems are desirable, but must be selected and designed carefully to meet this standard. In most NICUs, the ceiling offers the largest available area for sound absorption. The Standard for ceiling finishes includes areas that communicate with infant rooms and adult sleep areas (e.g., hallways, corridors, storage, and staff work areas) when doors are opened in the course of daily activity.

Ceilings with high acoustical absorption (i.e., high NRC ratings) do not have a significant barrier effect (i.e., offer protection from sounds transmitted between adjacent areas). A CAC-29 provides a moderate barrier effect and allows a broad range of ceiling products. Poor barrier effects can result if room-dividing partitions are discontinued above the ceiling allowing room-to-room cross-talk or if there are noise-producing elements in the ceiling plenum. If the ceiling plenum contains noise sources such as fan-powered boxes, in-line exhaust fans, variable air volume devices, etc. then a higher CAC than CAC-29 may be necessary.

VOCs and PBTs such as cadmium are often found in paints and ceiling tiles and should be avoided. Specify low- or no-VOC paints and coatings.

Standard 22: Ambient Temperature and Ventilation

The NICU shall be designed to provide an air temperature of 72°F to 78°F (22-26° C) and a relative humidity of 30-60%[23], while avoiding condensation on wall and window surfaces.

A minimum of six air changes per hour is required, with a minimum of two changes being outside air.

The ventilation pattern shall inhibit particulate matter from moving freely in the space, and intake and exhaust vents shall be situated to minimize drafts on or near the infant beds. Ventilation air delivered to the NICU shall be filtered with at least the efficiency specified in the AIA Guidelines[3]. Filters shall be located outside the infant care area so they can be changed easily and safely.

Fresh air intake shall be located at least 25 feet (7.6 meters) from exhaust outlets of ventilating systems, combustion equipment stacks, medical/surgical vacuum systems, plumbing vents, or areas that may collect vehicular exhausts or other noxious fumes. Prevailing winds or proximity to other structures may require greater clearance.

Interpretation: Heat sources near the exterior wall, if applicable, should be considered to ameliorate the "cold wall" condition, which in turn can be a source of convection drafts. This application of heat may also alleviate the conditions leading to condensation on these walls.

The air flow pattern should be at low velocity and designed to minimize drafts, noise levels, and airborne particulate matter. A HEPA filtration system may provide improved infection control for immunocompromised patients.

Because a regular maintenance program is necessary to assure that systems continue to function as designed after occupancy, NICU design should attempt to maximize the ease of maintenance while minimizing its cost.

Standard 23: Acoustic Environment

Infant rooms (including airborne infection isolation rooms), staff work areas, family areas, and staff lounge and sleeping areas and the spaces opening onto them shall be designed to produce minimal background noise and to contain and absorb much of the transient noise that arises within them.

- **In infant rooms and adult sleep areas, the combination of continuous background sound and operational sound shall not exceed an hourly L_{eq} of 45 dB and an hourly L_{10} of 50 dB, both A-weighted slow response. Transient sounds or L_{max} shall not exceed 65 dB, A-weighted, slow response in these rooms/areas.**
- **In staff work areas, family areas, and staff lounge areas, the combination of continuous background sound and operational sound shall not exceed an hourly L_{eq} of 50 dB and an hourly L_{10} of 55 dB, both A-weighted slow response. Transient sounds or L_{max} shall not exceed 70 dB, A-weighted, slow response in these areas.**

To achieve the required noise levels in infant rooms and adult sleep rooms, building mechanical systems and permanent equipment in those areas shall conform to Noise Criteria (NC) -25 based on manufacturers' noise ratings with allowance for other sound sources and adjustment for room loss if less than 10 dB. Areas in open communication with infant rooms and adult sleep rooms shall conform to NC-30. Building mechanical systems and permanent equipment in other areas specified in the Standard shall conform to a maximum of NC-35. Building mechanical systems include heating, ventilation, and air conditioning systems (HVAC) and other mechanical systems (e.g., plumbing, electrical, vacuum tube systems, and door mechanisms). Permanent equipment includes refrigerators, freezers, ice machines, storage/supply units, and other large non-medical equipment that is rarely replaced.

