



Topic Expert Group: NICU design

General layout of the unit

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Target group

Infants, parents, families, and unit staff

User group

Neonatal units, hospitals, health services, healthcare planners, architects, technical staff, manufacturers, and other relevant stakeholders

Statement of standard

A NICU is designed to support safety and healing through unrestricted parental presence, use of sensory supportive material and optimal working facilities, promoting close collaboration between families and staff in caring for the ill infant.

Rationale

NICU design comprises the built environment of a neonatal unit which aims at evidence-based design supporting family-centred care, safe and optimal working conditions for staff, and other relevant aspects of clinical practice, e.g. appropriate lighting and acoustic environment.

The optimal locus of care for most infants is in a room with their parents. (1) Evidence supports a NICU design with enough single-family rooms to accommodate all families who wish to stay with their infant(s). (1) Single-family rooms lead to better outcomes for the infant and reduced costs when the family is present for extended periods. (2) Single room care can reduce noise, ensure privacy for the infant and their family, is a better environment to prevent infections. (3–6) and may ameliorate or protect the infant from short- and long-term consequences of stress caused by intensive care treatment. (7–9) Parental presence is higher in NICUs providing facilities for overnight stay for the parents. (3,10) A “bed-in-a-unit” architecture for parent-infant closeness in NICUs is therefore important. (10) In settings where families are rarely present and staff resources are strictly limited, the NICU may also contain rooms with more than one patient-bed to accommodate those infants whose families are not present most of the time. (3,10) Also in these settings, enough space and facilities for parental presence and skin-to-skin care is a pre-requisite. (1,11) Each hospital planning team will use their demographics to determine the appropriate mix of beds in multi- and single-family rooms. (11) Other aspects of NICU



design which should be taken into account concern lighting and acoustic performance. Appropriate lighting levels within the NICU that optimise the ability of staff to perform care while meeting the health needs of patients, their families, and their caregivers are required. The build environment should be designed to avoid auditory discomfort and adverse effects on development, and should absorb a high level of background noise (above the hourly Leq 45 dBA threshold). (12) All materials used for patients (including monitoring devices) should be designed to minimise discomfort.

Benefits

Short-term benefits

- Improved medical outcomes (3,13–16)
- Minimised separation between infants and parents (3,10)
- 24/7 skin-to-skin care and improved physiologic stability (17,18)
- Improved comfort and sleep for infants (19–22)
- More attractive environment for prolonged presence for parents (20)
- Encouraged parent involvement from the first day since parents can participate in the infant’s care, both during intensive care and in a family room (consensus)
- Supported physical and mental well-being of newborn infants, their families, and the hospital staff by lighting with appropriate intensity, spectrum, location, and diurnal cycling (23)
- Improved family satisfaction (15,16)
- Enhanced clinician’s abilities to perform direct and indirect patient care tasks accurately while minimising visual difficulties (24)
- Reduced length of hospital stay by cycled lighting (10,25)
- More attractive working environment for healthcare professionals (26)
- Improved nurse satisfaction (15,16)

Long-term benefits

- Improved neuro-development (27)
- Facilitated parent-infant interaction and developmental care (28)

Components of the standard

Component	Grading of evidence	Indicator of meeting the standard
For parents and family		
1. Parents and family are informed by healthcare professionals about principles of the general layout of the unit and are part of the planning process for NICU design.	B (High quality)	Guideline, parent feedback, patient information sheet
2. Structural barriers to family presence and participation in the care of their infant are avoided. (10,19)	A (Moderate quality) B (High quality)	Guideline



