

Designing a Neonatal Unit
Report for the British Association of Perinatal Medicine
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INTRODUCTION

Neonatal Unit (NNU) design is governed by a number of factors including

- size of population served
- intensity of neonatal care anticipated
- relationship with local children's hospital including paediatric surgical services
- the model of care
- available finance

Of necessity therefore the following document provides guidelines and ideas only. Inevitably it often contains opinion rather than evidence base. This is in keeping with two documents which have outlined current standards of NNU design (2, 3). The Fifth Consensus Committee (2) has produced in the United States a number of recommendations which may be applicable to the United Kingdom. NHS Estates have recently revised their Building Note 21 on Maternity Units.

Before designing the NNU, clinical staff, families and all others involved should consider the following:

- clinical needs
- baby developmental (environmental) needs
- family needs
- staff facilities
- facilities for education and research

For definitions of intensive care, high dependency and special care, this document follows the current categorisation of the British Association of Perinatal Medicine (BAPM) (ref).

Refurbishing an existing NICU

This will almost always involve some compromise. The principles and standards in this document should be adhered to as closely as possible, and it essential to devote time to planning and prioritising. Modernisation is important and the project team must be aware of potential changes in local or regional service delivery. If compromise must be made due to limitation of space, be imaginative! Consider carefully which rooms can be dual purpose and select furniture and equipment modules which take up less space or can be easily stored when not required.

GENERAL PRINCIPLES

Position

Every new Neonatal Unit *must* be built as close as possible to the Labour Suite, including the rooms specified for operative deliveries. Ideally the NNU should be immediately adjacent to the Labour Suite and on the same floor. The postnatal wards should also be in close proximity. If the structure of the building precludes the NNU and Labour Suite being on the same floor, then they should be on adjacent floors and with a dedicated lift for emergency transfers.

The footprint

The size and shape of the new NNU will depend almost entirely on its function, and the size of each individual room as considered below. One recommendation is to address each individual room and ward as outlined below, summate the room sizes and then multiply the result by 1.3 in order to take outside corridors into consideration.

How many cots?

The number and distribution of cots must be decided locally. The following questions should be addressed.

- What is the size of the population served?
- What are the demographic trends which will influence the number of deliveries in the area served?
- Will the unit provide care for neonatal surgical patients?
- Will the Unit act as a tertiary referral centre?
- What are the existing and predicted networks in the Region?
- Does the Unit serve predominantly low-risk deliveries?
- Will the perinatal centre attract many *in utero* transfers of mothers with high risk pregnancies?
- Is it likely that nearby district general hospitals will close in the coming years, causing the Unit to expand its cot numbers?
- Is it intended to return babies closer to home to receive their high dependency and special care once they have completed their intensive care?

The following tables, taken from South East Thames Neonatal Census, provide data which may be used to inform this decision.

Table 1 Length of stay (days) according to gestation (weeks)

Admissions April 2002-December 2003 GESTATION in Weeks	NUMBER	LENGTH OF STAY in DAYS				TOTAL	SURVIVED	% SURVIVED
		NIC	HD	SC				
23 and below	19	22.9	1.2	5.9	30	2	10.5%	
24	56	33.6	9.7	22	65	24	42.9%	
25	54	34.4	14.9	36	86	41	75.9%	
26	96	19.4	14.1	36	69	81	84.4%	
27	104	14.1	12.8	36	63	95	91.3%	
28	127	9.4	11.3	36	57	118	92.9%	
29	154	5.8	8.7	35	50	144	93.5%	
30	190	4.1	5.8	32	42	181	95.3%	
31	266	2.3	2.4	26	31	261	98.1%	
32	377	1.6	2.1	22	26	369	97.9%	
33-36	2133	0.6	0	10	11	2113	99.1%	
37+	3104	0.4	0.1	4.3	4.8	3050	98.3%	

Table 2 Length of stay in days according to birth weight (g)

Admissions April 2002-December 2003	NUMBER	LENGTH OF STAY in DAYS				SURVIVED	% SURVIVED
		WEIGHT in grams	NIC	HD	SC		
0-999	337	23.4	13.8	31.7	68.9	247	73.3%
1000-1499	582	3.1	7.1	31.1	41.3	553	95.0%
1500-1999	1119	1.3	1.3	18.6	21.2	1099	98.2%
2000-2499	1268	0.6	0.7	9	10.3	1258	99.2%
2500+	3374	0.5	0.6	4.5	5.6	3322	98.5%

Work flow patterns

The NNU should be designed to allow efficient patient and staff movements within the unit. The following should be included.