Where personal address speakers are located in sensitive areas, announcing systems shall have adjustable volume controls for the speakers in each room and for each microphone that sends signal through the system.

Speech privacy[Error! Reference source not found.] and freedom from intrusive sounds shall be provided by acoustic seals for doors and building to meet STC criteria (below) for demising partitions in infant rooms, on-call and sleep rooms, family transition rooms, and conference rooms or offices in which sensitive staff and family information is discussed. All other penetrations for conduits, inset boxes, pipes, ducts, and other elements in sound demising partitions shall be sealed airtight to prevent noise flanking (leakage) through gaps and openings.

Interpretation: The acoustic environment is a function of both the facility (e.g., building mechanical systems and permanent equipment, the intrusion of exterior sounds, the sound containment afforded by doors and walls, and the sound absorption afforded by surface finishes) and operations (e,g, the activities of people and function of medical equipment and furnishings).

The acoustic conditions of the NICU should favor speech intelligibility, normal or relaxed vocal effort, speech privacy for staff and parents, and physiologic stability, uninterrupted sleep, and freedom from acoustic distraction for infants and adults[24]. Such favorable conditions encompass more than the absence of noise and require specific planning for their achievement. Speech Intelligibility

ratings in infant areas, parent areas, and staff work areas should be "good" to "excellent" as defined by the International Organization for Standardization ISO 9921:2003. Speech intelligibility for non-native but fluent speakers and listeners of a second language requires a 4 to 5 dBA improvement in signal-to-noise ratio for similar intelligibility with native speakers. The L_{eq}, L_{10} and L_{max} limits will safeguard this intelligibility and also protect infant sleep[25].

The permissible noise criteria of an hourly Leq of 45 dB, A-weighted, slow response in infant rooms and adult sleep areas is more likely to be met in the fully operational NICU if building mechanical systems and permanent equipment in those areas and the areas in open communication with them conform to NC-25 or less. NC-25 translates to approximately 35 dBA of facility noise. A realistic addition of 10 dBA of operational noise above this background will result in an Leq of about 45 dBA. Limiting operational noise to only 10 dBA above the background will require conscientious effort.

Acoustically absorptive surfaces reduce reverberation and, therefore, sound levels at a distance from the sound source. When possible, two perpendicular walls should be covered with sound absorptive surface materials with an NRC of at least 0.65. Where this is not possible the upper portions of all four walls (above areas likely to be damaged by the movement of equipment) should be covered with such material. Glass should be limited to the area actually required for visualization in order to leave wall surface available for absorptive surface treatment. While a variety of flooring will limit impact noise somewhat, specialized carpeting offers the most protection.

Fire alarms in the infant area should be restricted to flashing lights without an audible signal. The audible alarm level in other occupied areas must be adjustable. Telephones audible from the infant area should have adjustable announcing signals.

The type of water supply and faucets in infant areas should be selected so as to minimize noise, and should provide instant warm water in order to minimize time "on".

Noise-generating activities (e.g., linen and supply carts, conference areas, clerk's areas, multiple-person work stations, and travel paths not essential to infant care), permanent equipment and office equipment should be acoustically isolated from the infant area. Vibration isolation pads are recommended under leveling feet of permanent equipment and appliances in noise-sensitive areas or areas in open or frequent communication with them.

Post-construction validation of specifications for the building mechanical systems and permanent equipment should include noise and vibration measurement, reporting, and remediation. Measurement of NC levels should be made at the location of the infant or adult bed or at the anticipated level of the adult head in other areas. Each bed space must conform to the Standard.

With space at a premium, many incompatible adjacencies are possible in NICU designs (e.g., break area, meeting room, or mechanical room sharing a wall with an infant room or adult sleep room). Specialized wall and floor/ceiling treatments will help to meet criteria in these non-optimal conditions.

The criteria below are for sound transmission loss (TL) or attenuation through horizontal barriers (e.g., walls, doors, windows) and vertical barriers (e.g., between floors). The Sound Transmission Class (STC) rating spans speech frequencies and is relevant for separation of spaces with conversational and other occupant-generated noise. The Noise Reduction (NR) rating, which covers a wider frequency span, is more relevant for mechanical noise dominated by low frequencies. The recommended criteria for TL below apply to barriers between adjacent spaces and infant areas or adult rest or sleep rooms.