For healthcare professionals and relevant stakeholders		
3. The monitoring/workstation are designed so that the patient/family or vital parameters can easily be followed by healthcare professionals while maintaining privacy. (29)	A (Low quality)	Guideline
For neonatal unit and hospital		
4. The principles of the general layout and facilities within a NICU are agreed between planners, hospital, NICU staff, and parent representatives before commencing the planning process.	B (Moderate quality)	Guideline
5. The NICU is located in close proximity to the obstetric department to facilitate ease of transportation to the NICU. (30)	A (Moderate quality)	Audit report
Space for infant, family and staff		
6. Multiple-bed rooms have a minimal space of 18 m ² per patient (10,19,31–33); single-family rooms have a minimal space of 24 m ² , taking into account family integrity and privacy and providing at least enough room for (10,13,32): <ul style="list-style-type: none">• At least one comfortable and reclining chair (1)• Hospital bed• Lockable wardrobe• Easy access to rest-rooms and bathroom• Technical equipment• Ability for multiple care staff staying in the room at the same time	A (Moderate quality) B (Moderate quality)	Guideline, parent feedback
7. The stationary medical equipment is arranged and mounted with flexibility to allow easy transfer of the patient from incubator/cot to parents' chest for skin-to-skin care.	A (Low quality)	Guideline
8. An additional separate parent sleeping facility including easy access to rest-rooms and shower are located close to the neonatal unit.	B (Moderate quality)	Guideline, parent feedback
9. Family facilities including kitchen, laundry room, socialising lounge, and	A (Moderate quality) B (Moderate quality)	Guideline, parent feedback



playroom for siblings close to the unit are available. (1)		
10. A barrier-free room with window for expression is available within the NICU, providing: <ul style="list-style-type: none">• Sinks with equipment (soap, towel and disinfectant dispenser)• Comfortable chairs• Tables (see TEG Care procedures and TEG Nutrition)	B (Moderate quality)	Guideline, parent feedback
11. Access to a human milk bank is ensured and a milk preparation room is integrated into the NICU.	B (Moderate quality)	Guideline
12. Bereavement space with window and space to stay with the infant after death, including a cooling facility, is provided in a culturally and spiritually appropriate design.	B (High quality)	Guideline, parent feedback
13. The spatial organisation of the NICU is decentralised with distributed support spaces, medication, disinfection, and storage etc.	B (Moderate quality)	Guideline
14. Free opening dimension to patient room varies between 1600 mm-2000 mm depending on the turning radius of a caregiver's bed and corridor width.	B (Moderate quality)	Guideline
15. Private rooms for parent counselling are available on the ward.	B (High quality)	Guideline
16. Acoustically separate rooms for professional, administrative and personal needs providing privacy and reducing noise in the NICU.	B (Moderate quality)	Guideline, healthcare professional feedback
17. Wall colors radiating comfort and homeliness are used adapted to cultural values.	B (High quality)	Guideline
Lighting		
18. Lighting within a NICU are agreed between planners, hospital, NICU staff, and parent representatives before commencing the planning process,	B (High quality)	Guideline



including the following principles: (see description)

- Ambient lighting levels in infant spaces are adjustable
- Separate procedure lighting is mounted at each infant bed
- Illumination of support areas conforms to published specifications. (33)

19. Light sources have an appropriate color spectrum and are positioned in a way that will minimise glare, shadowing, and flicker. (35)	A (Moderate quality) B (Moderate quality)	Guideline
20. Switching and dimming options are provided to allow adjustment of lighting levels for utility, comfort, and circadian stimulus. (35)	A (Moderate quality) B (Moderate quality)	Guideline
21. Parents have ready access to daylight without having to leave the NICU. (1,32,36,37)	A (High quality)	Guideline

Acoustic environment

22. Sound-absorbing materials are used for building or renovating NICUs, e.g. wall and ceiling finishes; floor surface; furnishing; doors; windows. (32,38,39)	A (High quality)	Guideline
23. Appropriate ventilation, humidification, air conditioning and heating system with high-efficiency particle air (HEPA) filtration taking into account noise levels, is provided. (40)	A (High quality)	Guideline

Patient safety

24. In patient rooms, sinks with equipment (soap, towel, and disinfectant dispenser) and space for gloves, disposable apron/smock, visors and surface disinfectants are available. The sink is placed visibly by staff walking routes and with barrier-free access. In addition, equipment for hand disinfection are available at points of care. (32,41,42)	A (Moderate quality) B (Moderate quality)	Guideline
25. An antechamber/airlock (isolation room) is provided in at least one single-family room. It is equipped with a sink, facilities for hand disinfection, respiratory	B (Moderate quality)	Guideline



protection, apron and surface
disinfectants and cabinet/shelf for
nearby storage of textiles.