- Ready access of the NNU to Labour Suite including Operating Theatres
- All doors between Labour Suite and NNU, and also those within NNU, should be designed to maximise safety and convenience. Automatic opening, push-pad opening, swipe-card access, punch-code access and manual opening may all be appropriate in individual circumstances
- Positioning of NNU intensive care cots closest to the Labour Suite
- Access for mothers on trolleys or in wheelchairs. Widths of doors, corridors and corners should be considered so that mothers have access to *all* clinical areas
- Access to all cots in all clinical areas for X-ray, ultrasound and other mobile equipment. An MRI scanner ideally should be available nearby on the same floor
- Clinical support areas should be as close as possible to clinical care areas. Such supports include near patient testing laboratory, pharmacy, equipment storage, milk storage, clean and dirty linen store
- Family access to the waiting area, counselling rooms, support services (e.g. social work and community neonatal nursing) and recreational facilities
- Positioning of the Clinical Manager's office on the NNU floor, easily available to all staff and, by arrangement, to families
- Attending consultant's office should be in the NNU so that family interviews and staff interviews can take place readily
- Doctors' on call rooms should be in the NNU, sound-proofed, and sufficiently distanced from busy corridors and extraneous noises to allow adequate rest opportunities
- Consultant and research offices can be positioned further away from the clinical care area
- Ideally there should be ready access to the mortuary, a viewing area for the bereaved, and to the autopsy suite.

Atmosphere

The NNU should be thought of as "baby's first home". It must have a welcoming atmosphere. This is achieved by thinking of the comforts of the infant and family. Natural lighting and where possible views of the surroundings outside are beneficial. Internal decoration can convert a clinical area into a room which is appealing to families, and encourages all members of staff to treat the care area as the "infant's bedroom".

Model of care

The cot requirements in any given catchment area depend on the birth population and can be calculated by looking at the birth-weight distribution derived from the ONS annual figures and the birthweight-specific lengths of stay. Using the new BAPM categories of care, there is an approximately 25% shift of babies from intensive care

to high dependency. The number of babies requiring high dependency has further increased with the inclusion of babies of drug-abusing mothers. This means, in the average population, there is a requirement of .75 of an intensive care cot per 1000 birth population for intensive care, .7 cots per 1000 birth population for high dependency care and 4.4 cots per 1000 for special care. Not all special care occurs on the neonatal unit and although the percentage varies a significant amount of special care occurs next to the mother as transitional care.

Very careful study of the population needs must be made before the final decision is made about the numbers of cots allocated to intensive care, high dependency and special care. It is recommended that considerable flexibility is maintained within the NNU. Specifically, some designated special care rooms should be supplied with all facilities for intensive care. This allows emergency movement of infants from intensive care in the case of fire. It also allows special care cots to be used for intensive care at a time when an outbreak of infection has occurred in the intensive care rooms.

The Department of Health has developed a neonatal planning tool which allows for the catchment area of your hospital, predicted increases in your local population, weight-specific requirements for intensive care and length of stay and utilises queuing theory to allow for peaks and troughs. It will calculate your cot needs under either the 1996 BAPM Categories of Care or the 2001 BAPM Categories of Care. This planning tool has been issued to most strategic health authorities and is available from the Department of Health.

There is huge variation in modern Neonatal Unit design, and the allocation of cots per room typifies this. One model used in some units in the USA provides an individual bedroom for each infant and family. This model depends on continuous high quality electronic monitoring of all intensive care parameters beamed to a central console where dedicated staff are poised to respond to any information requiring intervention. Its success depends also on an individual nurse-call system.

Another model aims to put all the allocated intensive care cots into one large room. This design has the advantage that observation of the infants is unrestricted by walls and curtained windows. Disadvantages include increased noise levels and the perception by some parents that the Unit is impersonal.

Clinicians may prefer to choose a compromise solution. The current authors favour even numbers of babies (two, four, six, eight or ten) in clinical rooms: these are convenient and efficient even when nursing staffing falls below BAPM recommendations. Excellent communication between these rooms is essential for patient safety.

CLINICAL

Pendants, gantries, cabinetry or head-rails?

