

# STANDARDS FOR INTENSIVE CARE UNITS

*prepared by*

**The Intensive Care Society**

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## **Guidelines on Admission to and Discharge from Intensive Care and High Dependency Units**

*Department of Health, March 1996.*

### **Intensive Care**

is appropriate for:

Patients requiring or likely to require advanced respiratory support alone (e.g. IPPV).\*

Patients requiring support of two or more organ systems.

Patients with chronic impairment of one or more systems sufficient to restrict daily activities (co-morbidity) and who require support for an acute reversible failure of another organ system.\*

### **High Dependency Care**

is appropriate for:

Patients requiring support for a single failing organ system, but excluding those needing advanced respiratory support.\*

Patients who can benefit from more detailed observation or monitoring than can safely be provided on a general ward.

Patients no longer needing intensive care, but who are not yet well enough to be returned to a general ward.

Post-operative patients who need close observation or monitoring for longer than a few hours.

\* Categories of organ system monitoring and support are shown opposite

## **Categories of Organ System Monitoring and Support**

*Department of Health, March 1996.*

### **1. Advanced Respiratory Support**

- Mechanical ventilatory support excluding mask continuous positive airways pressure (CPAP) or non-invasive (e.g. mask) ventilation.
- Possibility of a sudden, precipitous deterioration in respiratory function requiring immediate tracheal intubation and mechanical ventilation.

### **2 Basic Respiratory Monitoring and Support**

- The need for more than 40% oxygen via fixed performance mask.
- The possibility of progressive deterioration to the point of needing advanced respiratory support (see above).
- The need for physiotherapy to clear secretions at least two-hourly, whether via a tracheostomy, a mini-tracheostomy, or in the absence of an artificial airway.
- Patients recently extubated after a prolonged period of intubation and mechanical ventilation.
- Patients who are intubated to protect the airway, but needing no ventilatory support and who are otherwise stable.

### **3. Circulatory Support**

- Need for vasoactive drugs to support arterial pressure or cardiac output.
- Support for circulatory instability due to hypovolaemia from any cause and which is unresponsive to modest volume replacement. This will include, but not be limited to, post-surgical or gastrointestinal haemorrhage or haemorrhage related to a coagulopathy.
- Patients resuscitated following cardiac arrest where intensive or high

dependency care is considered appropriate.

#### **4. Neurological Monitoring and Support**

- Central nervous system depression, from whatever cause, sufficient to prejudice the airway and protective reflexes.
- Invasive neurological monitoring.

#### **5. Renal Support**

- The need for acute renal replacement therapy (haemodialysis, haemofiltration, or haemodiafiltration).

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## Introduction

This document is intended to apply to adult general intensive care units. Many parts of the document, particularly those related to structure, are applicable to other areas offering a similar degree of care, such as cardiothoracic, neurosurgical or paediatric intensive care, or high dependency care.

Intensive care may be broadly defined as a service for patients who have potentially recoverable conditions, who can benefit from more detailed observation and invasive treatment than can be provided safely in an ordinary ward or high dependency area. It is usually reserved for patients with threatened or established organ failure, often arising as a result or complication of an acute illness or trauma, or as a predictable phase in a planned treatment programme.

Intensive care represents the highest level of continuing patient care and treatment. It is distinguished from the care and treatment pertaining to a special procedure of limited duration such as a surgical operation, plasma exchange or haemodialysis, although it may embrace such procedures.

Intensive care has, as its primary objective, the recovery of the patient to leaving hospital. The return of a patient to an intermediate care ward, such as a high dependency unit (HDU) is only the first step in this progression. Intensive care involves continuing supervision, care and treatment by doctors, nurses, physiotherapists, technicians, dieticians and others.

An intensive care unit (ICU) is a designated area offering facilities for the prevention, diagnosis and treatment of multiple organ failure. An ICU should have:

- A clear operational policy example, Appendix 1.
- A minimum nurse:patient ratio of 1:1, together with additional nurses according to patient needs, training requirements, the total number of beds, and the geographical arrangements within the unit.
- 24-hour dedicated on-site cover by medical staff.
- An identifiable consultant as director, supported by consultants with allocated intensive care sessions sufficient to provide continuous immediate non-resident availability.
- The ability to support common organ system failures, in particular, ventilatory, circulatory and renal failure.
- A sufficient case load to maintain skills and expertise.
- Multidisciplinary care and effective communication.
- Adequate administrative, technical and secretarial support.
- Continuing education and training of medical and nursing staff.
- Audit of its activities.

**Intensive care** (see p2) is appropriate for the following categories of patient:

Patients requiring advanced respiratory support alone.

Patients requiring support of two or more organ systems

(see: Categories of Organ Support, p3).

Patients with chronic impairment of one or more organ systems sufficient to restrict normal activity and who require support for an acute reversible failure of another organ system.

**High dependency care** (see p2) is appropriate for the following categories of patient:

Patients requiring support for a single failing organ system,

but excluding those needing advanced respiratory support.

Patients requiring a level of observation or monitoring not possible on a general ward.

Examples may include (but are not limited to) patients with invasive arterial pressure monitoring, central venous pressure monitoring or with a pulmonary artery catheter in situ, patients requiring epidural analgesia or intravenous opioid infusions for pain control, or patients no longer needing intensive care, but who are not yet well enough to be returned to a general ward.

High dependency care requires a level of care intermediate between that available on a general ward and that on an ICU. A high dependency unit (HDU) should be able to provide monitoring and support to patients with, or at risk of developing, acute or acute-on-chronic single organ failure. It should not manage patients requiring multiple organ support or mechanical ventilation.

An HDU can act as a 'step-up' or 'step-down' facility between the general ward and intensive care unit. HDUs admitting 'general' patients should be sited close to the ICU, but this may not be necessary for some specialist HDUs (e.g. neurosurgery). An HDU may be either single-specialty or multi-specialty, and this will influence the mix of cases and the nursing skills required.

The HDU should have:

- A clear operational policy.
- An average nurse:patient ratio of 1:2, with an additional nurse in charge and the flexibility to increase staffing numbers and skills according to patient needs. The grade and skill-mix of nurses needs to reflect the possibility that patients may be physiologically unstable and that nursing intensity around individual patients may fluctuate.
- Immediate availability of junior medical staff from either the admitting specialty or the ICU.
- Continuous consultant cover from either the admitting specialty or the ICU.
- An identifiable consultant as director. For general HDUs, this should be the director of the general ICU.
- Appropriate monitoring and other equipment for the work undertaken.
- Continuing education, training and audit.

### **Establishment of Standards in Intensive Care**

Several international standards documents have been published. These include those by the Task Force of European Society of Intensive Care Medicine (1997), the American Society of Critical Care Medicine (Task Force on Guidelines, 1988-94), and the World Federation of Societies of Intensive and Critical Care Medicine (International Task Force, 1993).

In the UK, existing standards relate mainly to buildings, services, deployment of nurses and for some items of equipment. There have, however, been differences of opinion about the organisation, staffing and structure of what constitutes intensive care, and it is now becoming increasingly important to draw together and direct standards which match the needs of patients and their carers.

The Department of Health\* (DoH) has produced guidelines about which patients and what therapies should be found in the ICU. The importance of audit has also been emphasised, for example by the Intensive Care National Audit and Research Centre (ICNARC) and the establishment of standards in Guidelines for Purchasers (Royal College of Anaesthetists and The Intensive Care Society, 1994). The Intercollegiate Board on Training for Intensive Care Medicine, a multidisciplinary body, is also driving standards appropriate for those units who wish to provide training for medical practitioners in the acute specialties (up to and including ICU directors).

\* *Guidelines on Admission to and Discharge from Intensive Care and High Dependency Units, DoH, March 1996.*

**The purpose of this new document is to improve patient care by bringing together in one source all aspects related to the design of an intensive care unit.**

The document (an updating of previous editions) presents to professional bodies, Trusts and District Health Authorities, the minimal standards required for an intensive care unit, both for the care of patients and training of staff.

It is based on the views of members of the Intensive Care Society and members of other medical, nursing, managerial, and related technical disciplines. It takes into account the relevant parts of the publications mentioned on the previous page. It expands on relevant Department of Health guidelines (e.g. HBN 27) and includes relevant European and occasionally American and Australasian guidelines.

Many aspects of intensive care are not covered by any standards other than those found in this booklet. Therefore the booklet concentrates on these aspects, and also attempts to distinguish between essential items and those which are merely desirable.

## **DESIGN CONSIDERATIONS**

### **1. Structure**

#### **1.1 Health Building Note 27: Intensive Therapy Unit**

HMSO 1992 (formerly Hospital Building Note 27, DHSS, 1974)

Health Building Note 27 (HBN 27) was first published by the DHSS in 1967 and updated in 1970 and 1974. The most recent edition was published in 1992, and is the main planning guide used in the UK.

HBN 27 contains much of value, and many recommendations in this guide have been made in accord with it. However, some parts or statements are inappropriate because the note is based upon the district general hospital model. It assumes that average lengths of stay and bed occupancies are 48 hours and 65% respectively (para 2.8e), which is not the case for many ICUs. The guide also assumes that a patient no longer requiring 'life support' (i.e. mechanical ventilation) will be quickly moved to another area.

HBN 27 excludes guidance on design of:

- specialist ICUs
- ICUs in teaching hospitals
- coronary care units
- neurosurgical units
- cardiothoracic units
- paediatric units
- neonatal units
- renal units
- burns units

Although HBN 27 is intended to define minimum requirements, it is often interpreted by health authorities and trusts as representing the maximum. The document must be considered only as a guide.

## 1.2 Siting

For clinical reasons, the ICU should be easily accessible to the departments from which patients are usually admitted, such as the accident and emergency department, recovery room, surgical and medical wards. HBN 27 suggests that the ICU should be near the theatres, to enable engineering services to be shared, but this is by no means an overriding factor: separation of engineering plant may increase failure protection.

There should be easy access to the high dependency unit(s). This has advantages to both units as a step-up or (more usually) step-down facility, and for patient evacuation in the event of fire or decanting in the event of closure.

Increasingly, it is desirable to site the ICU close to the imaging department. Access to the main pathology laboratories is less important because of the development of near-patient laboratory facilities, such as fully automated blood-gas and electrolyte analysers, or portable chemistry equipment.

Careful siting of departments can help to minimise the distances patients are moved. Where there is a lot of patient flow, large lifts and extra-wide corridors are mandatory.

Those hospitals which receive or transfer patients to and from specialist units in other hospitals, or who receive frequent transfers from outside the hospital, must consider the position of the ICU in relation to ambulance or helicopter access this may require dedicated external access. Patients receiving coronary care and routine post-operative care (recovery) should have a separate area/ward, although they may share facilities and staff.

(See also 1.5, Fire Safety).

### 1.3 Size

Earlier editions of HBN 27 estimated that 12% of the total number of acute beds in a hospital should be provided for intensive care, with an additional allocation for any specialist services on site. Setting the baseline requirement is now exceptionally difficult because of changes in working practices and case mix.

The DoH report of March 1996 contains indicators for the type of care (intensive care, high dependency care, ward care) needed for individual patients. A local indication of the underlying need and type of care may be measured using these indicators. Table 1 shows some factors to be considered when determining the size of an individual ICU.

Table 1: Factors to be considered in estimating size of an ICU.

- Number of acute beds in hospital or catchment area
- Type of acute bed (adult, paediatric)
- Previously calculated occupancies of wards, HDU(s) and ICU(s)
- History of refusals
- Location of other 'high care' areas (other ICUs or HDUs in hospital, other hospitals)
- Number of operating theatres
- Surgical specialties serviced and case mix (e.g. vascular, cardiac, thoracic, emergency, urgent, elective)
- Medical specialties (e.g. respiratory, cardiology)
- A & E department
- Subregional or regional services (e.g. neurosurgery, maxillo-facial surgery, complex orthopaedic, renal services, oncology etc.)
- Ability to transfer patient to an off-site ICU (staff, equipment, transport)
- Paediatric care
- Location motorways, holiday resort, mainline transport terminal (rail, coach, air)

HBN 27 (para 2.8 (e)) assumes an occupancy of 65% and a length of stay of 48 hours. Extra, separate or different provision should be considered when units undertake a high proportion of regional or supraregional work, e.g. cardiothoracic, liver transplantation. Occupancy in units which undertake a high proportion of elective (planned) work and which admit a low proportion of emergencies should be significantly higher.

The optimum size for ICUs is being evaluated by the NHSE Health Technology Assessment Group. At present, the size of ICUs in the UK varies from 3 to 18 beds. Those which are very large or small may be difficult to manage: for example, units with less than 4 beds may not benefit from economies of scale, whereas units larger than 8 beds present problems of clinical management. It has been proposed that small units should not be recognised for the purpose of training medical staff (Intercollegiate Board on training for Intensive Care Medicine, 1996).

If more beds are required, consideration may be given to creating separate ICUs for identifiable groups of patients, such as post-cardiac surgery or head injuries. The need for paediatric intensive care units (PICUs), is the subject of considerable debate (Care of the Critically Ill Child, British Paediatric Association, 1993; Paediatric Intensive Care, Report from the Chief Executive, March 1996) and must be considered in the light of local and regional provision of paediatric services.

The general recommendation is that general ICUs should have an average bed occupancy of 60-70% (British Medical Journal, 1970). Units which persistently run with occupancies of more than 70% are too small (i.e. require more facilities) while those units running occupancies of less than 60% are too large and require fewer beds (HBN 27, 1970). Larger ICUs could be expected to maintain a higher level of occupancy, yet still be able to accommodate unexpected referrals. ICUs should be able to accept 95% of all appropriate emergency referrals for admission (Royal College of Anaesthetists and Intensive Care Society, Guidelines for Purchasers of Intensive Care, Royal College of Anaesthetists, 1994).

A method for calculating bed numbers based upon mean occupancy plus two standard deviations from the mean is too simplistic, and generally results in over-provision: bed occupancy should be skewed towards fullness. A number of mathematical models are currently being studied to determine a best method for calculating optimal occupancy. The document 'Guidelines on admission to and discharge from Intensive Care and High Dependency Care Units' (DoH, March 1996) gives criteria for admission to and discharge from high care units. A local census of in-hospital population and outside referrals can determine local need, i.e. inappropriate use of ICU, HDU or ward facilities.

The ICU, coronary care unit and recovery room have very different patterns of work and should, in general, be separate units. In small hospitals, however, the variable need for intensive care may make a combined unit more worthwhile, allowing sharing of equipment, storage and services including multipurpose rooms for relatives and staff.