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| 26. In single-family room units, a high-level central monitoring system including a hand-held distributed alarm management system is implemented. | B (High quality) | Guideline |
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Materials

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| 27. The whole NICU (e.g. wall and ceiling finishes; floor surface; furnishing; doors; windows) is designed so that it is: <ul style="list-style-type: none">• Easy to clean• Can withstand cleaning and disinfection• Germ resistant• Free of harmful substances | B (High quality) | Guideline |
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For health service

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| 28. A national guideline on the space and layout requirements for a new NICU is available and regularly updated. | B (High quality) | Guideline |
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Where to go – further development of care

Further development	Grading of evidence
For parents and family	
<ul style="list-style-type: none">• Couplet Care: the post-partum mother and the infant are cared for in the same room after birth.	B (Moderate quality)
<ul style="list-style-type: none">• Electronic links with their infant and healthcare professionals are provided for parents when they are unable to be at the bedside.	B (Moderate quality)
For healthcare professionals	
N/A	
For neonatal unit	
<ul style="list-style-type: none">• Closely monitor developments in research on NICU design and operation and incorporate new evidence into existing structures whenever feasible.	B (Moderate quality)
<ul style="list-style-type: none">• Closely monitor new developments on unobtrusive and wireless monitoring, paying respect to avoid pain and stress caused by adhesive electrodes.	B (Moderate quality)
For hospital	
<ul style="list-style-type: none">• Monitor design standards of the NICU not being inferior to similar care areas in a hospital for infants/children and adults.	B (Moderate quality)
<ul style="list-style-type: none">• Provide readily-accessible, protected outside garden, balcony, or atrium for families and staff to use without leaving the hospital grounds⁷.	B (Moderate quality)
For health service	
<ul style="list-style-type: none">• Plan design standards and resources covering the care needs of all newborn infants needing intensive care in the administrative uptake area, limiting unnecessary transfers to other levels/hospitals of pregnant women or their infant.	B (Moderate quality)

Getting started

Initial steps

For parents and family

- Parents are involved from the earliest steps in the process of re-design/re-arrangement of the NICU in order to ensure that their needs are met.
- Furniture that supports family presence (foldable beds, chairs for skin-to-skin care and breastfeeding) is provided.
- Interior design is used to promote comfort and stress reduction.
- A room for parents to relax and to prepare food and drinks is provided.
- Parents are encouraged to form a support group that identifies shortcomings of the current NICU and advocates for change-in-place wherever possible.



For healthcare professionals

- Be aware of new concepts of NICU design through site visits, literature review, and conference presentations to begin thinking beyond the current situation and imagine the NICU of the future to be able to create a design that is not obsolete soon after completion.
- Protect newborn infants from bright, direct lighting by use of an incubator cover and by shielding the eyes during a procedure.
- Assure diurnal cycled lighting by exposure to 250-600 lux light levels during the day, <100 lux at night.

For neonatal unit

- Provide hygiene-alcohol dispensers at point of use.
- Evaluate and improve the acoustic environment, if needed.

For hospital

- Secure close and safe transportation paths to and from obstetric department.
- Improve signage for orientation of parents and families.
- Benchmark and visit units that have already gone through a re(building) process.
- Use sound-absorbing materials for renovating or building NICUs.
- Improve acoustics with absorbing material in ceiling, on walls etc.

For health service

- Develop and implement a national guideline on the space, layout, lighting, and acoustic requirements for a new NICU.

Description

Space for infant, family and staff

Depending on the NICU department size, it is important how to organise support spaces, medication, disinfection, storage, parent's kitchen etc. By decentralising the department so that the necessary resources are added within delimited units, personnel thus not need to walk unnecessarily long distances.

The bed/cot are placed so that the patient/parent can see who enters the room. This can support the feeling of control.