Adjacent Spaces	
Pedestrian-only corridor	STC 45
Equipment corridor	STC 55
Infant area	STC 40
Reception	STC 55
Meeting room with amplified sound	STC 55
Staff work area	STC 55
Administrative office, conference	STC 45
Non-related area	STC 50
Mechanical area	NR 60-65
Electrical area	NR 50-55

(adapted from Evans JB, Philbin MK. Facility and operations planning for quiet hospital nurseries. J Perinatol 2000; 20(8):S105-12. Revised and reprinted with permission of Jack B. Evans, PE, M. Kathleen Philbin, RN, PhD, The Journal of Perinatology, and Nature Publishing Company).

Sound transmission from the exterior of the building should meet the NC criteria inside all spaces identified in the Standard.

It is advisable to enlist the services of an acoustical engineer from the onset of the project through post-construction validation. This specialty service is usually not covered by architectural fees and can assist in program and design development, design of mechanical systems, specification of equipment and building construction, and test and balance validation. Enlistment of acoustical services late in the design process often results in fewer and more costly options for meeting performance standards.

Standard 24: Safety/Infant Security

The NICU shall be designed as part of an overall security program to protect the physical safety of infants, families and staff in the NICU. The NICU shall be designed to minimize the risk of infant abduction.

Interpretation: Because facility design significantly affects security, it should be a priority in the planning for renovation of an existing unit or a new unit. Care should be taken to limit the number of exits and entrances to the unit. Control station(s) should be located within close proximity and direct visibility of the entrance to the infant care area. The control point should be situated so that all visitors must walk past the station to enter the unit. The design should provide for maximum visibility of the nursery from the workroom or charting area. However, security considerations should not adversely affect the quality of spaces for families in the NICU. The need for security should be balanced with the needs for comfort and privacy of families and their infants.

Technological devices can be utilized in flexible and innovative manners within the design of the multiple-bed or single infant room NICU schematic. Such technology, when utilized in conjunction with the thoughtful planning of the traffic patterns to/from and within the NICU space, support areas and family space, can facilitate a safe, yet open family-friendly area.

Standard 25: Access to Nature and Other Positive Distractions

When possible, views of nature shall be provided in at least one space that is accessible to all families and one space that is accessible to all staff. Other forms of positive distraction shall be provided for families in infant and family spaces, and for staff in staff spaces.

Interpretation: Culturally appropriate positive distractions provide important psychological benefits to staff and families in the NICU. Looking out a window, viewing psychologically supportive art, or taking a stroll in a garden may help to reduce stress or increase productivity[26]. When possible, windows should have views of nature environments. These environments might consist of trees, plants, human and animal activity, gardens, and landscapes. In urban settings, appropriate nature elements might include planters or water features. When such views are not possible, artwork with nature images or other nature simulations (e.g., video and artificial representations) should be provided throughout the unit. Family and staff lounge spaces are ideal locations for views of nature and other positive distractions.

Provision should be made for direct access to nature and other positive distractions within the hospital complex. These nature environments may consist of outdoor spaces such as gardens or walking paths or indoor spaces such as greenhouses and atria. Amenities within the nature environment might include water features, plant and animal life and solitary and group seating. Other positive distractions might include fitness centers and access to music.

Standard 26: Operating Rooms Intended for Use by Newborn ICU Patients

Operating rooms in health-care facilities where infant procedures may be performed shall be constructed to operating room specifications except for the following modifications:

Assuming infant's eyes are shielded (eye patches) while in the operating room, no changes to the IESNA guidelines for operating rooms[11] are required. However, light sources meeting the CRI, FSCI and GA values identified in Standard 14 are recommended.

Laminar flow diffusers over the surgical bed shall be set at the low end of the air velocity range (approximately 25 ft/min) and balanced with the surrounding slot diffuser air curtain to minimize convective and evaporative heat and water loss from higher air flow onto the infant. In addition, ambient temperature and humidity shall be adjustable into the range of 72-78° F (22 to 26° C) with a relative humidity of at least 30-60%.