Choosing to equip the rooms with pendants, gantries or cabinetry is a crucial early decision.

Pendants

Pendants descend from the ceiling and are single-armed or double-armed. The pendants contain intensive care facilities including electrical outlets, oxygen and air pipes and a vacuum facility for suction. The clinician has the opportunity of specifying the number of electric sockets, and the number of shelves which are fixed to the pendant arms. These shelves can hold ventilators, monitors, syringes drivers, and indeed any intensive care equipment required to service the infants in the incubator.

Advantages of pendants

- Flexibility
- Cleaning

Disadvantages of pendants

- More space required
- More expensive
- Interruption of natural light and any view the NNU may have
- Cosmetic. The room can look intimidating to parents.

Gantries

Gantries have many of the advantages of pendants containing internally all the piping and wiring required to provide the oxygen, air, vacuum and power points as well as the computer networks. The clinicians again have the opportunity of specifying the number of sockets and the number of shelves. Many of the gantries allow movement laterally of the hangars and ventilators, monitors and syringe drivers can all be attached to the gantry.

Advantages of gantries

- Some lateral flexibility
- Less space-occupying than pendants

Disadvantages of gantries

- Less flexible than pendants
- Less pleasing cosmetically than cabinetry

Cabinetry

If designed carefully, cabinetry is fully consistent with the demands of intensive care. All intensive care and high dependency cots can be contained in spacious bays. Electric sockets, computer and piped gas outlets can all be positioned so that there is no interference with the movement of staff caring for the infant. It is recommended that all such bays be identical in the Unit, so that staff can be familiar with the work area no matter which room or cots have been allocated to them. The size of the bays is critical. Each must accommodate an incubator, a mother and father with comfortable seating, two members of nursing staff, and it should be possible to manoeuvre all machinery (e.g. for taking X-rays) within the allocated space. Such bays should be at least 3.2m wide and the bay walls may extend 2-3 m into the room.

Advantages of cabinetry

- Pleasing cosmetically
- Less intimidating for parents
- Preserves natural daylight and views
- Less expensive

Disadvantages of cabinetry

- Less flexibility
- More difficult to clean

Head-rails

It is possible to combine cabinetry systems with horizontal rails at the head of the incubator. These rails then carry most of the intensive care monitoring equipment. They are however less flexible than pendants and gantries.

Advantages of rail systems on headwalls

- Inexpensive
- Some lateral flexibility

Disadvantages of rail systems on headwalls

- Less cosmetic than cabinetry
- Less flexible than pendants
- More difficult to clean than pendants

The intensive care room

Each intensive care space must have a minimum of 12 sqm. In addition there should be space allocated as a conceptual walkway in the centre of the room, so that machines for radiography and ultrasonography can pass to the furthest cot without intruding on the space allocated to another family. In addition, there is a need within the intensive care room to allocate storage space. In practice therefore it is best to allocate a total of 20-24 sqm per intensive care cot. This recommended surface area applies equally to high dependency and to the special care area designated for emergency intensive care (during fire or infection, see above). Handwashing is provided at troughs or sinks big enough to avoid splashing. There should be one large trough for every three infants in the Unit, and the troughs should be so arranged that the incubators are never more than 6m away from a trough. Metal troughs tend to be sources of significant background noise and ceramic troughs may therefore be preferred. The troughs ideally should have heat-sensitive automatic sensors which activate the flow of warm water appropriately. Elbow-operated or knee-operated taps can also be satisfactory. Troughs should be designed to avoid standing or retained water. There should be pictorial washing instructions above each trough in the NNU so that staff and visitors are reminded to remove all jewellery and are shown how to wash and dry hands and forearms prior to handling infants.

Each intensive care room should have an X-ray viewing box.

Storage

Storage refers both to ward storage and baby's personal storage. Much of the latter can be accommodated in the incubator shelves. Storage space in the cabinetry must be very carefully considered. All regularly used facilities and supplies should be accommodated readily in each bay.

Each intensive care space should include 3 oxygen outlets, 3 air outlets, 2 vacuum suction systems, 20-24 electric sockets, a dimmer switch, 4 computer ports and an emergency call-bell. Fibre-optic ports may be included for use in future years.

The high dependency room

To allow flexibility of use of the space, the high dependency area should be so arranged to allow intensive care to occur.