Placing the patient in single rooms reduces the spread of infection between patients. Single patient rooms with anteroom can prevent droplet infection, contact infection and airborne infection between patients. Single rooms with airlock can prevent airborne infections. The lock should be such that air is prevented from passing between patient room and corridor and conversely so that the room can serve as both isolations of and from infectious patients. The lock must be dense.

It also contains easily adjustable workstations, tables and chairs. Materials and medicines, that are often used for patient care, are easily accessible from the patient/parent room and/or workstation.

It is important to have good view into the patient/parent room towards the patient. But the patient's/parent's privacy needs to be protected when the wall is transparent into the room.

A significant number of studies suggest that the ability to view nature from the built environment has a positive impact. It helps to reduce stress, promote more positive



emotions and support recovery. The ability to look towards nature in the NICU can affect staff performance and increase their well-being. Informal, spontaneous meetings with nature views act as a positive diversion and stress reduction.

Humidity and temperature are important for the perception of the environment in the department and thereby affect patients. Undesirable or unpleasant odours can increase the stress levels of patients/family. This can be reduced by good ventilation and access to fresh air from the outside.

Lighting

The following principles regarding lighting should be taken into account in NICU planning:

- Ambient lighting levels in infant spaces are adjustable through a range of at least 10 to no more than 600 lux. A color rendering index of no less than 80 and a gamut area of no less than 80 and no greater than 100 is available. Unnecessary ultraviolet or infrared radiation is avoided by the use of appropriate lamps, lens or filters. (11) Lighting fixtures are easily cleaned.
- Separate procedure lighting is mounted at each infant bed. The luminaire is capable of providing no less than 2000 lux and is framed so that no more than 2% of the light output of the luminaire extends beyond its illumination field. This lighting is adjustable so that lighting at less than maximal levels can be provided.
- Illumination of support areas within the NICU, including the charting areas, medication preparation area, the reception desk and handwashing areas is conformed to published specifications. (34)
- Ready access to daylight and nature without having to leave the NICU is ensured: At least one source of natural daylight is visible from an infant space or room, either from an exterior window or exterior clerestory located at each infant space or in each room, or from an exterior window or exterior clerestory in the staff work area adjacent to the infant space or room. Exterior window(s) located at an infant space or room are glazed with insulating glass to minimise heat gain or loss, and situated at least 0.6 m away from any part of an infant's bed to minimise radiant heat gain or loss. All external windows are equipped with shading devices that are neutral color to minimise color distortion from transmitted light.

Acoustic environment

The impact of sound reduction on short term medical outcomes, on sleep patterns at three months of age, on staff performance and on parents' satisfaction with the care needs to be evaluated in large and well-designed trials. (43) However, such trials are difficult to conduct for practical and ethical reasons. Thus, recommendations are based on the precautionary principle, as is common in environmental science. (44)

The US standards on NICU design (11) recommend that in newborn infant rooms, the sound level shall not exceed an hourly equivalent sound level (Leq) of 45 dBA, sounds should not exceed 50 dBA more than 10% of the time (L10) with transient maximum sounds (Lmax) below 65 dBA. In staff work areas and family areas, and staff lounge areas, the sound level should not exceed an hourly Leq of 50 dB, an hourly L10 of 55 dB, or with transient sounds (Lmax) not over 70 dB.



Strategies to reach these recommended levels have not been studied in depth. Using high-performance sound-absorbing materials to build or renovate the NICU has been suggested. (32,39) Single rooms seem to be quieter than open-bay rooms except for respiratory support equipment. (45,46) The continuous use of sound-monitoring equipment leads to reduction in the sound level for 2 months, but no longer. (47) Changing the behaviour of staff members and the culture of the NICU team is complex. Implementing a “quiet hour” could be a feasible first step. (22) Developmental care training could have an impact on the NICU environment. Providing an adequate acoustic environment to hospitalised newborn infants is not only based on protecting them from the deleterious effect of noise but also to offer them a nurturing environment enabling the access to biologically meaningful sensory stimuli (see TEG Infant & family-centred developmental care)

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