The acoustic environment set forth in Standard 23 shall be the basis for all design choices except for the necessary hard (cleanable) room surfaces. No effort need be made to achieve this standard in adjacent spaces if doors are expected to remain closed during most of the procedures.

Specialized Procedure Spaces or Rooms Within the Newborn ICU

Specialized procedure spaces or rooms within the NICU shall be constructed to achieve all of the above, as well as all of the requirements for an infant bed space elsewhere in these Recommended Standards, except for the following additional modifications:

Each procedure area must be physically separated from other areas so that during surgery or procedures patient and staff flow may be strictly controlled. Air flow must be designed so as to not disrupt the air curtain around the surgical field, and shall be adjustable so as to be able to increase to 15 changes/hr during procedures then return to baseline values set forth in Standard 22. A scavenging system to vent waste inhalation anesthesia and analgesia gases is required. HVAC equipment shall be of a type that minimizes the need for maintenance within the room.

Each procedure area shall have a minimum clear area of 225 square feet (21 square meters) excluding handwashing stations, columns and aisles. It shall be designed to comply with safety requirements for performance of laser surgical procedures.

It is assumed that infants having surgery in the NICU will be operated on and recover in their own beds and that surgical personnel will bring needed

sterile surgical equipment and supplies to the NICU. Therefore, no additional recovery or post-anesthesia areas are required nor are work areas for storage and processing of surgical instruments and separate corridors leading to the operative area. However, support areas for storage of clean and sterile surgical supplies shall be provided, and a scrub station shall be provided near the entrance to each procedure room in a corridor limited to authorized personnel and patients.

Ambient lighting recommendations set forth in Standards 14 and 15 shall be followed except where higher illuminances are required as set forth in IESNA recommendations for operating rooms[11]. Increased ambient lighting must still be adjustable and indirect.

Interpretation: Standard operating room environments may be temporarily modified to better accommodate term infants requiring surgery, but cannot be made optimal for some term and preterm infants, nor can the problems associated with transporting less stable infants away from the intensive resources of the NICU be avoided. There is now sufficient experience to conclude that certain procedures can be performed in the NICU without compromising patient safety or outcomes.

It is now also evident that the environment currently recommended for NICU design may have a positive impact on infant outcomes. This Standard now makes provision for infants requiring surgical procedures to be similarly benefited.

Standard 27: Private (Single-Family) Rooms

Rooms intended for the use of a single infant and his/her family shall conform to the requirements for infant spaces designated elsewhere in these standards, with the following exceptions:

- **Minimum size shall be no less than 150 square feet (14 square meters) of clear floor area.**
- **Each room shall have a hands-free handwashing station.**
- **An outside window is not required (see Standard 17 for further specifics).**
- **The requirement for wireless monitor and communication devices shall be identical to that described for isolation rooms (see Standard 5).**
- **Each room shall be designed to allow visual and speech privacy for the infant and family.**
- **Family space shall be designated and be able to include, at a minimum:**
  - **A comfortable reclining chair suitable for kangaroo/skin-to-skin care**
  - **A desk or surface suitable for writing and/or use of a laptop computer**
  - **No less than 6 cubic feet (0.2 cubic meter) of storage space**
- **Staff caregiver space shall be designated and include, at a minimum:**
  - **A work surface of no less than 6 square feet (0.6 square meters)**

- **A charting surface of no less than 3 square feet (0.3 square meters)**
- **Supply storage of no less than 30 cubic feet (0.85 cubic meter).**
  - **NOTE: The above requirements can be met by any combination of fixed and portable casework desired, but all storage must be designed for quiet operation.**

Interpretation: Private (single-family) rooms allow improved ability to provide individualized and private environments for each baby and family when compared to multi-patient rooms. In order to provide adequate space at the bedside for both caregivers and families, however, these rooms need to be somewhat larger than an infant space in an open multi-bed room design, and they must have additional bedside storage and communication capabilities in order to avoid isolation or excessive walking of caregivers.

Although desirable, it may not be possible to provide a window for each room due to a finite amount of outside wall area. It is most important to utilize the available window area first for the gathering spaces used by family and caregivers, and then secondarily for patient rooms.

Glossary

Adult sleep areas: Rooms designated for parent or staff sleep or rest.