The special care room

Rooms which are allocated to special care, and which are not to be used at any time for intensive care functions, should be designed carefully with the safety of the infant and the relaxation of families in mind. Such a room should have no pendants, and the bays of cabinetry are equally unnecessary.

There should be 3m between each cot centre. Including the central walkways, a special care room requires 9.5 sqm per cot. Space for sinks and storage require to be added to this. There should be one large hand-washing trough for every 3 or 4 infants cared for. Staff should give careful thought to storage of all items of care, including the infant's own clothes. A small wardrobe at each cotside may be considered ideal. There should be facilities for bathing the infant and changing napkins. The whole atmosphere should be geared to normality, and encouraging parents to take more and more responsibility for their infant's care. The clear emphasis should be towards an environment conducive to relaxation of the family and developmental care of the infant.

Transitional care

In the design of all large Neonatal Units, staff should consider creating a Transitional Care Area. In this facility, parents can look after their own infants with some supervision from trained Neonatal Unit staff. Transitional Care is interpreted in a wide range of ways. There is undoubtedly a group of babies who are not well enough to be looked after on regular postnatal wards and yet there are strong advantages in their parents carrying out the bulk of their care. Such infants include babies with hypoglycaemia when it is believed there is no underlying serious pathology, babies of 34 and 35 weeks gestation who are establishing breast feeding, and babies who have mild respiratory disease who do not require oxygen supplementation. Phototherapy may safely be given in Transitional Care. The Transitional Care Area can also be used by mothers who are gaining confidence immediately prior to discharge home. A four-bedded room may be 56 sq m in size. Each family area may be curtained separately, and should contain a single bed, a cot and a personal wardrobe for the mother. There should be television, telephone and *en suite* toilet and shower facilities. With the baby's developmental care in mind, there should be flexible control of the environment including heating, lighting and sound-reduction.

Resuscitation

Facilities for neonatal resuscitation should be carefully thought out for each area in which babies are cared for. In intensive care and high dependency areas resuscitation is commonly carried out in the incubator itself, supported with an emergency mobile trolley in each room. In special care areas it is exceedingly difficult to resuscitate infants in open-topped cots with fixed walls. Each room should therefore have a designated area for resuscitation containing an open radiant-heated cot or resuscitaire, with appropriate facilities including piped gases and vacuum suction, electric sockets, laryngoscopes, equipment for assisted ventilation and a secure store of drugs. Seldom-used resuscitation facilities may be stored for cosmetic reasons behind a screen; alternatively fold-up resuscitation facilities can be stored in the wall-space.

Inpatient treatment room

A tertiary referral centre requires a treatment room if only to carry out laser therapy for retinopathy of prematurity. The room should be at least 20 sq m and fully provided for intensive care. A pendant, gantry or cabinetry should be arranged to allow infants to be cared for under general anaesthetic. The room should be protected by screens which are proof against argon lasers, and fitted with a warning system to prevent staff from entering inadvertently while laser therapy is being carried out. The room should also have an open cot with radiant heater. Clinicians should consult with local anaesthetists and surgeons to discuss what facilities they require. Such a treatment room might be used for ligation of the ductus arteriosus, or drainage of the peritoneum following bowel perforation. This treatment room can also be invaluable as a facility for reviewing infants from the community (e.g. babies with jaundice or large weight loss) and who require clinical examination and phlebotomy to guide clinical management.

Outpatient treatment room

Many NNUs offer a daily “drop-in” clinic for unscheduled patients. These infants are commonly those who are noted in the Community to be jaundiced or to have lost more than 12% of their birth weight. An outpatient treatment room can be placed close to the NNU entrance, and is equipped with two chairs, an examination surface, good procedure lighting, and a locker with equipment including everything required for weighing, phlebotomy and transcutaneous bilirubinometry.

Telephones

Telephones should be available in almost all the rooms of the NNU including clinical and supporting areas. The following principles are important.

- High quality communication contributes to maximising patient safety
- Ringing telephones may disturb the sleep of babies
- Telephones in public areas, including wards, may breach patient confidentiality
- There should be designated telephones to transmit emergency calls, receive emergency calls, receive inquiries from relatives and friends, and for families to telephone relatives and friends

It is unacceptable to have ringing telephones at each cot space in the NNU. It is far preferable to have telephones which attract the staff by a flashing light, so that the infant is not disturbed from sleep. There may even be merit in having no telephones in the intensive care rooms, so that the staff caring for the infants are not distracted by many calls from relatives and friends. The Unit may prefer to have a central series of telephones answered by clerical staff who then convey messages to the appropriate staff members.