HBN 27 gives guidance for ICUs of up to 6-8 beds, but notes that support services are 'sufficient for up to 10 beds'. The guide makes no provision for pro-rata increases in storage space, office or staff space, or space for relatives (e.g. waiting room). In some cases, areas suggested for both large (10 beds) and small (4 beds) units are identical.

## 1.4 Accommodation

Accommodation should be planned and based upon an operational policy. The essential accommodation consists of the patient areas and management base, equipment and consumables storage areas and rooms, utility rooms, sisters' office, medical office(s), staff sitting room, lavatories, showers and cloakrooms, doctor's bedroom, laboratory (or within unit area), workshop, storage area for case notes, relatives' rooms, kitchen facilities, reception area and cleaners' room. Other accommodation required includes a seminar room, receptionist's office, computer room and a procedure room. When ICUs are grouped, a satellite pharmacy and additional dry storage (consumables, sterile supplies) rooms may also be needed. There may also be need for a storage area for specialist beds and other large items.

It is essential that patient areas, staff rooms and workshops should have large windows to permit natural lighting (see 2.1.12) and where possible a pleasant view. Patients should be able to see out of the windows. Natural views have a therapeutic effect.

### 1.4.1 Security

Although high levels of staffing tend to ensure security in the patient area, other parts of the complex may be more vulnerable. Security aspects should be considered in the light of hospital policies, and relate to patients, visitors and staff, their belongings, and the operation of equipment contained within the environs of the unit. Security measures include a single entrance, with a variety of locking devices (keys, codes, cards and card readers) and video surveillance. Specific and heightened security is required in units which admit children, because of issues surrounding child protection.

Complete separation of staff and visitors in non-patient areas (separate, locked staff entrance) assists some aspects of security, but the need for immediate access to areas for example the blood gas analyser, or to the patient by a wide variety of authorised personnel, makes absolute security impossible. Local advice must be sought, balancing threat against inconvenience and hazard to unstable patients. Video surveillance and recording may be the most effective means of both security and deterrence.

### 1.4.2 Patient Area

The unit should be fully air-conditioned, although windows should be openable when the system is non operational. The patient area should contain an open area for several beds together, plus at least one cubicle. Thereafter, a minimum ratio of 1 cubicle:6 bed spaces is required. However, in some **circumstances**, the ratio may need to be much higher, as in burns units. There may be an increasing need for cubicles because of the growth in numbers of immunocompromised patients or infectious cases (e.g. methicillin-resistant *Staphylococcus aureus*).

Various physical arrangements are possible. For convenient management there should be 4-7 beds in the open area, with at least 20m<sup>2</sup> floor area for each bed and 2.5m of unobstructed corridor space beyond the working area

(see also 2.2.1). Adequate separation of beds is a major aspect of infection control. In any multi-bed area, beds should be positioned to maximise patient privacy. This may preclude 'facing' beds. Siting and method of provision of services (e.g. gantry, stalactite) may alter the floor area required (see 2.2.1).

One basin with hot and cold running water (and appropriate elbow taps) should be available for at least every other bed in the main patient area. These should be conveniently sited away from the bedhead. Additional basins for clinical handwashing must be available close to each entrance to the ward area. All bed spaces in the main area should have space and facilities for renal replacement techniques. Simplification of renal replacement therapies has decreased the need for appropriate water supply and drainage.

Cubicles should be rectangular (not L-shaped) with an entrance wide enough and so positioned as to allow a bed with cot-sides, orthopaedic traction and other equipment to pass easily. There must be adequate space at the foot of the bed. Each room requires hand washing and scrub facilities. The area of a single room and anteroom should be not less than 32.5m<sup>2</sup>, with the anteroom of not less than 7.0m<sup>2</sup>. The anteroom must contain a basin large enough for surgical handwashing, with hot and cold running water, and facilities for gowning. Single rooms increase the need for nursing staff.

Where highly infective or particularly vulnerable cases (e.g. patients with burns, immune deficiency) are regularly admitted, the anteroom must act as an air-lock, and the whole room ventilated using reversible positive/negative airflow, with at least 15 air changes/hour. Electronic means of communication with the open area is needed. All bed spaces must be equipped with an alarm call facility, irrespective of any other communication facility. This may be incorporated in monitoring equipment. The necessity for facilities for haemodialysis should be considered and if so a sluicing drain is desirable. Haemofiltration requires no special facilities (see 2.1.10). Heating and lighting are covered in Section 2.1.11, 2.1.12.

Doorways to all areas including fire exits must be wide enough to allow easy passage of a bed including associated equipment such as traction and cot sides. The design, positioning and security aspects of the doorway(s) should take into account movement of patients and beds around the unit, and into and out of the facility.

All floors should be strong enough to support the weight of special equipment including special beds which may weigh as much as 1 tonne. Likewise the roof and ceiling structure above and around the bed space should be strong enough to carry the weight of any suspended equipment, e.g. X-ray gantry, pendant arm systems and bedside services. Walls must be strong enough to support suspended equipment, e.g. monitors, or that supported by a rail (monitors, ventilators). Wall mounted rail must be able to carry 20kg every 60cm. They should be placed at both low level (below the lowest level of the bed for hot water humidifiers) and at around chest level for monitors, ventilators, flowmeters and blenders, etc. Consideration must be given to the choice of materials and design to minimise noise within the unit, which may be high (Balogh et al, 1993; Kam et al, 1994). Maximum permissible noise

exposure should be less than 24hr of 45dB(A) (US Environmental Protection Agency, 1974).

Detailed ergonomic design information is included in HBN 27. There is, however, no space included in their recommendation for 'bed dividers' or chart boards, which may be used to separate adjacent patients, and provide either privacy or an illusion of the

patient's own 'space'. Whatever the means chosen, there must be suitable screening between each bed. The materials used should be easily cleaned.

### **1.4.3 Central Station/Services**

The following management functions need to be accommodated within or adjacent to the patient area, although their precise distribution may vary.

#### *a) Communication*

The management base/nurses' station must be sited in such a way that it commands a clear, unobstructed view of the whole of the main patient area. This base serves as the central communications area for all the clinical management of the patients.

The central station requires at least 4 telephone extensions, all with STD facility. They must be capable of receiving direct-dial incoming calls without need for hospital switchboard. For national calls, no block requiring switchboard intervention should exist. At least two lines must be able to receive e-mail or fax transmissions, and be of ISDN standard. Call hold, transfer, group pickup, and conference facilities should be available on each phone, or twin or triple extensions must be available. Other facilities, e.g. camp-on-busy, call divert, hunt group, are extremely useful in busy units. The communication facilities are based upon a maximum unit size of 8 beds.

A personnel locator system for all parts of the complex may complement or replace some telephones (see 2.1.14), but each patient area requires an internal telephone extension.

Considerable noise will be generated in this area and sound deadening must be considered. Solutions may include telephone cubicles or telephones fitted with lights rather than bells.

The increasing quantity of electronic communications means that the nurses station must be large enough to incorporate two visual display units (VDUs).

#### *b) Monitoring*

Visual display units and other equipment should allow an overview of bedside monitor activity, access to the hospital information systems and local area networks. The height at which equipment is best positioned is shown in HBN 27 Appendix 1.

#### *c) Drugs: Controlled drug storage, drug cupboards or trolleys, drug refrigerators*

Because of the large quantities and ranges of drugs required in large units, a drug cupboard may be of 'walk-in' size. For security reasons, walk-in drug cupboards should have glass walls or large windows. Consideration should be given to the need for air-conditioning or temperature control when a number of refrigerators are in operation. Refrigerators may be needed to store large volumes of pre-packed parenteral nutrition bags (3-4L each). Intravenous and haemofiltration fluids must be stored in an adjacent area. Some fluids may require storage at higher temperatures (e.g. haemofiltration fluids, urological irrigation fluids etc.) and require a large warming cabinet. Microwave warming is not recommended.

*d) Storage of notes, radiographs, request forms, and other medical stationery*

Facilities are needed for writing and for multiple radiograph viewing (e.g. roller type viewers), but these may be sited outside the patient area for example in the Medical Office. In future, digital radiograph viewing facilities may be available. Requirements for their installation should be discussed with departments of clinical imaging. It is sensible to install structural cabling for future increases in electronic communication in any new or refurbished facility. Alternatively, all cables should be routed via conduits, making additional cabling a relatively simple 'pull through'.

*e) Blood refrigerator*

A blood refrigerator should be available in the ICU unless a blood store is available in the immediate locality, or another means for immediate delivery of blood (vacuum tube system) is available. Use of such a refrigerator will be governed by national and local blood transfusion service regulations.

*f) Cardiac arrest/emergency trolley*

In some units, consideration should be given to storage space for ultrasound machines.

*g) X-ray machine parking, with electrical socket for charging*

In some units, consideration should be given to storage space for ultrasound machines.

*h) Cardiac arrest/emergency trolley*

A second cardiac arrest trolley/defibrillator should be sited at a distant part of the unit, and units with more than 6 beds should have a third cardiac arrest trolley. At least one defibrillator must be equipped for external cardiac pacing.

*i) Emergency medical equipment*

This should be kept in the management area and should include emergency airway equipment for tracheostomy, bronchoscopy and thoracotomy, high power torches and spare cylinder spanners.

*j) Storage of shared medical examination equipment*

This may include neurological examination equipment, nerve stimulators, respirometers, peak flow or inspiratory power meters.

*k) Safety facilities*

Within-ICU facilities needed in the event of a major failure of external power sources should be close to the management area. These should include large (size G or J) compressed oxygen and air cylinders and appropriate regulators, terminal connectors, flow meters and vacuum adapters, battery operated portable lights, electric air compressor and vacuum pumps. The backup services should be able to support patients for at least 1 hour. Requirements for emergency electrical supplies etc. are dealt with in paras 2.1.1, 2.1.3 and 2.1.4.

*l) Security control*

The increasing need for security makes it likely that the central station will need to have means of control of access to the ICU site. See 1.4.1 Security.

**1.4.4 Storage** (see also Section 5, Management of Equipment)

Adequate storage space outside the patient area is essential. EEC directives on manual handling make the means of storage and access increasingly important. Much heavy, or bulky, but mobile equipment (e.g. ventilators, drip stands) requires storage and cannot be placed on shelves.

Deep storage is inappropriate, because items may be easily lost at the back of shelves. Furthermore, only small quantities of equipment can be stored on shelves above arm height (1.5m).

The storage space suggested in HBN 27 is inadequate for units with more than 4 beds as it does not increase space pro-rata with bed numbers. This applies to areas referred to in HBN 27 as 'bulk' storage, 'clean' utility, 'dirty' utility, disposal hold, linen bay, clinical equipment store, furniture store, equipment service room, laboratory and lobby.

If possible, storage should be approachable both from the patient area and from the supply route, which should be separate from the patient area. The storage area should be a maximum of 30m from the furthest bed.

Storage should consist of:

- a) Storage for consumables (CSSD items, plastic and electronic disposables of all types). The floor area should be at least 5m<sup>2</sup> per bed, with shelves, cupboards and drawers. This may be divided between an immediate store adjacent to the patient area, and
- b) a back-up store. Whatever, method is suitable, deep storage should be avoided. Consumables are often small with a relatively short half-life.
- c) Storage for equipment (e.g. ventilators, dialysis and haemofiltration machines, traction equipment, monitoring

apparatus, infusion pumps and syringe drivers, drip stands, trolleys, blood warmers, portable suction apparatus). In larger units, a separately located electrical equipment store, workshop and a bulk furniture store for beds, traction frames, etc. may be preferred.

- d) A total floor area of at least 5m<sup>2</sup> per bed is needed, with shelves, cupboards, drawers, wall rail and bins. The furniture store requires
- e) at least an additional 15m<sup>2</sup>: actual need is dependent upon local case mix, e.g. need for tank ventilators, spinal beds, paediatric incubators etc.
- f) Storage for linen. This should be adjacent to the patient area. 2m<sup>2</sup> of floor space is needed for each bed. This area may be reduced if laundry turn-around is rapid (twice daily top-up service).
- g) X-ray/imaging equipment bay close to or within the complex. Floor area should exceed 4.5m<sup>2</sup>.

#### **1.4.5 Dirty utility room(s)**

For bedpan storage and destruction and dirty dressings disposal. An area with bench space and sink for dismantling dirty ventilators etc. may be needed, depending on unit sterilising policy. These areas may be separate: a total area of 20m<sup>2</sup> is needed.

A separate area is required for storage of bagged clinical waste. The floor space required will be at least 2m<sup>2</sup>, but may be greater depending upon frequency of waste collection.

#### **1.4.6 Clean utility room**

Larger units will need separate accommodation for laying up trolleys, etc. At least 10m<sup>2</sup> is needed, adjacent to the immediate consumables store. Local policies may allow location of this space in the main ward area.

#### **1.4.7 Nurses' office(s)**

At least 15m<sup>2</sup> is required with separate telephone extensions, computer, hospital information system terminal and notice boards. The senior sister requires a separate office (10m<sup>2</sup>) dependent upon the total size of the unit, or its staff numbers. Specialist nurses, e.g. training nurse, research nurse, may require office space.

#### **1.4.8 Manager's office**

An office of 15m<sup>2</sup> is needed as a business office close to the intensive care complex. This requires telephone (with all facilities for direct dial, hold, transfer etc.), computer terminal and fax.

#### **1.4.9 Medical office**

At least 15m<sup>2</sup> is needed, with separate telephone extension, computer terminal, hospital information system, and intercom terminal.

#### **1.4.10 Consultant's office(s)**

At least 10m<sup>2</sup> is required, with an extra 5m<sup>2</sup> for each additional consultant. Computing is needed on each work station, together with appropriate telecommunications and information systems.

#### **1.4.11 Clinical Director's (or equivalent) office**

At least 15m<sup>2</sup> is needed for the clinical director's office. This should be separate from the consultant's office. Facilities similar to the consultant's office are needed together with e-mail, fax and an additional telephone.

#### **1.4.12 Audit office**

At least 10m<sup>2</sup> is required for the audit assistant. This office requires two telephone points, one of which will be used for computer modem. This room will house at least two computers and a significant amount of sensitive data. Security aspects must be considered.

#### **1.4.13 Secretarial offices**

Secretarial services are needed for the clinical director and manager (amounting to at least 1 WTE in large units), together with 0.5 WTE secretaries for each full time consultant (or equivalent sessions). An office of at least 15m<sup>2</sup> is needed for these staff.