Ambient Lighting: The continuous "background" illumination for a specified area.

Ambient Temperature: Thermal measurement of the generalized space around the neonate. Usually refers to room temperature.

Backsplash: A vertical, protective surface located behind a sink or counter.

Biohazardous: Refers to human tissue, cells, body fluids, or culture materials that may contain infectious or other hazardous materials.

Brominated Flame Retardants: bromide compounds that stop or diminish fire. Brominated flame retardants (BRFs) such as polybrominated diphenyl ethers (PBDEs) are used in many products including furniture, textiles, and electronic equipment to reduce the risk of fire. When heated, BRFs produce dioxins and furans (VOCs). BRFS are persistent bioaccumulative toxins and suspected endocrine disruptors.

Cabinetry: Box-like furniture constructed for storage; could consist of drawers, counters, or shelves.

Casework: The components that make up a cabinet.

Clear floor space: The space available for functional use that excludes other defined spaces (e.g., plumbing fixtures, anterooms, vestibules, toilet rooms, closets, lockers, wardrobes, fixed-based cabinets, and wall-hung counters).

Color rendering index (CRI)[27]*:* A measure of the degree of color shift that objects undergo when illuminated by a lamp, compared with those same objects when illuminated by a reference source of comparable correlated color temperature (CCT). A CRI of 100 represents the maximum value. A lower CRI value indicates that some colors may appear unnatural when illuminated by the lamp. Incandescent lamps have a CRI above 95. The cool white fluorescent lamp has a CRI of 62; fluorescent lamps containing rare-earth phosphors are available with CRI values of 80 and above.

Cubicle: Space enclosed on multiple sides with full height or partial partitions with at least one opening without a door.

External windows: Windows located on the exterior skin of a building, looking outside the building or into courtyards.

Full-Spectrum Color Index (FSCI)[27]*:* A mathematical transformation of full-spectrum index into a zero to 100 scale, where the resulting values are directly comparable to color rendering index. An equal energy spectrum is defined as having an FSCI value of

100, a “standard warm white” fluorescent lamp has an FSCI value of 50, and a monochromatic light source (e.g., low pressure sodium) has an FSCI value of 0.

Gamut Area[27]*:* A measure of color rendering based upon volume in color space. It is the range of colors achievable on a given color reproduction medium (or present in an image on that medium) under a given set of viewing conditions.

Hands Free Washing Station: An area that provides a freestanding sink, meets all handwashing station requirements described in Standard 7, such as space for cleaning agents and drying capability, and in addition, is operable without the use of hands.

Infant Bed: Furniture or equipment used to hold an infant.

Infant Room: Contains the infant space.

Infant Space: The area surrounding the infant bed and containing all support equipment and furniture.

Luminaire: A complete lighting unit consisting of a lamp or lamps and the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamp(s) to the power supply. (Also referred to as fixture.)

Non-Public Service Corridors: Designated traffic pathways that are restricted to staff use for staff access and patient or material transport.

Parent-Infant Rooms: Separate rooms in or adjacent to the NICU designed for parents to room-in with their infants during some portion of the NICU stay. These rooms include infant care space, parent sleeping space, and facilities as described in Standard 10.

Perfluorochemicals: Perfluorochemicals (PFCs) are a family of man-made chemicals used to make products that resist heat, oil, stains, grease and water. Common uses include nonstick cookware, stain-resistant carpets and fabrics, as components of fire-fighting foam, and other industrial applications. Two chemicals in the PFC group are perfluorooctane sulfonate (PFOS; $C_8F_{17}SO_3$) and perfluorooctanoic acid (PFOA; $C_8F_{15}O_2H$). The chemical structures of PFOS and PFOA make them extremely resistant to breakdown in the environment and they are considered to be PBTs and VOCs.

Persistent Bioaccumulative Toxins: Persistent Bioaccumulative Toxins (PBTs) are substances that transfer easily among air, water, and land, and are stored in fatty tissue. As a consequence, they accumulate or magnify as you go up the food chain, and, thus, also span generations. Effects to human health range from eye, nose, and throat irritation to organ and nervous system damage to cancer.