The issue of confidentiality should also be carefully addressed. Telephones within the wards may be an efficient means of conveying information to inquiring relatives, but all information conveyed by staff is potentially available to all visitors in the ward.

Laboratory

Near patient testing is essential for the progressive Neonatal Unit. It is standard to be able to test blood gas tensions within the confines of the Neonatal Unit and a major advantage to be able to measure concentrations of electrolytes, sugar, lactate, bilirubin and coagulation.

Pharmacy

Many Units are served by a central Pharmacy in the hospital. Some Units may prefer to have a satellite Pharmacy within the Neonatal Unit. A central room of 8-10 sq m can be used for preparation of drugs. This is not a substitute for the central Pharmacy which can prepare total parenteral nutrition under the strictest aseptic techniques.

ADMINISTRATIVE WORK AREAS

Reception

Each Neonatal Unit requires a reception area, which becomes the organisational centre of the Unit. Here families are greeted, telephone calls are received, specimens are uplifted, results delivered, and letters are sent and received. An open-plan area of 15 sq m should be close to the geographical centre of the Unit. It is fitted with three telephones, at least one computer, and must be fitted with adequate drawers and cupboards. There are strong communication advantages in this central reception area being contiguous with the Duty Room (see below).

Unit Office

Next to the Reception Area, the Unit Office will be one of the most frequently used areas of the Neonatal Unit and therefore deserves extra planning according to the Unit's needs. The room should be large enough to accommodate 4 people, may therefore be 20 sq m, and should have work surfaces on at least two walls. Each surface should accommodate two work stations, appropriately equipped with computers which have internet connections. The room should also have two telephones, a fax machine, and a large amount of storage space for Unit stationery.

Supporting offices

Every Neonatal Unit needs to be supported by dedicated staff offices. In these, members of staff or relatives can have confidential discussions with senior staff. Such offices should be at least 10 sq m in size and are furnished with a work station, telephone, computer, three chairs and shelving. These offices may be individualised for a **Ward Coordinator**, the **Service Manager** and the **Attending Consultant**. Shared offices, of 15 to 20 sq m each, are similarly allocated to junior medical staff, research fellows, community nurses and nurse education staff. If the Neonatal Unit has a dedicated Transport Team, then they may also require an office in which policies and audit can be further developed.

Each full time consultant is entitled to an individual office. This may be placed outside the NNU, but should be close at hand. The consultants offices should immediately adjoin each other and that of secretarial staff in order to maximise efficiency and enhance communication. It is also recognised that specialist registrars also require to have an identified area of where work can be carried out in privacy. Each office should be at least 10 sq m in size, and is equipped similarly to the individual offices (see above).

Seminar room, meeting room and skills lab

In small Neonatal Units seminars and meetings may be held in the same room. In large Units two separate rooms are required. The **seminar room** should be sufficient for an audience of 20 people and therefore should be at least 40 sq m. It should be equipped with white-board, full projection facilities including PowerPoint, a screen, a computer, a large table and stacking chairs. The **meeting room** should be of a similar

size, and is also equipped with table, stacking chairs, and projection facilities. A **skills lab** can be invaluable for learning and practising simulated procedures. This should be equipped with a resuscitaire, incubator, ventilator, mannequin, a storage surface, and several chairs.

Library

The library should be at least 20 sq m in size, and should have extensive shelving containing medical and nursing textbooks and journals. There should be two work-tops with two work stations in each. All four computers should have Internet connections.

ENVIRONMENTAL DESIGN

Windows, internal and external

The design of the Neonatal Unit must allow maximum staff efficiency. It is almost inevitable therefore that some rooms can have daylight, and some will be lit entirely artificially. Parents who are under great stress appreciate daylight. It is possible to design the Unit such that all clinical areas, quiet rooms and parents' bedrooms receive natural lighting. The storeroom, linen cupboard, laboratory, seminar room, pantry, dark room and duty room can all be placed centrally, and do not require daylight for their ideal functionality.

Babies' cots should be placed so that at all times they are at least 61cm from external windows. There should be double-glazing to minimise radiant heat loss, and some shading to prevent rooms from overheating. The latter can be achieved by reflective glass, Venetian blinds sandwiched between two panes of glass, or internal washable blinds.