Equipment must include communications systems (one telephone extension shared with each consultant) and word processing facilities. The office will contain a number of filing cabinets and notice boards. Depending upon the size of the complex, or whether audit assistants are shared, there may be a need for additional office space (fitted with computer terminal and two telephones). Up to 10m<sup>2</sup> will be required for a large unit. All computers should be networked.

#### **1.4.14 Staff rooms**

a) A staff rest-room with beverage bar, communications systems, television and radio should be provided. Kitchen facilities may be integral or preferably immediately adjacent see 1.4.18. The beverage bar should be equipped to reheat food, e.g. with a microwave oven. A food refrigerator should be available. A plumbed in dishwasher is useful. An ice-making machine somewhere in the complex is useful, but local Health and Safety regulations may override the provision of these machines in the hospital complex. If this is the case, there must be alternative means of cooling severely pyrexial (>40°C) patients. The staff rest room should be provided with external windows and comfortable seating.

An area of not less than 21m<sup>2</sup> should be provided and increased pro-rata from 8 beds (and equivalent staff) upwards (3m<sup>2</sup>/2 beds). The area should be segregated from the relatives' room and through routes to the main ward area. Security precautions are necessary.

b) Staff require facilities for changing, lockable lockers, showers and toilets. At least one wash hand basin and a drinking water facility is necessary. At present, the ratio of female:male nursing staff in many ICUs is 2:1. Changing facilities should be provided on the unit at the rate of about 0.75m<sup>2</sup>/nurse with a minimum of 15.5m<sup>2</sup> for female staff and 7.5m<sup>2</sup> for male. Separate staff shower facilities and WCs should be available in each changing room. Both the changing room and lockers must be individually lockable. These requirements may be modified if the hospital has centralised changing facilities for nursing staff.

#### **1.4.15 Doctor's on-call room/study**

The bedroom/study should have a floor area of 15m<sup>2</sup>, and be equipped with a bed, wash hand basin, shower, WC, wardrobe, telephone extension, intercom terminal and television. A secure locker must be available. There must be a desk and bookcase to allow study or preparation of notes or projects. A secure window and outside view is needed: it must be quiet. Although it needs to be close to the patient area and be within the unit complex, for privacy it should be segregated and out of direct routes between unit entrance, visitors' sitting room and the patient areas. The room must be protected from noise by positioning, the use of double doors and of sound reducing materials.

#### **1.4.16 Laboratory**

The laboratory area should be at least 15m<sup>2</sup> in size. Facilities should include blood gas analysis (tension and saturation), haemoglobin and electrolyte measurement. Adequate bench space is needed with at least 12 electric points, a sink, specimen fridge, freezer and centrifuge.

Consideration should be given to providing a system for fume extraction. Uninterruptible power supply is needed for at least the blood gas machine. A communication system must be available. In some ICUs, additional laboratory facilities may be best provided as an alcove in the main unit: local considerations should apply. It would be appropriate to have adequate space for a computer terminal within this complex.

#### **1.4.17 Medical equipment workshop satellite facility**

This requires a floor area of 15m<sup>2</sup> in addition to any storage area. Workbench, storage space, sink, compressed air, oxygen and vacuum terminals, and scavenging outlet are needed. There should be at least six electrical outlets, increased according to the role of the workshop.

Some ICUs may use the facility only for minor repairs, adjustment, assembly and testing of equipment, whereas others may consider it appropriate to perform all servicing and repairs in an ICU workshop. Under these circumstances relocation of area from the main workshop may be needed: an area as large as 50m<sup>2</sup> (and office space) may be needed for large ICUs. Local

considerations should decide the best practice for medical engineering. Whatever solution is chosen, the workshop should be separated from the patient area. (see also 5.2.3; 5.2.4)

#### **1.4.18 Kitchen (see also 1.4.14 Staff rooms)**

This is needed for limited preparation of patients' special feeds and staff snacks. It should be situated adjacent to the staff rest room. Facilities must include microwave oven and refrigerator, which requires at least daily checks on its efficiency. Local regulations may prevent the provision of a deep freeze. A sink for cleaning of utensils, drinking water tap and a separate wash hand basin is required.

#### **1.4.19 Reception area**

15m<sup>2</sup> are needed for the reception area, although this may be reduced in small units. The area should be manned by the ward clerk or receptionist during the working day, with clearly displayed information out-of-hours. The area requires an intercom terminal and visitors' call bell, with clear instructions for their use. Access to the unit may require a remote door control device, with video link. There must be alternative access to the unit for staff, in order to prevent continuous disturbance of staff by relatives, and to give staff some privacy.

#### **1.4.20 Relatives' room**

At least two waiting areas are needed. They should be adjacent to the reception area, and include one of 10m<sup>2</sup> suitable for interviews including breaking of bad news and bereavement counselling and one of 20m<sup>2</sup> with drinks dispenser, radio, TV aerial socket, WC and wash basin. A separate pantry area (6.5m<sup>2</sup>) may be needed in large units. The position of the relatives' room must prevent relatives from having continuous access to staff and be outside the area of medical and nursing staff accommodation. Siting should also prevent relatives from overhearing staff conversation, whether related to patients or personal issues. Items of value such as television sets should be securely fixed in place.

#### **1.4.21 Receptionist's office**

This should be of at least 15m<sup>2</sup> floor area and be adjacent to the reception area and consultants' office, with a counter surmounted by a glass screen to limit noise. In small units, this may not always be necessary. The office could also be used by a secretary or receptionist for typing, filing etc. An intercom terminal and telephone extension are needed.

#### **1.4.22 Procedures/treatment room**

This room may be required to enable some interventional procedures to be undertaken within the ICU, instead of in the operating theatre. A procedures room will be at least 20m<sup>2</sup> in area, containing all bedside facilities, high intensity lighting and scrubbing-up sink. The walls should be screened if image intensification is envisaged. Appropriate power supplies for special equipment should be considered, and at least four electrical sockets should

be included in the unit's uninterruptible supply. In some units, practical considerations such as the shape of the room, may make it more sensible to absorb this space into the main ward area.

#### **1.4.23 Seminar/multipurpose room**

Where formal teaching is undertaken, a room of at least 30m<sup>2</sup> floor area will be needed, with seating, projection facilities, wall board, X-ray screen, computer terminals and printers. This room must be adjacent to the ward area, so that staff are not dispersed during teaching sessions. The room will often house expensive teaching equipment, library and journals. This room should also be considered for use in case conferences. The room requires fitting with personnel locator and other communication systems as well as simple emergency call. Security access is required.

#### **1.4.24 Computer room/technician's room**

This will need to be 10-20m<sup>2</sup> equipped with a bench, at least 8 electric sockets, 4 of which should be served by an uninterruptible power supply (see 2.1.1). There should be at least two telephone extensions of ISDN standard.

#### **1.4.25 Cleaner's room**

For storage of cleaning equipment and materials. There should be 6-8m<sup>2</sup> of floor space for every 8 beds, with at least two electrical outlets and a sink/sluice.

#### **1.4.26 Patients' bathroom facility**

The need for this will be dependent upon local case mix, but should be considered whenever the unit regularly admits long-stay patients, e.g. those suffering from Guillain-Barré syndrome. The room must be fitted with hoist, oxygen, air and vacuum, in addition to the usual facilities. Because of the patient dependency, the situation, shape and size of the bathroom must be locally agreed, but should not be less than 8m<sup>2</sup> because of the need for all round access. The bath should have both shower and sitting facility.

#### **1.4.27 Satellite pharmacy (see also 1.4.3.(c) Drugs)**

In large units or those with a distant pharmacy, an air-conditioned drug storage room or satellite pharmacy may be required. The area should be 15m<sup>2</sup>, with bench, sink, refrigerator(s), 6 electrical sockets and telephone extension.

#### **1.4.28 Outside complex**

a) Relatives' residential accommodation with bedroom(s), sitting room, bathroom, toilets and telephone. At least one bedroom should be permanently available to relatives from the unit. The size, disposition and total number will, however, be dependent upon the size and specialties in the whole hospital complex.

b) Resuscitation teaching room, containing manikins and related equipment permanently on display.

c) In most units, there is also a need for a bed store containing, for instance, Stryker frames, high air-loss bed, as well as orthopaedic traction equipment (see 1.4.4).

Some of this area could be shared with other wards and departments which have similar needs.

#### **1.4.29 Clinical waste disposal holding area**

There are requirements related to safe disposal of clinical waste, which may necessitate a disposal holding area which must be locked. Additional regulations related to the safe disposal of 'sharps' may be expected in the future. The size and nature of this space will be dependent upon local arrangements for clearance, in particular the frequency of clearance rounds.

## **1.5 Fire Safety**

### **1.5.1 General**

Sources of information include Hospital Technical Memoranda (HTM) 81, 82, 83, 85 and 87 and the Intensive Care Society's own publication Fire safety in the Intensive Care Unit (1991), which deals specifically with the problem of fire in ICUs and similar environments. Structural fire precautions and means of escape are laid down in the Building Regulations, while aspects of management and housekeeping may in part be controlled under the Fire Precautions Act 1971.

Although fires affecting ICUs are mercifully rare, it is essential that plans exist to prevent and to deal with them. It is mandatory that the problem is discussed with the fire officer and that all unit staff know what action to take.

ICUs are particularly vulnerable because the patients' lives depend on services which may be disrupted, while they cannot easily be evacuated. Closure of the hospital oxygen pipeline, which may be necessary in the event of fire, can have a lethal effect upon patients in the ICU whose only source of inspired gas comes from the pipeline. Pipeline supplies are uncontaminated by smoke, so that a ventilated patient's safety only becomes compromised when disconnected from pipeline gas supply and allowed to breathe atmospheric air, e.g. via a self-reinflating bag. Local arrangements may allow pipeline closure not to occur in the ICU if this is considered in the design stage, or may allow isolation of the ICU gas supply and internal reprovision via in-house cylinders feeding the isolated ICU pipeline.

The ICU should preferably be at ground level to facilitate escape, but other considerations during the building and design stage may preclude this. Nevertheless, the basic principles of fire safety are the avoidance of fire, the safeguard of life and reduction of material damage.

### **1.5.2 Floor Plan**

A plan should be prepared to a scale not less than 1:100 and should show the following:

- a) the department with its compartments and sub-compartments
- b) the circulation space within each and their entrances
- c) location of internal hydrants, hose reels, fire fighting equipment
- d) electrical mains, medical gas, suction and ventilation plant control switches or valves
- f) positions of fire-resisting doors
- g) special hazard areas
- h) protected escape routes.

### **1.5.3 Smoke and toxic gases**

Fire produces smoke and toxic gases which may be flammable, colourless and odourless, so that their presence may not be readily detected. Three techniques commonly used for control of smoke are containment (by using fire resisting walls, ceilings, floors, doors, and cavity barriers), dispersal (depending on natural or mechanical ventilation) and pressurisation (to prevent the entry of smoke or to blow it out). Only pressurisation is suitable for the patient areas of an ICU, but plenum ventilation, other than in single rooms is not usual, or often possible.

### **1.5.4 Means of escape**

There should be alternative means of escape to a place of safety, and the escape route should be as direct as possible. The furthest distance to a fire escape exit should be 18m if there are two routes of escape, or 15m for a single route. Consultation with the local authority is necessary (HTM 81. Fire precautions in new hospitals: paras 17.78-17.81).

The basic principle of escape is for the occupants to turn their backs on the fire and travel away from it along protected escape routes (lateral evacuation). The need for total evacuation depends on the size of the fire and its rate of spread. In a modern large building a place of safety may be reached within the building by moving into an adjoining safe area. Critically ill patients receiving intensive care will be unable to resist cold and the place of safety should, therefore, be protected from wind and rain.

Patients dependent upon electrical or mechanical apparatus for their survival cannot be disconnected and moved down stairways and out into the open air without the risk to life. These patients should, therefore, be evacuated horizontally in their beds. Only as a last resort should ICU patients be moved down stairways.

Adjoining areas should be considered when designing ICUs, which are particularly important if a large number of patients require moving. Appropriate areas include another ICU, theatres or recovery areas, or an HDU. The possibility of safe areas elsewhere should be considered, because even if a patient is self sufficient (i.e. has his own source of oxygen, ventilation and battery powered monitors) the space occupied by a patient in his bed is large. Primary and secondary evacuation areas must be sufficiently large to accommodate the moved patients, irrespective of the provision of adequate services (piped gases etc.).

Each patient's bedhead equipment should include an evacuation case containing a small (D) oxygen cylinder, regulator and appropriate self inflating bag which can only obtain its gas supply from the cylinder and cannot entrain atmospheric, possibly contaminated, air. The case should also contain a simple anaesthetic face mask for use if the patient is not intubated.

### **1.5.5 Other fire precautions**

Closed fire doors may be a hindrance, especially if they interfere with visual and auditory contact essential for good nursing care of patients. Fire doors should be located so that users will have no cause to wedge them open. If it is necessary to provide a fire resisting door an automatic electro-magnetic or electro-mechanical device can be used to hold it open.

Where piped gases and electrical wiring are enclosed, the wiring must be run in separate conduits so that it cannot come into direct contact with the piped gas installation. Service ducts or voids containing piped gases must have adequate ventilation to prevent gas concentrating in the event of leakage. Pipelines must be suitably protected against damage and must be bonded to earth, but must not themselves be used for earthing electrical equipment.

Fire extinguishers should be provided in sufficient numbers to cover parts of the unit not reached by hose reels. Advice about fire extinguishers is given in the Intensive Care Society's document, *Fire Safety in Intensive Care Units*. This should be checked against the most up-to-date advice provided by the local hospital Fire Safety Officer, because of the variety of causes of fire and the potentially accelerative nature of the atmosphere, with both oxygen and nitrous oxide supporting combustion.

Situation and types of extinguisher are decided by the Fire Officer. The laboratory must also be provided with appropriate extinguishers, which may differ from those in the rest of the ICU. The Fire Officer will also decide the placement and nature of automatic fire detection apparatus, in particular whether this is a heat or smoke detection system.

All hospitals are automatically linked to the local fire brigade in order to minimise delays. The hospital usually has an administrative 'fire team' who are contacted automatically in the event of a fire. Their communication system may be tested daily in the same way as that of the hospital cardiac arrest team.

## DESIGN CONSIDERATIONS

### 2. Services

#### 2.1 Central Services

Pipeline shut-off valves and switches must be clearly marked to indicate the type of service and the part of the hospital supplied. Shut-off valves or switches for the ICU should be located adjacent to the unit where their operation can be controlled by the staff. Shut-off valves and switches should also exist within the ICU to isolate separate ward areas, e.g. the main ward, each side ward or cubicle and the equipment testing room. It should not be possible to cut off compressed gases or suction at any intermediate point between the source and the ICU.