Phthalate Plasticizers: Phthalates currently are not listed as PBTs because there is some evidence that fish and mammals can break these down within 24 hours of entry; however, phthalates are often volatile organic compounds and are pervasive in our environments. Phthalates are a family of chemicals used to soften plastics such as children’s toys, adhesives, and floor and wall covering. In healthcare, DEHP [Di(2-ethylhexyl) phthalate] is most often used to soften PVC medical devices including IV

bags and tubing, catheters, and enteral nutrition feeding bags. Phthalates also are used as fixatives in perfumes, as time-release coatings on medications, and in nail polish, to make them more flexible. AKA “plasticizers,” they may be absorbed through the skin, inhaled, or ingested. They are associated with reproductive and developmental harm, suppression of the immune system, and damage to organs and the nervous system.

Polychlorinated biphenyls (PCBs): Polychlorinated biphenyls (PCBs) are mixtures of organic chemicals that are non-flammable, chemically stable, and have high insulating qualities, making them ideal in industrial and commercial applications including paints, plastics, and rubber products. PCBs are considered to be PBT substances that build up in the food chain and accumulate to levels that are harmful to environmental health and carcinogenic to humans. PCBs also can be VOCs.

Positive distractions: Sensory experiences which enable an individual to focus on psychologically supportive and compelling stimuli. These stimuli are intended to divert attention from negative experiences. Positive distractions should be culturally- and age-appropriate and could range from nature and art to video games and music.

Room: Space enclosed with full height partitions or walls equipped with a door.

Single-family rooms: Rooms within the NICU analogous to private patient rooms elsewhere in the hospital that are designed to provide for the care of one or more infants from a single family. These rooms have the usual provisions for infant care as well as space for family members to stay at the bedside or in the room for extended periods of time. A sleeping area for family members is often provided within these rooms, but may also be situated immediately adjacent to them, or elsewhere in the NICU or hospital.

Volatile Organic Compounds: Volatile Organic Compounds (VOCs) are the primary source of indoor air pollution and are measured as organic gases. VOCs such as formaldehyde and urethane are released from products during use and often are found in pressed wood products and household products including paint and wood preservatives. Importantly, the EPA reports that levels of VOCs average 2-5 times higher in indoor environments than outdoor. Health effects are directly related to the amount of exposure, but range from allergies to nervous system disorders to cancer.

Acoustic Terms (Disclaimer: The following terms are defined in conceptually although not technically accurate language. Technically precise definitions can be found in official documents and professional textbooks.)

Allowable Sound Level Criteria, Noise Criteria (NC) and Room Criteria (RC):
Sound levels can be measured over the entire spectrum of audible frequencies. For some technical purposes (e.g., spaces in which verbal communication is important) the spectrum can be divided into smaller frequency spans, such as octaves or specific narrow band widths. Background noise within a room is often measured in octave bands for comparison with a family of smooth, balanced curves, called Noise Criteria (NC) or Room Criteria (RC). This criteria system is used for design and validation of building spaces because it is more descriptive than a single number such as dB or dBA, which does not carry enough information to distinguish between a pure tone, a balanced spectrum, or sound dominated by lower or higher frequencies.

Areas in open acoustic communication: Areas without a barrier wall or an operable door between them or areas separated by a door that is intended to remain open most of the time.

Background or Facility Noise: Background noise refers to the continuous ambient sound in a space due to the mechanical and electrical systems of the facility or building itself and to permanent equipment. Background noise is produced by sources outside the building and by the building's own heating, ventilation, and air-conditioning systems, vacuum tube systems, elevators, plumbing, automatic doors, etc. Because occupant-generated noise will add to the "noise floor" or background noise of the building, allowable background level criteria are set low enough to prevent annoyance, reduced speech intelligibility, sleep disturbance, or other disturbance after the building is occupied.

CAC (Ceiling Articulation Class): Rates a ceiling's efficiency as a barrier to airborne sound transmission between adjacent closed offices [rooms]. Shown as a minimum value, previously expressed as CSTC (Ceiling Sound Transmission Class). A single-figure rating derived from the normalized ceiling attenuation values in accordance with classification ASTM E 413, except that the resultant rating shall be a designated ceiling attenuation class. (Defined in ASTM E 1414). An acoustical unit with a high CAC may have a low NRC. (cited from www.armstrong.com)

Ceiling plenum: The area between the finished ceiling and the underside of the structure above, often used for ductwork, electrical wiring, plumbing pipes, etc. as well as for recessed ceiling lights.