Windows may link clinical rooms to internal corridors. Full transparency of such windows can interfere with the privacy of baby and family. Translucent windows combine the advantages of transmission of some natural daylight with preservation of family privacy.

Lighting

Lighting should be chosen very carefully. Ambient lighting should vary from 10-600 lux (1-60 ft candles). All artificial ambient light should be indirect, except for lights required for procedures. Specifically, light fixtures at each cot side should be directed upwards to illuminate the ceiling directly. Each light must be individually switch-controlled. In addition each cot should have its individual spot-lighting controlled by a dimmer switch. This system provides maximum flexibility, and is particularly important in special care areas where the relatively well child can sleep in darkness, even when another infant in the same room is being examined. The ability to achieve darkness is very important, not just for the sleeping infant, but also for procedures such as echocardiography and chest transillumination.

Sound control

Walls, floors, sinks and ceilings can all be designed to absorb sound

- Walls can be built at obtuse angles to dissipate sound. They may consist principally of vinyl-covered sound-absorbing panels. They can also be hung with washable tapestries or sound-absorbent material ("baffle boards").
Windows can be partly covered by sound-absorbent blinds

- Floors may be carpeted by easily-washable, thin-pile, durable material, although it may then be necessary to increase the size of the incubator castors so that they remain readily mobile
- Ceramic cause less transmission of sound than stainless steel sinks
- Ceilings can be made of highly-absorbent tiles. Ceilings should have a noise-reduction coefficient (NRC) of at least 0.9. They can also have sound-absorbent foam added, and this can be combined with cosmetic advantages e.g. by using foams in the shape of clouds, stars, suns, moons

Temperature

The NNU should be air-conditioned throughout and should have the following standards as specified by the Fifth Consensus Conference in NICU Design:

- Air temperature of 22-26 deg C (72-78 deg F)
- Relative humidity of 30-60%
- A minimum of six air-changes per hour
- Minimising drafts on or near infant beds
- Filtration of ventilation air at least 90% efficient

Security

An individual security firm should be asked to study the Unit and provide advice. Careful consideration should be given to closed circuit television access to the Unit for visitors, and card-swipe or number-pad access for staff. The security programme should protect the physical safety of infants, families and staff in the NNU. The security system of the NNU should also minimise the risk of infant abduction.

Parents' sitting room

Each Unit should have a designated family area where parents can relax. The room should be tastefully decorated and should appear welcoming. In this area there may be lockers for their possessions. These may be accessed by refundable coins, and may need to be emptied on a daily basis. Keys do not work: within days all lockers are used, and within weeks most keys are lost. It may be an advantage to keep the parents sitting room as an open plan area, to ensure that the area is not abused e.g. by smokers or for the consumption of other drugs. Parents often have other siblings in their charge and it is therefore essential to provide a **children's play area** within the parents sitting room.

Adjacent to or contained in the parents' sitting room, there should be a family education area. This area should contain a guide to the NNU, leaflets on common neonatal conditions, information on help available to families, and Internet access and audiovisual resources for educational purposes.

Parents' bedrooms

Any Unit which provides neonatal intensive care should have bedrooms for parents in close proximity to the child's incubator. This is particularly important for Units which are tertiary referral centres who provide facilities for parents from homes many miles from the Neonatal Unit. A bedroom for parents should be approximately 20sqm, including *en suite* toilet and shower-room. There should also be a double bed, couch, television, desk and telephone. The décor of the room is important. In this room parents may receive good news, bad news, or even hold their dying infant for the last time. Curtains and pictures should be chosen with great care.

Quiet rooms

Quiet rooms may be multipurpose facilities both for families and for staff. A large intensive care unit requires 2 rooms in which detailed counselling of distressed parents can take place, free of the demands of the Unit and other members of the public. These rooms can be intimate, and a recommended size is 12 sqm. There should be no telephone nor television. These rooms should be available for prolonged discussions and planning. They are designed for a couple to be interviewed at length, free from fear of interruption, by a doctor and nurse who are caring for their infant. Such rooms may also be used for staff appraisal or policy discussions. Good news and bad news may be imparted here. A great deal of thought should be put into all the furnishings, which should be comfortable and dignified. There should be facilities for serving refreshments. These rooms should feel special.