All compressed medical gases should be supplied at the same pressures to prevent cross leakage and contamination through gas mixing devices. Because absolute control of pressure is not possible, oxygen pipeline pressure may be controlled to a level marginally above compressed air (both nominal 4 bar). In any case, individual devices receiving both air and oxygen at high pressure, e.g. gas mixers within ventilators or supplying them, should be disconnected from the wall if the equipment is not in use. Although fitted with internal non-return valves, these can backleak. Installations should conform to HTM 2022 (1992) Medical gas pipeline systems covering piped medical gases, medical compressed air and medical vacuum (Department of Health and Social Security and Welsh Office. Piped medical gases, medical compressed air and vacuum installations. Health Technical Memorandum. (5 parts). HMSO 1992). The specifications of this document are, however, flawed in a number of aspects, particularly related to the number of terminal outlets, and expected average and total flows (HTM 2022 Design considerations, para 4.28).

Liquid oxygen storage vessels (Vacuum Insulated Evaporator, VIE) must be located in the open and the surrounding area should be so controlled that no combustible material, smoking or naked lights are allowed. The site should be railed off as necessary to prevent unauthorised interference. The size of the VIE and the cylinder backup system should be reconsidered whenever additional intensive care facilities are added.

Peak demands for gas supplies for an eight bed unit are detailed in HTM 2022 and HBN 27 but are too low (52L/min for an 8 bed unit, HTM 2022, para 4.28; 70L/min HBN 27, para 6.9). Peak demand for oxygen can reach 160L/min with all beds in use, and double this volume may exceptionally be needed (see below). Demands are based partly on the assumption that each bedhead will contain only two terminal units (HTM 1022, Design considerations, para 3.9), and not four (see para 2.2.4).

Gas scavenging devices (Anaesthetic Gas Scavenging AGS) should be incorporated at the design stage to take into account developments in sedation, using nitrous oxide or volatile anaesthetic agents, potentially toxic

agents such as nitric oxide and nitrogen dioxide used in manipulation of pulmonary physiology, or toxic medications administered via the patient breathing circuit. The need for AGS in the ICU is not specifically mentioned in HTM 2022, but requirements should be similar to the operating theatres, with all sites where the patient may remain for any period equipped with AGS. This will include procedure rooms. The AGS system should be of the active variety. Passive systems are not appropriate. Average expired minute volumes will usually be less than 15L/min/bed, but gas powered ventilators and continuous positive airway pressure (CPAP) systems

will often generate much higher flows. Peak flows may momentarily reach 100L/min. Charcoal based adsorbent systems are not effective for all agents used in the ICU.

Low pressure warning panels for oxygen, air and other pipeline services (e.g. vacuum, nitrous oxide) must be visible in the ICU; the warning must be both visible and audible. Local policy may also include pipeline surveillance for oxygen purity using a pipeline bleed. This surveillance system must be gas specific (e.g. based upon a paramagnetic analyser) and must have visible and audible alarms. The incorporation of automatically and randomly re-calibrating oxygen analysers within modern mechanical ventilators, makes the requirement for pipeline purity surveillance less important in units where such ventilators are standard. The ward manager must be aware of the actions necessary in the event of pipeline failure (pressure or purity) for any of the services.

The height, positioning and arrangement of terminal outlets for gases, vacuum and scavenging must be considered during the design stage because repositioning is not straightforward. HBN 27 (Appendix 1) shows ergonomic considerations for various services. The choice of service arrangement (e.g. wall, gantry, stalactite, stalagmite, overhead) will have a major impact upon service arrangements, and upon operational use. Because of potential crossed pipeline problems, outlets not in use should be disconnected. Easy access is necessary.

### **2.1.1 Electricity**

The electrical supply should conform to Health Technical Memorandum 2011, Emergency Electrical Services, HMSO, 1992 [(i) Design considerations (ii) Management policy (iii) Operational management (iv) Validation and verification 1992)] and IEE Regulations for Electrical Installations, (Institute of Electrical Engineers) 16th Edition (1991) (and amendments). Power supply must be 240V single phase, with a single common earth ground and with all outlets in the patient areas on the same phase. Electrical supplies must be provided in PVC insulated cables concealed within steel conduit. Supply lines must not cause interference with electronic and other equipment, e.g. monitoring or computers. HTM 2011 (Design considerations) gives advice on maximum demands.

The patient areas should be served by a maintained stand-by power source with the highest priority rating (to trip in at 185V). There should be less than 5 sec interruption when switching to the stand-by source. HTM 1022 (Design

considerations, para 2.21, and Management policy, para 2.5) allows a response time not exceeding 15 seconds, which may be acceptable provided there is an uninterruptible power supply to essential areas. The stand-by generator should be tested at least every month. Two such separate rings are required in the patient area (see HTM 1022, para 2.2).

Separate uninterruptible power supplies (UPS) may be required for individual items of equipment, e.g. computers, lighting. Each bed area requires uninterruptible supply to at least three sockets. These priority sockets should be distinguishable, perhaps by colour. Only priority equipment (e.g. ventilator, monitor) should be supplied from them. The system should be able to supply power for at least 1 hour (HTM 2011) and should itself be supplied by the essential supply circuit (HTM 1022, paras 2.40, 3.34, 3.68-3.76).

Depending upon the size of the unit and the case mix, additional sockets equivalent to 1/bed should be placed at strategic points in the unit. There must be a visible and audible warning that the UPS has taken the load, or is failing to charge. Local decisions on siting and numbers of these essential outlets are necessary, being based upon the choice of equipment for which continuous supply is essential.

A third ring main, which need not be supplied by the stand-by supply source, should serve sockets for mobile X-Ray and domestic purposes throughout the unit. Each type of power source should be clearly identified.

When choosing monitoring and other equipment, both fixed and portable, consideration should be given to its own internal battery backup. In conjunction with the hospital medical engineering department, the service should review its requirement for uninterruptible and emergency power supplies every 4 years (i.e. half way through any planned equipment replacement program). The positioning and height of sockets is described in HBN 27, Appendix 1

### **2.1.2 Vacuum**

The ICU should have a central medical vacuum supply capable of generating a pressure of 500 mmHg (66.6 kPa) below atmospheric pressure and of maintaining 40L/min air flow at each bedhead when all outlets are in use. HTM27 gives a peak demand flow for an 8 bedded unit of only 100L/min. However, HTM 2022 assumes that each terminal unit will maintain a flow of 40L/min, but that only 25% of terminals are in use (Design considerations, para 4.69). Each bedhead should have a minimum of two terminals. For an 8 bed unit this equates with a flow of 160L/min.

### **2.1.3 Oxygen**

A supply of 100% medical oxygen should be available at a pressure of 4 bar (60 psi, 400 kPa). This pressure should be maintained when the flow is 20L/min at each outlet when all outlets are in use (European Society of Intensive Care Medicine, Minimal requirements for Intensive Care Departments, 1997). In an 8 bed unit, with each bedhead fitted with 4 outlets, this equates to 640L/min. Such a demand is exceptionally rare, with a more

realistic peak demand being 320L/minute (i.e. 8 beds fitted with 4 terminal outlets, with 2 outlets in full use). HBN 27 quotes a typical maximum demand of 70L/min. Falls in oxygen pressure may lead to cross-contamination if faults exist in equipment non-return valves. Terminal wall outlets do not incorporate non-return valves.

Where the unit has its own system, it should be supplied from cylinders having a total capacity of about 1,000 cubic feet (30m<sup>3</sup>, 30,000L) divided into two banks with automatic change-over controls incorporating a visible indication in the unit to warn when one of the banks of cylinders is exhausted.

Consideration should be given to the demand for oxygen supply in the unit in the event of failure or emergency closure of the external supply. The within-ICU back-up system should be able to supply all beds with a nominal flow of 10L/min for at least 1 hour, i.e. the ICU should be equipped with cylinder supplies (e.g. G-size) holding a total of 4,800L for each 8 beds on a pro-rata basis.

#### **2.1.4 Compressed Air**

A supply of medical compressed air, filtered and free of particles including bacteria, carbon, oil and water droplets (HTM 2022, para 2.9), should be available at a pressure of 4 bar (60 psi, 400 kPa). This pressure should be maintained when the flow is 20L/min at each outlet when all are in use. In an 8 bedded unit, with each bed head fitted with 3 outlets, this amounts to 480L/minute. A more realistic peak demand would be half this. HBN 27 quotes a typical maximum demand of 300L/min.

Pressure in the system should not exceed that of the oxygen supply to prevent inadvertent dumping of air into the oxygen pipeline, in the event of a crossed pipeline incident. Terminal wall outlets do not contain non-return valves. The direct interconnection of air and oxygen lines to each other downstream of any flowmeter should be discouraged if the gas mixture remains at high pressure (e.g. to drive a gas powered ventilator, nebuliser etc.) and is not in use. Cross-contamination of pipelines may then occur if pipeline pressures are not identical: compressed air pressure is subject to some fluctuation because it is usually produced from the local compressor (see below).

The air supply should be produced by a fail-safe tandem pair compression pump on a high priority (185V) instant switching stand-by supply. A cylinder bank, with a visible indication in the unit that it is in use, should be provided to ensure an uninterrupted supply in the event of mains failure.

Measures to be considered to overcome a short-lived failure or planned loss of external supply include a limited within-ICU cylinder supply or the availability of small electrical air pumps, recognising that some mechanical ventilators will not operate without a supply of both air and oxygen at pressure (400 kPa). An alternative strategy would include purchase of ventilators which have their own internal compressor.

Compressed air supplied at 7 bar should not usually be available in the ICU. Air at this pressure is supplied to the operating theatre as a power source for some orthopaedic tools. Consideration should be given to its installation in a procedures room and equipment servicing areas.

### **2.1.5 Nitrous Oxide**

A supply of nitrous oxide is provided at a pressure of 4 bar (60 psi, 400 kPa). This pressure should be maintained when the flow is 10L/min at each outlet when all are in use.

The supply may take the form of either:

- a) 100% nitrous oxide, or
- b) 50% nitrous oxide/50% oxygen (Entonox).

If nitrous oxide is used, an active anaesthetic gas scavenging system (AGS) must be provided. Standards must be similar to the operating theatres (see HTM 2022 Design considerations, Anaesthetic gas scavenging systems, para 16.0 - 16.52).

### **2.1.6 Other gases**

The use of new gaseous agents in the ICU may require specialist piping, and new non-interchangeable connection devices, fitted with non-return valves. Nitric oxide currently requires special plastic or stainless steel piping. Specific expert advice must be taken for such innovations, the detailed advice about which is subject to change.

### **2.1.7 Anaesthetic and toxic gas scavenging systems**

(HTM 2022, Medical gas pipeline systems, Design considerations: Anaesthetic gas scavenging systems, paras 16.1 - 16.52).

Increasing use of gases (nitrous oxide, nitric oxide), vapors (isoflurane), aerosolised medicaments (pentamidine) and the presence of toxic products (nitrogen dioxide) require active scavenging systems of a standard similar to that provided as part of anaesthetic gas services within the operating theatres. All bed areas including side wards and equipment test rooms require this service.

### **2.1.8 Fuel gas**

This is now rarely required for laboratory appliances (e.g. flame photometers) and the use of equipment requiring fuel gas should be discouraged. In other areas within the ICU complex other sources of power should be used. Gas appliances should be fitted with flame failure safety devices. The use of such equipment and storage of flammable/explosive gas, e.g. propane, requires consultation with fire services and local safety officers.

### **2.1.9 Ventilation** (see also 1.4.2. Patient Area)

The ICU should be fully air-conditioned. Should this not be possible then windows must be able to be opened. 'Tilt and turn' windows are a useful design. Security must be considered when the unit is sited on the ground floor, or is otherwise easily accessible.

Within the clinical areas at least, all air should be filtered to 99% efficiency down to 5 microns (see also 1.4, Accommodation). Air movement should always be from clean to dirty areas. If not fully air-conditioned, plenum ventilation of the multi-bed area should also incorporate heating/cooling systems.

Even when the main bed area in the ICU is not air-conditioned, at least one of the cubicles must have air-conditioning plant to allow a choice of temperatures (from 16° to 27°C), a choice of humidity (from 25% to 95% RH) and a choice of positive or negative operating pressures (relative to the open area). Cubicles usually act as isolation facilities, and their lobby areas must be appropriately ventilated in line with the function of an isolation area (i.e. pressure must lie between that in the multibed area and the side ward).

Air-conditioning may also be needed for rooms containing heat-generating apparatus such as computers and laboratory equipment. Pharmacy refrigerators generate significant quantities of heat. Mechanical extraction will be needed for single rooms and for the lavatory, sluice, laboratory and relatives' and staff rest room(s). Part-opening windows should also be provided in the last two of these and in the doctor's bedroom, if air-conditioning is not universal. Security considerations may affect the provision of opening windows. Smoking should not be allowed in the ICU complex. Where air-conditioning

is not universal, cubicles should have fifteen air changes per hour and other patient areas at least three per hour. The dirty utility, sluice and laboratory need five changes per hour, but two per hour are sufficient for other staff areas.

Storage and use of some toxic agents (e.g. nitric oxide supplied in cylinders) may require the unit to increase its general ventilation as a safety measure, in the event of inadvertent leakage of toxic gas. Extraction fans or fume cupboards are needed when local disinfection of some equipment is required, e.g. using glutaraldehyde for cleaning fibre-optic bronchoscopes (COSSH regulations).

### **2.1.10 Water supply and plumbing**

This should conform to HBN 27. The number and positioning of sinks in the patient areas is discussed in 1.4.2. Sinks should be designed for elbow use. The hot and cold water pressures should be equal throughout the unit at all times. Sinks in patient areas may require heated water (U-bend) traps, which require an attendant electrical supply.

A de-ioniser or reverse osmosis system may be needed for haemodialysis or other special techniques in each single room and at least two spaces in any larger patient area (e.g. the multi-bedded unit). Low level self-sealing trapped drainage outlets will be required for use with dialysis machines. Some ICUs will require all bed spaces and the equipment room(s) to be plumbed for dialysis (water and drainage). Rarely, laboratory quality de-ionised water will be needed in the laboratory.

### **2.1.11 Heating**

This should conform to HBN 27. Heating should be designed for continuous operation all the year round. Patients are often lightly clad in the ICU, so that a thermo-neutral temperature is required. Should small children need to be accommodated, environmental temperature may need increasing. The agreed environmental temperature may also require review if the unit has some specialist roles, e.g. burns management.