Demising partitions: A "demising" assembly, partition, floor, ceiling, etc. is one that separates the space of one occupant or department from that of another, or from a corridor. Partitions within an occupant or department space are non-demising partitions. For example, the wall between two patient rooms is demising, but the partition within a patient room that encloses the bathroom for that room is non-demising. Likewise, the wall between one office suite and another is a demising wall, but the walls within the suite itself are non-demising. The wall between a mechanical or electrical equipment room and any occupied space is a demising wall. In a residential apartment building, the partition between two units is demising, but the partitions between rooms within the same apartment are not demising.

Facility vs. Operational Noise: Exterior sources (e.g., street traffic and outdoor building mechanical equipment) and interior sources (e.g., air conditioning and exhaust systems) generate facility noise. It exists in the empty building as it is constructed. The people and equipment that occupy the building generate operational noise.

Operational Noise: Operational noise is generated by people and equipment that occupy the building and are separable from the building. A general rule of thumb states that occupants and their equipment will add about 10 dBA to background noise. However, this generalization does not apply to all room uses. For example, two or three people in an office environment with 45 - 55 dBA background might add about 10 dBA, but the same group in a quiet conference room with a 35 - 45 dBA background might add 20

dBA. A large group of people might add 40 dBA. In intensive care units with hard surfaces, close spacing of patient beds, and large amounts of staff and equipment the occupied room noise may be 20 dBA or more above background with brief excursions well above that.

Occupant-Produced Noise: Occupant noise is not under the control of architects and engineers but can be incorporated as a design parameter through the use of a matching architectural requirement (e.g., wall and ceiling absorption criteria). Control of occupant-produced noise lies primarily in the realm of quality assurance programs and hospital management.

Permanent Equipment: Large equipment that is necessary for essential functions of the NICU and that is rarely replaced. Such equipment includes refrigerators, freezers, ice machines, mechanical / electrical storage systems for supplies and medication. Permanent equipment is distinct from medical equipment used for direct patient care.

Reflective and Absorptive Surfaces: Noise Reduction Coefficient (NRC):
Within any closed space, sound levels are affected by reflections of sound waves from surfaces. When the surfaces are predominantly hard, sound pressure builds up in the space, increasing the original level with reverberation. Conversely, when the surfaces are soft or acoustically absorptive, reflected energy is reduced and sound pressure does not build up. Acoustically absorptive surface materials are rated by a Noise Reduction Coefficient (NRC), which is an average of absorption coefficients in the middle range of the audible spectrum of sound frequencies. Although an oversimplification, the NRC rating of a material can be thought of as the percentage of sound energy absorbed. If the NRC of a wall panel, for example, is 0.65, about 65% of the sound energy of a source is absorbed and about 35% reflected back into the room.

Speech privacy: "Methods used to render speech unintelligible to the casual listener." This definition embodies two key concepts: (a) the measurement of intelligibility/unintelligibility, which is a practice familiar to five generations of acoustics professionals since the first work done on the Articulation Index in the 1940's by Leo Beranek and others; and (b) the viewpoint of the "casual listener." That is, this definition of speech privacy does not cover intentional or assisted listening (quoted from the webpage of the American National Standards Institute (ANSI), and the Glossary of American National Standard T.1-523-2001, a standard maintained by the U.S. Department of Commerce, National Telecommunications and Information Administration, Information Security program (INFOSEC).)

Vibration: Vibration is perceptible to humans at a certain magnitude or level and can cause discomfort or annoyance. Larger magnitudes of vibration can cause rattling of lightweight building elements, superficial cracking in partitions, or even structural damage. Very small magnitudes of vibration not perceptible to humans can disturb high magnification optical microscopes or very sensitive electronic equipment. Sources of vibration common in hospitals are helicopter flyovers and landings/take-offs, magnetic resonance imagers, sound systems, and heavy trucks. Buildings can be constructed to prevent the propagation of vibration through the building.

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