Staff counselling

Neonatal intensive care is stressful. Even the most dedicated staff make mistakes. Some may have uncertainties about their future career. Some may wish to be counselled or appraised. Designers of an NNU should think carefully about where confidential communication between staff may occur. The requirements are similar to those of the parents' quiet rooms.

Doctors' on-call rooms

It is not clear what the future will bring in terms of medical cover for Neonatal Units. It is likely that Consultants in large Units will require to be resident on call. Middle-grade doctors and Neonatal Nurse Practitioners may in future also have a role as on-call professionals. Today it would be wise to create 2 on-call rooms within the Neonatal Unit or within very easy access of the Unit. On call rooms should be at least 10 sq m in size and should have a single bed, wash-basin, desk, chair and wardrobe. They should also have ready access to shower and toilet facilities. There should be a telephone in each room. Careful attention should be paid to sound-proofing so that the on-call clinicians are not recurrently disturbed at night by ward telephones and monitoring alarms.

Staff rest room

Both nursing and medical staff are compelled today to take statutory rest periods. It is essential that a rest room is available in the Neonatal Unit. In addition there should be the opportunity for Neonatal Unit staff to take meal-breaks away from the Unit in the hospital canteen. Within the Unit however the staff should have access to a rest-room. For a large Neonatal Unit this should be at least 36 sq m in size, and may require to be larger in a very big unit. There should be a dining table, chairs, armchairs, a sink with draining board, a source of boiling water, a refrigerator and cupboard space for storage of crockery and cutlery.

Changing facilities

These do not require to be within the confines of the NNU, but should be nearby. They may be facilities which are shared with other disciplines in the hospital.

Equipment store

For reasons of security and Fire and Health and Safety Regulations, no equipment should ever be stored in corridors. Clinicians must decide about how large the Equipment Store should be, and this decision depends heavily on what arrangements are made for cleaning and recycling used items of equipment. If the hospital plans to clean all equipment outwith the Unit then a smaller store is adequate. If however all incubators, ventilators, monitors and phototherapy machines are to be cleaned “in house” then this should be very carefully addressed. A large Neonatal Unit should have a store room of 300 sq m to house all the equipment which is required to provide care for a tertiary referral centre. The room should be equipped with extensive shelving. It is particularly important to provide at least 20 electric sockets, because it is here that battery operated equipment will be charged in readiness for neonatal transports.

Transport incubator store

Transport incubators are bulky and should not be stored in public corridors. There should be a designated area for storing them within the Equipment Store (see above).

Pneumatic tube system

Careful thought should be put into how specimens can be transferred urgently to central laboratories in the Hospital. If a pneumatic tube system is chosen, it should be easily accessible, robust and reliable. The outlet might be best positioned at the central station next to the Unit Office. Readily available personnel can then identify problems if the system were to fail to send an urgent specimen.

Stationery

Although some NNUs are striving towards becoming paperless, most will not achieve this in the next five years. There should therefore be a room of 12 sqm with extensive shelving for storage of all the paper sheets and forms necessary for the efficient running of the NNU.

Pantry

This is a resource for staff so that they store food and soft drinks in ample refrigerator space. Four large refrigerators will be needed in a large NNU. The room should also contain a dispenser of boiling water and a source of ice cubes.

Milk kitchen

The milk kitchen is used for refrigeration and freezing of expressed breast milk. Parents and staff should have ready access to this area. Where NNUs strongly encourage mothers to express breast milk, four refrigerators and two large freezers are essential.

Milk expression

A pleasantly furnished room of at least 8 sq m is required to encourage mothers to express breast milk for infants who are nasogastrically fed.

X-ray processing

A room of at least 6 sq m allows X-rays to be developed on the Neonatal Unit so that emergency films can be carried out and examined as fast as possible. Once developed

the images should be available on screen in the NNU X-ray room so that they can be improved digitally. With sophisticated computer monitoring, it is possible within minutes to have a computer image of the X-ray at the appropriate infant's bedside. Every Unit should plan to have Picture Archiving and Communication Systems (PACS) facility in the X-ray processing room.

Clean utility

The design should ensure that clean materials should not pass through the dirty utility area. In this room there are stored clean items such as sterile water, crystalloids and disposable paper towels. This room should be at least 20 sqm.