Single patient cubicles should have a choice of temperature from 16-27°C (see 2.1.9), but other patient areas should be kept at 21°C. Staff areas should be at 18-21°C, apart from the dirty utility sluice (16°C) and stores (10°C). The temperature in pharmacy store rooms or drug cupboards must not exceed 20°C. Unless specified, most crystalloid fluids for intravenous use can be stored at temperatures up to 25°C.

### **2.1.12 Lighting**

Natural daylight with an outside view is essential for both patients and staff. Where solar heat gain occurs solar-tinted glass is needed. Lighting should conform to HBN 27, HTM 1022, to the recommendations of the CIBSE Lighting Guide (No 12, Hospitals and Health Care Buildings) and BS5266 Part 1 "Emergency Lighting". Lighting should be glare free and should give a natural appearance to flesh tints to assist recognition of cyanosis, i.e. lighting must be colour-corrected.

The general lights should dim without flicker. There should be an independent control of light over each bed, with individual patient lighting independent of general background lighting. Good spotlighting and low level lighting to illuminate drains and underwater seals are needed at each bed.

Instantly-acting emergency lighting must be provided locally, independently of the stand-by generator system, in accordance with HTM 1022 (1992), Emergency Electrical Services. Such lighting should be independent of the general uninterruptible power supply. Lighting may be of the 'luminaire' self-contained type, and must be able to supply adequate light for at least 2 hours. Standby lighting directly over the patients bed space should be of intensity and quality close to normal lighting (HTM 1022 (1992), para 3.11). Escape lighting should follow that proposed in HTM 1022. In corridors, staff rooms etc., uplighting may be appropriate or preferred.

### **2.1.13 Noise**

Every effort must be made to minimise noise. Despite paying great attention to the reduction of incoming noise from road, rail and air traffic, hospitals often

attach little importance to internally-generated noise pollution. Although ICUs are not intended to be hushed, investigation has shown that noise levels are excessive, and may exceed that of traffic noise. While some noise can be minimised, e.g. by conducting ward rounds away from bed areas, other noise is less avoidable. Consideration should be given to minimising noise by the choice of sound deadening materials, position of beds, doors, rest rooms, design of alarms, use of lights on telephones etc. (US Environmental Protection Agency (1974). Information on levels of environmental noise levels requisite to protect health and welfare with adequate margin of safety. Environmental Protection Agency. Report No. 550-9-74-004, Washington. Noise pollution in the anaesthetic and intensive care environment, Kam PCA et al, 1994).

### **2.1.14 Communications**

Measures to avoid disturbing patients are required with all systems.

#### *a) Telephones*

(see Communications, 1.4.3, need for internal facilities, fax, e-mail)

The number of telephones required are:

- a) 4 at the nurses station, all with direct dial facility (see 1.4.3)
- b) 1 telephone in each patient area
- c) 1 telephone in each side ward
- d) at least 1 telephone in each office (medical director, consultants' office, business manager's office, doctors' sitting room and bedroom, secretarial and receptionist's offices.
- e) 1 telephone in bereavement/counselling room with direct dial facility and silencing device
- f) 2 extensions, at least one with direct dial facility, in the computer room
- g) 1 telephone in the relatives' waiting room/sitting room (payphone, with facility for incoming calls and with privacy area). The telephone should be adapted for use by the hard of hearing.
- h) 1 telephone in the relatives' overnight stay room (payphone with facility for incoming calls). The telephone should be adapted for the hard of hearing.
- i) any ICU workshop (1.4.17) requires both telephone and fax facility.

The use of cellphones should be prohibited within the vicinity of the ICU because stray electronic signals may interfere with medical equipment such as ventilators and infusion pumps. Adequate telephones should be provided for use by relatives, visitors and staff. In addition, because of improvements in information technology, its use in distance learning and for access to medical and nursing information databases, the number of external lines must be

maximised and carefully sited. Where there is restriction of numbers of these lines, their siting should be reviewed at least annually.

Consideration must be given to the security of computer systems attached to telephone lines. It is important to adhere to internal hospital policies related to access to external communication systems through internal telephone and computer systems (including mobile telephones).

*b) Alarm calls*

When provided, these should operate from each bedside and should generate visible and audible alarms in all parts of the unit outside patient areas. Ideally a single button or pull-cord should be capable of activating the hospital cardiac arrest system without recourse to the telephone exchange.

*c) Personal communications systems*

The on-call resident unit doctor must be provided with a personnel locator with 2-way communication. This system will also function as a 'crash bleep', and will avoid the need for carrying multiple communications devices. Other doctors on-call may require less sophisticated systems. Personnel locator systems should be available to connect all rooms in the ICU and relevant adjacent areas.

The consultant on-call requires an in-house bleep, a long-distance radiopager or a cellphone. At present, because of communication blackspots and the need to switch off these devices within the vicinity of electronic equipment, the cellphone cannot entirely replace the radiopager.

*d) TV aerial and radio sockets*

These should be provided at each bedside, in the staff rest room, the doctor's bedroom, seminar rooms and the relatives' waiting room.

### **2.1.15 Monitoring**

The physiological variables monitored will vary according to the type of unit. Minimal monitoring standards for ICUs are to be found in provided in Application for Recognition of Intensive Care Units (Intercollegiate Board on Training for Intensive Care Medicine, 1996), which is based upon Guidelines for Purchasers of Intensive Care (Royal College of Anaesthetists, 1994). All electrical monitoring systems must comply with the electrical safety regulations (IEC 601-1, BS 5742 Parts 1 and 2).

Provision should be made early in the design of the unit for the installation of any likely future system. Steel conduit or trunking of at least 50mm size, bonded to the common earth, should be distributed both circumferentially and radiating from the management base. The final choice of links may depend upon the decision to use 'ethernet' or 'daisy chain' computing networks. All equipment should be located so as to interfere as little as possible with nursing procedures. Connecting leads should not cross lines of communication.

For convenience and safety, a junction box into which all the physiological monitoring leads can be plugged may be located close to the patient. The junction box may be fixed to the bed (with a single cable led across to the display unit) or may be incorporated in a boom, stalactite or stalagmite (see 2.2.1, Bedside Layouts; HBN 27).

Physiological information derived from monitoring devices should be displayed at the bedside where it is immediately available to the staff. The display should not normally be in the patient's line of sight and is best wall or gantry mounted and not free standing. When staffing is at minimum levels or staff are distracted (e.g. during breaks, times of crisis), it can be advantageous for staff to be able to view other patients' display or alarm conditions from any (other) single monitor. Displays may be repeated in the vicinity of the management base. This is of secondary importance in a general ICU and should not cause staff to leave the patients' sides. Central hard copy recording, and down-loading of summarised monitoring is advantageous.

#### **2.1.16 Backup services** (electricity, oxygen, air, vacuum, lighting and heating)

The increasing sophistication of equipment, and reliance on external sources of power and other services makes continuity of supply increasingly important. Each ICU should review its servicing arrangements, its equipment, and its purchasing policy to ensure that it is capable of continuing to function in the event of failure of any individual service. Such events, although rare, may be disastrous.

Events to be considered include contamination of oxygen pipeline, and partial or complete loss of electrical power. These events may be unexpected or be part of a planned service shutdown requiring a 'Permit to Work'. Closure of a contaminated pipeline can result in several days of shutdown because of the need to check all outlets within the structures supplied, before the line can be re-opened. Design considerations (e.g. multiple shut off and bypass valves) may be helpful in preventing prolonged closures. These considerations will be particularly important in large units with high occupancy rates.

## **2.2 Services in Patient Areas**

### **2.2.1 Bedside Layouts**

The key requirement for layout of the bed area is the need for easy access to the patient. This creates a number of conflicts and HBN 27 considers a number of bedhead designs in terms of ergonomics. Services must be delivered in such a way that they do not impede basic nursing care, as several carers will frequently be involved simultaneously in routine procedures such as lifting, turning and washing.

All sockets and service outlets should be distributed on both sides of the bed. They should be organised in such a way as to minimise the loss of window space. In a free-standing arrangement at least half the outlets should be located on a gantry, boom, stalagmite or stalactite, with the remainder on the wall adjacent to the bed (see below). No outlet should be beyond the reach of

the shortest nurse: some may be at a low level (e.g. 600mm from the floor) with the majority at a higher level (1300-1600mm). Adequate separation of outlets is essential. Beds positioned diagonally across bedspaces may increase access to patients, but require that some of the services are differently positioned, e.g. horizontal gantry, vertical gantry arrangements.

### **a) Bedhead to wall layout**

Traditionally the bed is located with its head towards the wall. Services are brought from the wall across the head of the bed to the patient and equipment. Equipment which has to be connected to the patient may be supported on wall-mounted rails or shelves. The wall may need to be reinforced for this purpose. Some rail-mounted equipment may weigh 20kg. Where equipment is too heavy or bulky, it will have to be trolley mounted and on one or both sides of the bed.

An advantage of wall mounting is familiarity for staff. Wall mounting of service outlets may be easier from an engineering point of view if the walls are sufficiently strong. The disadvantages of bedhead wall mounting are that access via the head of bed (e.g. for resuscitation) is hindered by cables and pipes which traverse the gap between wall and bed, and that nursing staff have to pass round the foot of the bed to get from one side of the patient to the other. Work surfaces have to be located alongside, or at the foot of, the bed because the wall space behind the bed is not accessible. Lateral spacing of beds in multi-bed rooms must take this requirement into account.

The use of an external wall for providing services partly prevents the use of this wall for purposes of natural lighting. The services (medical gases, vacuum, electricity) are usually dropped from ceiling height in the wall space and further limit the area available for insertion of a window space at the bedhead.

### **b) Free-standing arrangements**

The bed is located 1m away from the wall and services are brought directly to it.

i) Services may be brought from the wall or ceiling to a boom or trunking over the bed, to one or both sides of the bed, usually

at the bedhead.

ii) Services may be brought down from the ceiling on a 'stalactite', usually situated at the head of the bed, perhaps to one side.

iii) Services may be provided entirely from above the bed using shelving and rails capable of supporting infusion devices, ventilator, etc. with ventilator breathing circuit reaching the patient from above.

iv) Services may be brought up from the floor on a 'stalagmite' structure.

v) Services may be supplied from a gantry hanging at the head of the bed, with or without shelving capable of carrying monitors and ventilators,

suspended from the ceiling at either side of the gantry. 'Drip poles' are suspended, rather than floor standing.

Combinations of these arrangements may be suitable.

The ICS will be able to provide a list of units which have used various solutions.

Advantages of these systems are that the head of the bed becomes freely accessible. Nurses can pass readily in both directions around the bed, and cables and pipes arise close to the bed and do not trail across lines of communication. As the wall behind the bed is free, a work surface and storage space can be located close to the 'busy' end of the patient. Provision of engineering services will often be easier with these systems.

Disadvantages are the capital cost of the boom, gantry, stalactite or stalagmite, the need to strengthen the roof for gantry or stalactite, and the need to allow additional space in line with the long axis of the bed. Other than the overhead shelf/rail system all these techniques are limited in their size. Even with space, the wall or some free standing trolleys are still needed to carry/hold patient equipment, so that these solutions do not completely open up space behind and/or below the bedhead. Hot water humidifiers, for instance, must be placed below the level of the patient's airway in case they are tipped over.

### **2.2.2 Electricity** (see also 2.1.1)

At least 24 sockets are required at each bed. The sockets should not all be placed at the same location but should be distributed equally on both sides of the bed. Exact positioning will be dependent on the choice of service supply. In addition, there should be at least three sockets with an uninterruptible supply, to supply essential electronic monitoring and mechanical ventilator.

### **2.2.3 Vacuum** (see also 2.1.2)

A minimum of two outlets for each bed is required. These are needed for:

- a) Suction controller for tracheal aspiration, etc.
- b) Suction controller(s) for continuous drainage suction.

In specialist ICUs (e.g. cardiothoracic, liver, trauma) at least one additional vacuum outlet for each bed will be required for suction drainage.

### **2.2.4 Oxygen** (see also 2.1.3)

Four terminal outlets are required for each bed. The outlets should be grouped and not spread singly across the bedhead, gantry etc. Terminal outlets are required for:

- a) flow meters
- b) gas mixing devices

- c) ventilators
- d) bronchoscope entrainer injector etc.
- e) in an emergency, to drive suction apparatus.

Although a single terminal outlet is often used to supply a double-flow meter, supply to ventilators is single and dedicated. It is not good practice routinely to use a single outlet to provide a double terminal outlet, because pipe sizing etc. has been calculated against an agreed flow from the primary gas outlet, and not the flow after multiple splitting via double terminal outlets. Because of disruption to the unit should there be a need to upgrade the oxygen supply, it is sensible to overprovide oxygen outlets. Insertion of additional outlets requires pipeline closure and recommissioning.

### **2.2.5 Compressed Air** (see also 2.1.4)

At least two outlets are required for each bed. The grouping of the flow meters should be considered, but they should be adjacent to the oxygen terminal outlets. Compressed air is needed for:

- a) flowmeters
- b) gas mixing devices
- c) ventilators

As with oxygen terminal outlets, it is sensible to overprovide air outlets. Insertion of additional outlets requires pipeline closure and recommissioning.

### **2.2.6 Nitrous Oxide** (see also 2.1.5)

Where 100% N<sub>2</sub>O or 50:50 N<sub>2</sub>O:O<sub>2</sub> (Entonox) is supplied, not more than one outlet is needed for each bed. An active scavenging point will be needed at any bed supplied with nitrous oxide (see HTM 2022 Design considerations, Anaesthetic gas scavenging systems, para 16.0 - 16.52) (2.1.7).

### **2.2.7 Water supply**

At least one hand washing basin is needed for every other bed in the open area and in each cubicle and its anterooms to minimise transfer of infection. In the open area, sinks may be shared. Wash hand basins at each entry to the unit are required. Self-sterilising heated traps may be useful.

### **2.2.8 TV aerials and radio sockets**

Each bed and all staff room require local outlets. The main ward areas require additional central outlets for large screen TVs, which may occasionally be needed.

### **2.2.9 Bedside Storage**

Storage may be of four main types:

- a) wall mounted open shelves

- b) bins, trays, etc., on wall rails
- c) shelves under a worktop
- d) mobile intensive care storage units (workstations)

It is desirable that each bedspace be self-contained for basic equipment, acting as a nursing workstation: nurses should have to leave their patients as little as possible. Storage units or workstations should not prevent staff from seeing throughout the patient area. Local fire regulations will require that workstations are mobile and not fixed.

Equipment for drug administration, tracheal aspiration and emergency resuscitation and ventilation must be easily accessible by the bed at all times. Frequently used items requiring less immediate availability may be stored in a bedside cupboard or drawer. Examples are eye cleaning packs, mouth care material, linen, washing equipment and personal belongings.

### **2.2.10 Charts and Notes**

The charts upon which patient's observations are recorded must be located at the bedside. Their position should be easily accessible to the nursing staff, clearly visible to the medical staff and out of the patient's sight (see also 1.4.3 and 4.7.1). There is now a move towards paperless recording via visual display units, automatic data acquisition and the use of light pens. Such systems will require at least some hard copy and central (within ICU) printing facilities must be available. Ideally the ICU should have direct access to the pathology laboratory through each such monitor.

This document is not intended to make recommendations related to security, verification and acquisition of computer derived records and other aspects of the Data Protection Act.

## **OPERATIONAL RECOMMENDATIONS**

### **3. Staffing**

#### **3.1 Medical Staff**

##### **3.1.1 Consultants**

A designated consultant should bear administrative responsibility for the unit. In many trusts this will be the clinical director, but if not a 'lead consultant' should be appointed with responsibility for clinical policies, staffing, audit and have input into budgetary controls. Specific sessions set aside for administration and management will be required if the unit has 4 or more beds. Clinical responsibility may be shared by more than one consultant, but excessive numbers may jeopardise continuity of care.

Intensive care medicine should be consultant-led at all times, with a high proportion of direct consultant input to patient care and immediate consultant availability for advice or recall at all other times. There should be adequate sessional allocation in Consultant job plans with specified 'fixed' sessions and adequate 'flexible' sessions to reflect the out-of-hours workload. The Society recommends for all units of 4 or more beds that each weekday daytime session should be covered by a consultant with no other commitments. The minimum number of fixed consultant sessions allocated to intensive care should thus be 10, but this may require to be increased to reflect the length of the normal working day and any regular ward rounds and visits at the weekend. Out-of-hours emergency and on-call commitment should be reflected in flexible consultant sessions with a minimum allocation of five. Out-of-hours work should, however, be accurately audited particularly the number of hours that consultants spend in the hospital when on-call out of normal working hours, and flexible sessions negotiated to reflect the intensity of this workload. Where out-of-hours workload is particularly heavy, or there is a lack of adequately trained junior staff, each consultant's fixed session in their job plan should be reduced in agreement with management.

The Society recommends that the minimum weekly allocation of consultant sessions to an ICU of 4 or more beds should be 15, of which 10 should reflect fixed daytime sessions. A minimum of 7 consultant fixed daytime sessions dedicated exclusively to the practice of intensive care medicine is required to achieve training recognition (Intercollegiate Board of Intensive Care Medicine, 1997). In larger units it may be necessary to have two simultaneous consultant sessions with up to 15 fixed daytime sessions allocated. The impact of the reduction in trainees' hours of work, coupled with the Calman training proposals, suggest that the need for two consultants simultaneously is increasing in order to provide adequate clinical and technical skills. Large units may require up to 30 consultant sessions per week, not only to cover daytime commitments but also to cover nights, weekends and periods of leave. Some of these daytime sessions may be shared with other duties, but arrangements must be such that a consultant remains immediately available at all times.

### **3.1.2 Trainee Medical Staff**

The intensive care resident should be responsible only for the ICU and should have no commitments, other than those which are a natural extension of the post, e.g. membership of the cardiac arrest team, membership of the trauma team. Any extension to the post should exclude activities off the hospital site, e.g. transfer/transport team, unless alternative arrangements for immediately available residential cover are made. The responsibility is continuous throughout the 24 hours, so the trainee should be resident within the unit complex. The resident should be involved in all decisions about the patients.

Hours of work and training arrangements will alter the traditional arrangements for medical staff cover. Options include partial or full shift working, requiring a rota containing at least 5 residents, and often rostered time off and annual leave. Any new training programme will need to account for protected time-out for education and specific time for practical training and ward meetings. Handover periods and meticulous notes are essential, particularly with shift-type working patterns.

The requirements for ICUs intending to act as bases for training in intensive care medicine are laid down in Application for Hospital Recognition, Intercollegiate Board on Training for Intensive Care Medicine. This document specifies the facilities, documentation etc. needed by both the ICU and the hospital to allow training of doctors in intensive care medicine. The combination of a reduction in hours-of-work and Calman training recommendations will reduce the clinical time spent in the ICU by individual trainees and will reduce their available service hours.

The increasing involvement of consultants and the changes in rostering and training of non-consultant staff make it likely that more guidelines and protocols will need to be introduced.

### **3.1.3 Other Medical Staff**

Patients should be treated on lines agreed by the admitting and intensive care consultants, often using written policies, guidelines or protocols. Because of the wide variety of conditions encountered it may be necessary to obtain opinions from consultants in many disciplines.

Where a full range of specialists is not available, a fully comprehensive intensive care service cannot be provided. In the UK, at present, PICUs are uncommon and many general ICUs will be expected to admit a proportion of children. In the UK, children make up about 12% of admissions to adult units. Even in specialist units (e.g. neurosurgery) the availability of consultant paediatric advice is essential.

### **3.1.4 Education and Training**

Consultants in intensive care medicine need to be specialists in all aspects of acute medicine and resuscitation in the broadest sense. They should also be skilled in the administration, planning and organisation of an ICU. They should be familiar with the details of audit. Proper training will produce clinicians who are fully competent in all aspects of the management of critically ill patients,

irrespective of whether they will ultimately devote all or only part of their time to duties in intensive care.

In future, consultants with sessions in the ICU (either actual or cover) will be expected to have undertaken at least one year's training in intensive care medicine. Full time consultants in intensive care medicine, and/or directors of ICUs will be expected to hold a post-graduate Diploma in Intensive Care Medicine, as well as their primary postgraduate qualification (e.g. FRCA, MRCP, FRCS). It is envisaged that a CCST (Certificate of Completion of Specialist Training) will be awarded at the completion of training.

It is proposed that postgraduate training in intensive care medicine is undertaken at three levels:

### **1. Basic training**

This should be a three month exposure to the specialty at senior house officer level. Large numbers of trainees from acute specialties will be expected to undertake this training. The main purpose of this short exposure is to teach the trainee to recognise those patients for whom intensive care is appropriate, and to begin resuscitation of these patients using relatively straightforward skills, which would also be appropriate for use on an HDU or general ward.

### **2. Intermediate training**

This training is aimed to equip the doctor with sufficient skills and knowledge to accept a sessional or cover commitment to the ICU. Each trainee would spend 6 months on an accredited ICU training program. Trainees whose base specialty was anaesthesia would be expected to undertake 6 months training in internal medicine, with exposure to an appropriate and varied case mix and case load (e.g. cardiology, nephrology, neurology, chest medicine, infectious diseases). Trainees with a base specialty of internal medicine, would be expected to undertake training in anaesthesia, again with a varied and appropriate case mix. Most surgical trainees will require training in both internal medicine and anaesthesia and will require a programme tailored to their individual needs.

### **3. Higher training**

This training period, lasting a further 1 year, is aimed at those doctors wishing to take up a post in which their major sessional commitment is to be intensive care medicine. This period will expose the doctor to both general and specific intensive care (e.g. cardiothoracic, coronary care, neurosurgery, hepatic, paediatric), to research and to the management, audit and budgetary parts of the position. When a total exposure to intensive care medicine is more than 1 year, the trainee may acquire a diploma by examination, provided that the trainee has already obtained his primary postgraduate qualification.

The detailed training recommendations and syllabus are laid down by the Intercollegiate Board on Training for Intensive Care Medicine, but continue to be subject to change.

### **3.2 Nursing Staff**

Intensive care is synonymous with a 1:1 nurse-patient ratio (Guidelines on Admission to and Discharge from Intensive Care and High Dependency Units, Table 1; para 7.1, Department of Health, March 1996). However, this has to be applied contextually and realistically to each individual intensive care and high dependency unit. The following factors should be taken into account when assessing appropriate staffing levels for each unit:

- patient throughput, case-mix and dependency
- nursing staff skill-mix and experience
- medical staff skill and availability
- unit layout
- training requirements.

There will be occasions when a patient in the ICU does not require the undivided attention of a nurse at all times. Usually this will be a patient awaiting discharge, but it could also be a patient at risk of precipitous deterioration in respiratory function, who could not reasonably be discharged to a high dependency unit (HDU) (see pages 2-3). Conversely, some patients are so seriously ill that a single nurse is unable to perform all the necessary duties. Thus two patients requiring both positive pressure ventilation and haemofiltration will clearly require more than two nurses. These patients are now not uncommon in the ICU. Allowance has to be made for such situations when establishing a nurse:patient ratio, and the ability to utilise staff flexibly is important.

The staffing requirement necessary to provide a nurse at the bedside at all times is at least 6.3 WTE/bed. This figure takes account of annual and required professional leave, but takes no account of sickness or maternity leave, the latter being particularly important in units which have a high proportion of female nurses. This staffing level does make provision for either a supervising nurse-in-charge and/or a 'runner'. If the full complement of beds is to be maintained at all times, an allocation of 7 WTE/bed is realistic. A further increment of nurses will be necessary should unit design include multiple sideways or cubicles. Consideration should be given to requirements for training, research, audit and data collection.

### **3.2.1 Dependency Categories**

As a general rule:

- patients requiring intensive care need at least 1:1 nursing
- patients requiring high dependency care, require, on average,  
1 nurse:2 patients.

Patients who should receive intensive care and receive 1:1 nursing in an intensive care unit can be identified by reference to Guidelines for Admission to and Discharge from Intensive Care or High Dependency Units (DoH, March 1996, tables 1-3).

These tables show the level of care and technology appropriate to the placement of the patient in an ICU. The Guidelines will show that some patients who are receiving care in an ICU require care more appropriate to an HDU, while other patients being nursed in ward areas may need either high dependency care or even intensive care.

The true need for intensive care and high dependency care will become apparent in the next few years as recurrent local and national audits refine the need for care.

### **3.2.2 Training Requirements**

There should be a senior nurse with several years' experience and an appropriate level of qualification in charge of the unit, supported by appropriately experienced senior nursing staff. As with numbers, the appropriate level of qualification will need to be assessed for a particular unit, but post-registration education in intensive care nursing would be the desired minimum for senior staff.

It is suggested that at least 25% of senior nursing staff should hold a formal qualification related to intensive care (e.g. ENB 100, Diploma of Nursing etc.). Those units who are involved in providing members of a cardiac arrest team may require Advanced Life Support (ALS) certification, in addition to Basic Life Support (BLS) training and certification. It is beyond the scope of this document to specify training requirements in more detail, only to recognise the importance of appropriate opportunities from both the patient care and personal nursing development aspects.

#### *Pre-registration Nurses*

These nurses may spend part of their training in an ICU, provided that there is a separate nurse teacher, teaching sister (or equivalent) to supervise them, and that they are supernumerary to and not replacing the trained staff. Such trainees are best assigned to senior bedside nurses in the unit, and must be protected from the need to make complex decisions related to patient care.

The value of proper orientation to the unit even for fully qualified nurses is well recognised, and any new nurse must spend a period of time in a supernumerary position. The duration of this should be tailored to previous experience and local knowledge.

#### *Other nurses*

Other nursing groups may spend time in a familiarisation role in the intensive care unit. These nurses may include those assigned to accident and emergency, burns, anaesthesia and renal medicine.

#### *Auxiliary Nurses and Care Assistants*

Auxiliary nurses may be employed to assist the trained staff. Depending upon their role it may be possible to use these assistants to reduce the requirement for nursing staff to perform non-nursing duties, thus allowing more time for their involvement in direct patient care. Such tasks include cleaning, stores

ordering and restocking. However, introduction of these staff must not be allowed to reduce skillmix to an inappropriate level to deliver patient care. Each unit will need to judge its own skill mix and the requirement for unqualified staff.

### **3.3. Technicians and Technical Support**

The multitude of complex equipment used in the ICU must function with the utmost reliability. This will depend on good management (see Section 5), of which regular user servicing is an essential part. Doctors and nurses are seldom able to undertake this and the availability of a technician is essential at all times.

The increasing complexity of equipment in use within the ICU means it is unlikely that a single technician will have all the skills necessary to run, maintain or service equipment. It is more likely that dedicated engineers responsible for all equipment in the hospital will be needed in addition to technician time within the ICU, the purpose of the ICU technician being one of equipment set up and simple repair.

Depending upon the size and complexity of the ICU and its equipment, larger units will require more than one technician, particularly when out-of-hours servicing is required. It may be possible to share daytime cover among technicians of various disciplines, e.g. intensive care and theatres or haemodialysis, but even in small units this will amount to at least one whole-time equivalent.

Technical support is needed in the ICU for:

- a) Repair, care and maintenance, and de-contamination of ICU equipment.
- b) Operation and care of ICU monitoring, measurement and therapeutic equipment, including care of 'self service' blood gas and electrolyte analysers.
- c) Emergency cover for out-of-hours fault repair, major monitoring, urgent servicing and de-contamination, particularly at weekends and bank holidays.
- d) Management, updating and training in the use of computers for audit, word processing, use of multimedia training etc.
- e) Education of nursing and medical staff in user care and operation of equipment, e.g. syringe drivers, non-invasive blood pressure devices, blood gas analysers (Clothier report).

### **3.4 Other staff**

#### **3.4.1 Physiotherapist**

The services of a physiotherapist experienced in ICU work should be available on a 24-hour 7-day basis.

### **3.4.2 Radiographer**

The services of a radiographic team capable of mobile X-ray and ultrasound imaging should be available on a 24-hour, 7-day basis.

### **3.4.3 Dietician/Nutritional Team**

A dietician or clinical nutrition team may be required to advise about feeding patients. Recent re-emphasis on enteral nutrition makes these skills increasingly important.

### **3.4.4 Pharmacist**

Pharmacists should be considered part of the ICU team. They may routinely accompany medical staff on the main round of the day.

### **3.4.5 Clerical Support**

The clinical director will require at least part time services of a secretary. Additional secretarial time is needed for the senior nurse specialist and business manager. Secretarial assistance is also for typing patient summaries, duty rosters, etc. A ward clerk should be available for the purpose of filing laboratory reports, completing records, taking calls, handling requests for investigations, stores etc. This may be combined with that of receptionist, but it may be necessary to employ more than one full time equivalent to cover this work.

The requirement for data collection and input for ICNARC requires, in the average unit, at least 0.5 WTE audit clerk.