Dirty utility

This room is for cleaning items which are already soiled, such as cots, incubators, humidifiers and basins. Once materials have been cleaned they should be transferred directly to the equipment store. This room should be at least 20 sqm. It must contain a trough with full hand-washing facilities. This room should have negative air pressure enabling air to be exhausted completely to the outside. It is essential that there is a one-way system of passage, so that clean equipment is removed via an exit separate from the entrance for dirty equipment.

Disposal store

In this area are stored syringes, needles, ventilator circuits, humidifier taps, catheters, intravenous lines and suction tubes. This room should be at least 20 sqm.

Waste disposal

Near the NNU exit should be a waste disposal room. This may be 10 sqm in size and with a door wide enough to accommodate hospital skips/rubbish trolleys.

Cleaner's room

Each NNU must have a room where domestic staff can store their cleaning equipment, including mops, buckets, floor-polisher and vacuum cleaners. A room of 10 sqm is suitable, and it must have at least one sink and a waste disposal unit.

Laundry/clothing

The NNU will find it convenient to clean all dirty clothes, sheets, towels and blankets, including parents bedding from the parents' bedrooms and transitional care. Drying facilities are also contained in this room. This room should be at least 20 sqm.

Toilets

It is important to plan the number and position of water closets in the Neonatal Unit. Parents' bedrooms, Transitional Care, medical on-call rooms, and the area dedicated to counselling (Parents' Quiet Rooms) should all have separate toilet facilities. In a large Neonatal Unit there should be at least 3 further toilets for staff and the general public. Standard toilet facilities tend to be around 3 sq m.

PATIENT SAFETY

Corridors, fire doors and patient flows

Widths of corridors, and numbers of fire doors are strictly regulated by hospital planning authorities. It is however important that staff contributing to the designs of a Neonatal Unit should play an active role in this area. Calculate the widest and longest objects which may be required to travel along the corridors. This may be a mother in a mobile bed who is being transported to visit her infant. Ensure that her journey can be safely accomplished from Labour Suite to the Neonatal Unit. Staff should also contribute to the discussions as to which way corridor doors will open, and whether they open automatically or by push-button. Medical and nursing staff should combine to role-play the movement of a hand-ventilated infant being transported from Labour Suite to the Neonatal Unit. Such patient flows may inform the eventual design of the Unit and its connections with the rest of the hospital.

Alarm call bells

It is essential in all large NNUs to be able to summon help to an emergency within the NNU. This should be done from each cot space at the press of a button. Staff planning the NNU should consider where they want to summon help from and how staff reacting are reliably and rapidly informed about where in the NNU the emergency is taking place. An on-screen computer plan of the NNU which automatically illuminates the ward area in question can be very effective.

Air conditioning

Temperature and humidity control within the neonatal unit is of paramount importance. Outside walls and windows should have a high 'U' value and the air-conditioning system should be such as not to either promote significant drafts within the unit or temperature gradients within the room. This requires a system which has air-mixers so that the air coming into the room is at the right temperature, not of the type that either bleeds in hot air or cold air in order to adjust the temperature. The air should be diffused into the room over a wide area so as to get an even temperature. The consequences of not having the appropriate air-conditioning plant installed leads to incubators which, when run at high humidity, have rain-out increasing the risk of infection to the babies and of the staff becoming over-warm and an increased sickness rate. Particular attention must be placed on the quality of the air-conditioning which must be of the highest standard.

The authors of this paper wish to acknowledge with gratitude the invaluable advice provided by Dr Neil Roy.

Appendix

Recommended list of people who should be involved in NNU design

Parents
Nurses
Midwives
Doctors
Ancillary NNU staff
Architect
Quantity Surveyor
Hospital planner

Plumber
Electrician
Infection control officer
Health and safety officer
Fire-prevention officer
IT designer
Accountant
Lawyer
Executive Board

Further reading

- 1) BAPM definitions of intensive care etc.
- 2) Recommended standards for newborn ICU design. Opinions of the Fifth Consensus Committee. *J Perinat* 2003;23:S3-24
- 3) NHS Estates HBN 21 'Facilities for maternity care'. London HMSO
- 4) Maternity Department Health Building Note/Scottish Hospital Planning Note 21. London HMSO. Pp3.183-3.225
- 5) Basler DS. Principles of building a perinatal center. In: *Clinics in Perinatology. Innovative planning of perinatal centers.* Ed Brans YW. Pp9-30. Feb 1983. WB Saunders