### **3.4.6 Cleaning Staff**

The unit should have its own cleaning staff who are familiar with the work of the unit, the importance of the treatment undertaken, the dangers of disconnecting patient apparatus, and other problems relating to patient care such as infection control.

## **OPERATIONAL RECOMMENDATIONS**

### **4. Unit administration and operational policies**

#### **4.1 Clinical Management**

Two different patterns of clinical management are seen in the UK, and the actual arrangement adopted should be defined, agreed and understood by all the consultants concerned. In either case routine management should be prescribed and supervised by unit medical staff. Decisions of a more specific nature should be taken in consultation with the referring clinician.

##### **4.1.1 a) 'Closed Unit':** Intensive care consultant completely responsible for clinical management

The intensive care consultant(s) may have complete clinical responsibility for the care of patients admitted to the unit. They take over when the patient is admitted and may transfer care to another appropriate consultant at the time of discharge. In this case, the consultant who originally admitted the patient to hospital may continue to act in a purely consulting capacity. Consultants from other specialities may also be invited to give advice.

This arrangement is well suited to units in which the patients are from a very homogeneous group, such as neonates, those with head injuries, myocardial infarcts or renal failure and those who have had cardiac surgery.

##### **4.1.1 b) 'Open Unit':** Clinical management remains responsibility of admitting consultant

Patients are admitted to the ICU under the care of their admitting consultants and remain so throughout their stay. The ICU consultants are usually deemed to be in consultation but the extent of their responsibility will be agreed locally. Other consultants may also be called in consultation according to need.

This arrangement is better suited to general ICUs serving a wide range of admitting specialties, none of which could sustain their own dedicated unit. Units in which the intensive care consultant has had a high degree of autonomy and control of patients in the intensive care environment have been consistently shown to produce better patient outcomes (e.g. Zimmerman, 1993; Knaus, 1986).

#### **4.1.2 Administrative responsibility**

The apportionment of administrative responsibility among the intensive care consultants, and between them and the senior nurse, should be defined. The introduction of a business management approach, if not already in use, should be considered in the definitions of areas of responsibility.

The main areas concerned are operational policies, equipment management, audit, financial management, staffing, safety (including Health and Safety at

Work), research and teaching, hospital and medical administration, liaison with other departments, Divisions, Directorates, and purchasers.

#### **4.2 Admission and discharge policy**

A formal policy for admission and discharge of patients must be adopted. Admissions should be agreed with the consultant in charge of the unit at the time, particularly when all staffed beds are occupied. Non-unit staff, no matter how senior, should not be permitted to order patients into the unit. Every case must be considered on its merits. Many units do not admit patients who are on the point of death. Conversely, only in exceptional circumstances will a patient whose death is imminent be transferred out of the unit.

When a patient is ready for discharge it is the responsibility of the admitting clinician to find a bed. At discharge, the ICU is responsible for handover of the patient to the receiving team, and ensuring that appropriate therapies are continued. Should the patient die, the ICU must notify admitting and co-opted teams and the patient's family doctor as soon as possible, i.e. immediately during office hours or immediately the following morning if death occurs at night or weekend.

Whatever approach is made, it is necessary to provide a clear audit trail, necessary for generation of appropriate medical statistics.

#### **4.3 Therapeutic Policies**

To avoid confusion and in the interests of training, a consistent approach to common therapeutic procedures should be adopted within the unit.

For example, insertion of a chest drain should be carried out in the prescribed manner in all patients, unless there is a special reason for not doing so. Similarly the technical arrangements for continuous infusion of drugs such as inotropes should be consistent.

The actual writing of prescriptions should preferably be the responsibility of the intensive care resident. A standard handbook describing these policies should be readily available to all staff, preferably on disc. Regular (6 monthly) updating or review is appropriate. Local policies and procedures established by a Drug and Therapeutics Committee should be adhered to and diversions from such policies acknowledged by the Committee.

#### **4.4 Investigational Policies**

Uniform procedures should be adopted for routine investigations. For example the timing of 24-hour urine collections, the method of calculating nitrogen losses and the frequency of repetition of routine biochemical tests should all be consistent. Automated analysis profiles may be arranged with the pathology laboratories for admission and daily investigations. Specific profiles of investigation should also be agreed with the laboratory for common emergencies, e.g. investigation of coagulopathy following massive transfusion. In order to standardise urine collections it is convenient to choose the start of the 'ICU day' and to begin this at either 07.00 or 08.00 related to the start of nursing shifts and the opening time of the pathology laboratory.

The arrangements for collecting, transmitting and reporting on laboratory samples must be fast, reliable and clearly understood. Laboratories should give appropriate priority to samples from ICUs.

Even when an ICU is situated adjacent to the main pathology laboratory, a unit should have its own laboratory for certain urgent estimations and near-patient investigations such as blood gas analysis, electrolytes, haematocrit and osmometry. If the laboratory is distant or off-site this need becomes essential. Any within-ICU laboratory must be subject to regular maintenance and quality control testing, preferably by the main pathology service. This may be carried out by the ICU staff under the supervision of the pathology service.

Microbiological investigations, frequency of samples, surveillance sampling should be agreed for routine patients and those with specific diagnoses, e.g. investigation of pneumonia in an immunocompromised patient.

Investigational policies should be agreed with consultants in, for example, laboratories and imaging departments.

#### **4.5 Infection Control**

With the concurrence of the consultant microbiologist and infection control team, infection control procedures should be agreed and enforced regarding:

- a) antibiotic policy
- b) clothing of staff and visitors
- c) hand washing
- d) sterilisation
- e) aseptic precautions for invasive procedures
- f) use of disposables
- g) filtering of patients' respired air
- h) changing of catheters, humidifiers, ventilator tubing and other equipment
- l) isolation of at-risk or infected patients
- j) cleaning of the unit

Where possible, policies should follow those laid down in hospital procedures (e.g. lumbar puncture, dressing of wounds and intravenous cannular sites). Many procedures are unique to ICUs, such as tracheal suction, care of vascular catheters and extracorporeal circuits, changing of oxygen masks, humidifiers and ventilator circuits. Local procedures should be agreed and documented.

Increasing use of disposable equipment leads to problems with disposal of clinical waste. Hospital incinerators may be reaching their maximum capacity, and local authority disposal systems may also be under pressure. Before the

introduction of additional use of disposables, the mechanisms for disposal should be discussed with the providers of local facilities.

In control of infection, discipline and behaviour is more important than design. Design should be such as to encourage discipline and appropriate behaviour: an absence of sinks will reduce the possibility of hand washing, but an abundance of sinks will not necessarily ensure that this behaviour is adopted.

In some hospitals, it may be appropriate to admit all patients to the ICU via an isolation cubicle until it has been determined whether they are colonised with methicillin-resistant *Staphylococcus aureus* (MRSA).

#### **4.6 Rounds, Staff Meetings and Teaching**

Regular unit rounds are recommended in the early morning and at midday or late afternoon to review progress and treatment. These will normally coincide with staff handover times. A minimum of two consultant rounds, by the consultant in clinical charge of the unit on that day, is necessary to provide adequate senior guidance, irrespective of specific calls to individual unstable patients. Ideally there should be a consultant handover round at the end of the normal working day if the day consultant is not clinically responsible for patient care during the ensuing night.

An evening round after the beginning of the nurse and medical trainee night shift is appropriate, particularly if patients are complex or unstable. The consultant(s), junior staff and senior nurse should be present. Members of admitting teams should attend at least the day time rounds to discuss the progress of their patients. Certain rounds may be designated teaching rounds and members of other departments and students should be encouraged to come to these.

There should be regular, preferably weekly, meetings and discussions amongst the medical, nursing and other professional staff associated with the unit to deal with:

a) management problems and policy in the day-to-day running of the unit

b) a review of cases and patient management, both within the unit and in conjunction with other departments

c) teaching sessions for nurses, doctors and students

d) business rounds (financial, planning etc) for senior medical, management and senior nursing staff. These should take place at least every two weeks. Senior trainee medical staff might usefully attend these meetings as observers, giving them an insight into the problems of running a resource limited service. Divisional meetings, with all interested parties, usually permanent staff, should occur at least every two months, although local views should take precedence.

## **4.7 Audit and Research**

Details of the numbers of cases treated, illness severity, age, outcome and treatments, must be recorded. The figures should be analysed at regular intervals both as an indication of therapeutic achievement and for administrative purposes. In-house audit must be a regular feature. Purchasers may require performance data. The College of Anaesthetists and the Intensive Care Society provide guidance for purchasers (Guidelines for Purchasers, RCA and ICS, 1994). The Intensive Care Society has provided details of the minimum data set necessary for audit (Intensive Care Audit, ICS 1990). Ideally units should subscribe to ICNARC in order to be able to relate their performance against a larger group of ICUs.

### **4.7.1 Individual Patient Records**

a) Patient charts, usually covering periods of 24 hours, provide a record of changes in physiological variables. Graphs may be designed to assist recognition of physiologically significant changes and assist with recording drugs administered, fluid balance, medical orders, laboratory results, other treatment given or important events, and severity and dependency scores.

Increasingly, automatic data collection and electronic display is taking the place of the paper record. Should this become normal practice, the means by which back-up records and hard copies are obtained, and the security aspects, must be agreed with the hospital information service.

b) Case summary sheets.

c) Medical notes.

d) Nursing Kardex or Care Plan. In some hospitals this paper record has been replaced by electronic records and electronic handover, although the latter will be unusual in the ICU with a 1:1 nurse patient ratio.

e) Radiographs are best kept in association with the viewing box.

These measures ensure that a complete record of the patient's information is available in one place. An alternative is to keep them in a mobile trolley. Electronic records are available in some hospitals. Adequate viewing terminals must be available in the ICU, with at least one in the each patient area and the main medical office.

### **4.7.2 Activity Data**

Units should keep clear records of their activity by collecting data on all admissions. The ICS is committed to data collection which, by the use of standardised rules and definitions, will allow audit of outcomes throughout the country (ICS UK APACHE II study, 1985). Each unit should use at least one method common to all patients.

Items recommended to be collected for the basic analysis of the work of an ICU have been listed previously (Intensive Care Audit, ICS, 1990). Data are

collected around the time of starting intensive care and are based upon the APACHE II and TISS methods.

Information is collected on:

- administrative details · admission details
- past medical history · physiological data
- treatment details · nursing details
- outcomes

The ICS Audit Document highlighted the importance of national audit, and made a number of suggestions for the future. These suggestions led to the formation of ICNARC in 1994, aided by a grant from the Department of Health and Welsh Health Common Services Authority.

### **ICNARC Case Mix Programme**

It is recognised that case mix adjustment is necessary to allow meaningful outcome comparisons. The ICS Audit document recommended collection of patient physiological data based on the APACHE-II for case mix adjustment. However, with this and other such methods, there are a number of problems with standardisation of data collection, especially of physiological data. Similarly, determining the reason for admission can be problematical since it is not always well described simply by the admission diagnosis.

These, and other, problems have been addressed during the development of the ICNARC Case Mix Programme, following experience gained from the ICS UK APACHE-II study. Since 1995, when the Case Mix Programme began, data on all admissions to participating units have been collected using standard rules and definitions. The ICNARC dataset is shown in Appendix 2.

Audit is an ongoing activity and must be sustainable. Dedicated staff are required to facilitate this. Help and advice on these matters is obtainable from ICNARC. Because of the need for standard definitions in all areas of data collection it is recommended by the ICS that all units register with the ICNARC Case Mix Programme. This will allow confidential, independent, objective audit of clinical practice, and meaningful assessment of outcomes. Units are encouraged to use the definitions in the ICNARC dataset, even if they do not subscribe to the rules and Case Mix Programme.

Case Mix adjusted outcomes also relate to issues of structure and process within units, e.g. does having a full-time director with sole responsibility for the unit affect patient outcome? Annual audit of the provision of intensive care services will be undertaken by ICNARC and commence in May 1997.

### **4.7.3 Clinical Research and Investigations**

Investigations for purposes of clinical research should be carefully assessed since patients in ICUs are unable to give informed consent.

The Intensive Care Society actively encourages research into management of patients requiring intensive care. Advice on grants and general organisation of research projects can be obtained from the Scientific Subcommittee.

## **OPERATIONAL RECOMMENDATIONS**

### **5. Management of equipment**

#### **Introduction**

This section attempts to provide guidance in an important but neglected field.

The sub-sections on selection, purchasing and replacement are based on HEI 98 (Management of Medical Equipment and Devices, 1990).

The sub-section on maintenance also includes elements of this document but is augmented by consideration of storage and sterilisation.

Some devices (e.g. infusion pumps) have enhanced requirements. New safety electrical safety rules are being introduced during 1998.

#### **5.1 Consumables**

These are considered separately, because although they are items of equipment, their management is different from that applied to re-useable items or single patient use items. They require no maintenance, but because of their bulk, may impose storage and disposal problems. It is possible to switch manufacturers at short notice, either to an improved design or to a cheaper version, so a policy of frequent review is needed. The advantages of bulk purchase with allied departments should always be considered because this not only reduces costs, and increases the rate at which newer designs can be brought into use, but also means that internal stock controls need not be as rigorous. Prevention of cross infection is absolutely fundamental to intensive care and the use of disposable equipment is one of the main factors involved. Guidelines for disposable and single patient use equipment have been published (The reuse of medical devices supplied for single use, Medical Devices Agency, MDA DB 9501, 1995).

A separate store is needed for consumables. This will need to be divided between an immediate store in the nursing area and back-up space in the main store. Stock control should be operated. A feature of ICUs is the very large number of special items which must be kept immediately available within the unit. It is seldom feasible to rely on a central hospital store for such items. Units may make specific arrangements with manufacturers for call-off orders, or regular small deliveries to reduce the total volume of stored disposables. Paragraph 1.4.4 discusses the problems of storage space in the ICU. Heavy disposables should not be stored on high shelves.

#### **5.2 Durable Equipment**

Management of durable equipment should follow HEI 98 (1990) Management of Equipment, which gives recommendations about all aspects of equipment management. Many of these concern the hospital or district rather than the individual unit. The following notes should be read in conjunction with this document. Faults on equipment (particularly alarms) require incident reporting. HSG (93)13 gives guidance on subsequent reporting. Medical Device reports go to the MDA Advice Incident Centre. Structural faults are reported to NHS Estates.

### **5.2.1 Selection** (see also 5.2.6, Replacement)

A continuously updated selection policy is recommended. Medical and nursing staff should review available equipment by assessing it in use, with a view to eventual purchase. This avoids ill-considered last minute selections. Business planning disciplines can be helpful in deciding types and quantities of equipment, recognising that much high value equipment will require 'single order tender' action. The cost and availability of spares, maintenance and essential disposables, should be considered during the purchasing work-up.

Where evaluation programmes have been carried out the results should be heeded, and where British Standards or equivalent exist the equipment selected should conform. Compatibility with existing equipment should be considered. Technical advice should be sought from the hospital electronic/medical engineers, who may be able to advise on performance and service. Methods of sterilisation must be compatible with existing hospital facilities. Manufacturers or their agents may need to be pressed on these points.

### **5.2.2 Purchasing**

The users should agree with the manufacturer or agent which items (e.g. in a modular system) will actually be required. The list should include all recommended spares, extra copies of instruction books and a stock of disposables if needed. A quotation should be obtained for the items on the list. In the case of electro-medical equipment the supplier is asked to complete a standard Pre-Purchase Questionnaire (PPQ) on the electrical safety of the item. Liaison with the medical engineering department (or equivalent) is a sensible precaution.

The order, which will normally be handled by a supplies officer, should define clearly which items are to be supplied, any commission or installation work required, acceptance procedure, delivery date and other conditions of supply. Any discount or trade-in should be agreed at this time. A copy should be sent to the intensive care consultant in charge.

Many hospitals and trusts have clearly defined routes for equipment purchase, aimed to limit or control unexpected revenue consequences of these capital purchases. They may require from the ICU a fee to cover such revenue consequences as service, repair and disposables if equipment is obtained directly from charitable sources. This levy may be as high as 50% of the purchase price, or at least 10% per annum of the capital cost. Before

equipment is accepted, it is usual for the medical engineering department to perform 'acceptance testing' (HEI 98, Code of Practice).

### **5.2.3 Storage** (see also 1.4.4 Storage)

A separate store is needed for hardware (ventilators, pumps etc) because of the need for servicing and testing. The store should have a bench, electrical sockets, medical gases outlets and a sink. For 'covers off' servicing, certain other equipment must be available, e.g. residual current device.

The walls of the store should be fitted with shelves capable of carrying weights at least 50kg per metre length, of 0.3m width. Wall rail should be fitted for storage of rail-mounted equipment. At least part of the wall area should be kept clear to a height of 1.5m to accommodate free standing items. Because of the large quantity of floor standing equipment used within the ICU (e.g. ventilators, drip stands, dialysis machines), this storage area must be of a considerable size (see 1.4.4). Lockable storage should be provided for small but valuable items, and for fibre-optic equipment. Disposables which are fitted by maintenance staff may also be stored here.

### **5.2.4 Servicing** (see also 1.4.17)

#### *a) User servicing*

This includes cleaning, inspection, functional safety checks and simple replacement of parts (e.g. ventilator tubing) by ICU staff. User servicing should be specified, ideally on the surface of the equipment, with full details on a user card or instruction book. An equipment log or fault card must be kept for all major items (e.g. ventilators, dialysers) to record faults, modifications and other aspects of its performance over time.

#### *b) In-house servicing*

This ranges from the limit of user servicing to full maintenance carried out by hospital instrument or EBME (Electro BioMedical Equipment) technicians. Typically it is performed by a technician who has been specifically trained to service the equipment. He/she in turn will usually be responsible for user training. An inventory of all ICU equipment must be maintained. Some may be subject to capital charges. A central record of all servicing, with dates, should also be kept.

#### *c) Manufacturer servicing*

This entails a contract with a manufacturer or agent to make periodic visits for routine service. It may be backed by an emergency call arrangement either with the same organisation or with in-house technicians. Manufacturers or their agents will usually provide training facilities for in-house technicians.

#### *d) Handover after servicing*

A certificate of serviceability which would act as, or may be combined with a user warning, should be signed by the technician who did the service.

### **5.2.5 Sterilisation** (see also 4.5 Infection Control)

a) Satisfactory methods of sterilising all non-disposable parts (which come into contact with patients) must be decided. If necessary the manufacturer's assurance must be sought about suitable techniques.

b) Sterilisation facilities must be provided either in a room in the unit or centrally within the hospital. Unit facilities should be adjacent to the dirty utility room (where decontamination is performed) and the equipment store (where items await re-use).

The use of glutaraldehyde will require installation of a fume cupboard (para 2.1.9, COSHH regulations). Staff working with glutaraldehyde require protective clothing and regular medical examination by the occupational health department. In the case of central sterilisation a system of identification of equipment must be employed, to prevent loss of rare and expensive items. It is preferable for packs to be made up in the unit, labelled and then sent for sterilising.

Decontamination of equipment is necessary to protect servicing departments (HN (87) 22)

### **5.2.6 Replacement**

A realistic policy for replacement should be formulated. Most large items will become worn out or obsolete within 10 years. The NHSE provides guidelines on the lifespan of equipment needed to assess capital charges. For instance, ventilators are considered to have zero value (i.e. should be replaced) after 8 years, while computers have zero value after 5 years. Parts may require earlier renewal or replacement by modified designs. Decisions about replacements should be made well in advance. It is recommended that a continuing policy of review of available equipment is followed. It will usually be necessary to emphasise these points to purchasers.

### **5.2.7 Training**

The Clothier report, published as a result of the Allitt enquiry into a number of unexpected patient deaths, requires that all staff who use equipment are trained in the use of the equipment and in the management of the common faults and problems occurring during its use, e.g. response to alarms (Report of the Independent inquiry relating to deaths and injuries on the children's ward at Grantham and Kesteven Hospital 1991, (the "Allit Inquiry") by Sir Cecil Clothier 1994).

This training and familiarisation applies to all staff (medical, nursing, professions allied to medicine, including medical engineering departments), who make use of equipment and is best conducted at the end of the tour of the ICU which new staff are required to undertake.

## **Appendix 1:**

### **General Intensive Care Services: Operational Policy**

#### **A Basis for the Organisation of an Operational Policy**

1. Purpose and Principles of Service
2. Functional unit
3. Workload
4. Planning Principles
  - (i) Nursing patients/Work production
  - (ii) Accommodation
  - (iii) Hospital adjacencies
  - (iv) Nursing patients/practices
  - (v) Staffing considerations
5. Workflow
6. Hospital Policies
  - (i) Catering
  - (ii) Dietician
  - (iii) Domestic services
  - (iv) Linen
  - (v) Pharmacy
  - (vi) Supplies - M & S Items (stock and non-stock)
  - (vii) Disposal
  - (viii) Portering
  - (ix) Equipment repair
  - (x) Safety equipment
  - (xi) Hospital storage area
  - (xii) Staff changing
  - (xiii) Delivery of information into department
7. Planning Solutions
  - (i) Communication routes

- (ii) Fire escape routes
- (iii) Isolation points - medical gases
- (iv) Control of infection
- (v) Compatibility of furnishings

#### 8. Environmental Services

- (i) Building
- (ii) Security
- (iii) Lighting
- (iv) Finishes
- (v) Sound transmission
- (vi) Other comments

#### 9. Engineering

- (i) Ventilation
- (ii) Hot & cold water supply
- (iii) Heating
- (iv) Drainage
- (v) Medical gases
- (vi) Antipollution
- (vii) Fire precautions
- (viii) Telephones/e-mail/fax
- (ix) Patient/Staff call system
- (x) Intercoms
- (xi) Alarm systems
- (xii) Radio & TV access
- (xiii) Electrical supply
- (xiv) Computer terminals/cabling
- (xv) Other services

## **Appendix 2: ICNARC dataset**

- Raw data are collected because this is simpler, avoids duplication, and is easier to validate.
- Data are collected from the time of physical admission to the ICU.
- All data collected must be documented in the permanent patient record.
- Although based on the APACHE II and PRISM methods, the ICNARC minimum dataset can be expanded to include the SAPS II, APACHE III, MPM II<sub>0</sub> and MPM II<sub>24</sub> methods. The ICNARC minimum dataset will change over time as new methods with greater validity, reliability and acceptability are developed and tested.
- The ICNARC Coding Method is used to code the reasons for a patient's admission for intensive care. The codes so produced are being mapped to the Read system.
- Since the Case Mix Programme is designed to ensure patient confidentiality, the minimum of demographic details are collected for the central returns to ICNARC. Recommended demographic details not included in the minimum dataset:

Patient	- Name, Address, Telephone number, Ethnic origin - District Health Authority
GP	- Name, Address, Telephone number
Hospital	- Hospital number, Referring Specialty

### **Overview of information collected**

- Admission details
- Past medical history
- Reason for admission
- Worst physiological data in first 24 hours  
(determined from collection of lowest and highest values)
- Other conditions
- ICU outcome
- Hospital outcome
- Full ICNARC dataset, as above but including other variables

**Admission details**

ICNARC number (Code number for participating unit)

Admission number (unit admission number)

Postcode

Date of birth

Sex

Date of admission to hospital

Date/time of admission to ICU

Date/time of start of care if managed by ICU team before admission

Planned admission to ICU

Admitted for pre-surgical preparation

Source of admission to ICU

Location immediately prior to source of admission to ICU

Theatre or Recovery same hospital

Classification of surgery - planned or emergency

X-ray, endoscopy suite, CT scanner or similar, same hospital

Ward, same hospital

A&E, same hospital

HDU or other intermediate care area, same hospital

ICU, same hospital

Date/time of original admission to ICU

ICU, other hospital

Date of original admission to hospital

Date/time of original admission to ICU

Other hospital (not ICU)

Date of original admission to hospital

Clinic or home

CPR within 24 hours prior to admission to ICU

## **Appendix 2: ICNARC dataset (continued)**

### **Past medical history**

Is there evidence available to assess past medical history

Past medical history present for:

Biopsy proven cirrhosis

Portal hypertension

Hepatic encephalopathy

Very severe cardiovascular disease

Severe respiratory disease

Home ventilation

Chronic renal replacement therapy

AIDS

Steroid treatment

Radiotherapy, chemotherapy, metastatic disease

ALL, AML, multiple myeloma, CLL, CML

Lymphoma

Congenital immunohumoral or cellular immune deficiency state

### **Reason for admission**

Primary reason for admission to ICU

Secondary reason for admission to ICU

### **Worst physiology data in first 24 hours**

(determined from collection of lowest and highest values)

Central and/or non-central temperatures

Blood pressures

Heart rates

Non-ventilated and/or ventilated respiratory rates

Arterial blood gas with lowest PaO<sub>2</sub>

## **Appendix 2: ICNARC dataset (continued)**

Intubated arterial blood gas with highest FiO<sub>2</sub>

Arterial pH/H<sup>+</sup>s

Serum bicarbonates, sodiums, potassiums

Serum creatinines

Urine output

Serum glucoses

Total serum bilirubins

Total and/or ionised serum calciums

Haemoglobins/haematocrits

White blood cell counts

Platelet counts

Prothrombin and/or partial thromboplastin times

Pupillary reactions

Sedated, or paralysed and sedated, for whole of first 24 hours

Expected neurological status

Glasgow Coma Score / Pre-sedation GCS

### **Other conditions**

Other condition relevant to this ICU admission - 1

Other condition relevant to this ICU admission – 2

ICU outcome

Ultimate primary reason for admission to ICU

ICU treatment withdrawn

Date/time of decision to withdraw treatment

Status at discharge from ICU

If alive, Date/time of discharge from ICU

If dead, was brainstem death declared

## **Appendix 2: ICNARC dataset** (continued)

If death outside ICU

Date/Time of death

Date/Time declared brainstem death

Date/Time body removed from ICU

Organ donor

Reason for discharge

Fully ready for non-ICU care

Discharge for palliative care

Early discharge due to shortage of ICU beds

Delayed discharge due to shortage of ward beds

ICU care continuing in another ICU

Self-discharge against medical advice

Destination following discharge from ICU

Other hospital (not ICU)

Other ICU, other hospital

Date/Status at ultimate discharge from ICU

Ward, same hospital

HDU or other intermediate care area, same hospital

ICU, same hospital

Date/Status at ultimate discharge from ICU

Normal residence

### **Hospital outcome**

Date/Status at discharge from hospital

If alive, destination following discharge from ICU

Another acute hospital

Hospice or equivalent

## **Appendix 2: ICNARC dataset** (continued)

Long-term institutional care

Rehabilitation unit

Normal residence

Date/Status at ultimate discharge from hospital

Full ICNARC dataset

As previously described but including the following variables:

For MPM II - admission model

Systolic blood pressure at admission to ICU

Heart rate at admission to ICU

Mechanical ventilation at admission to ICU

Coma or deep stupor at admission to ICU

Intracranial mass effect at admission to ICU

For APACHE III

Serum albumins

For SAPS II

CPAP administered during the first 24 hours in ICU

Serum urea

Surgery up to one week before and/or one week after admission to ICU

Classification of surgery up to one week before and/or one week after admission to ICU

For MPM II<sub>24</sub> - 24 hour model

Infection confirmed in the first 24 hours in the ICU

Continuous i.v. vasoactive drug treatment for one hour or more in the first 24 hours in the ICU

Coma or deep stupor at the 24 hour mark in the ICU

### **Outcomes**

A record should be kept of major complications of therapy and critical incidents which occur during the period of ICU care. Although information on

## Appendix 2: ICNARC dataset (**continued**)

health status and quality of life at 6 and 12 months after discharge is desirable, it is not considered feasible to collect this routinely. Ad hoc audits are planned within the Case Mix Programme, and a systematic review of outcomes following intensive care is to be commissioned by the NHS Research & Development National Health Technology Assessment programme in 1997.

Several other scoring systems are available for use in the ICU. Units are encouraged to use other methods to audit their performance, e.g. the use of TRISS for trauma patients in the National Major Trauma Outcome Study.

### **Treatment details**

A record of major therapeutic procedures/interventions should be maintained. This should include details of type of artificial airway, ventilatory support, cardiovascular monitoring and circulatory support, blood purification techniques, neurological monitoring and therapy, route of nutritional provision, need for cavity drains, sedative/analgesia regimens, and unusual or experimental therapies, e.g. nitric oxide. For some of these procedures/interventions, the total duration of use should also be recorded.

### **Nursing Details**

Data on the number of nurses, and a Nursing Dependency Score assigned to each patient on a daily basis, is recognised as being invaluable for logging the workload of the unit. A simple score has been proposed (Intensive Care Audit, ICS, 1990) ranging from 0 (staffed but empty bed) to 2 (ventilated patient requiring frequent interventions/on extracorporeal organ support).

Systems which focus on severity of illness, injury or medical interventions should not be used for scoring nursing dependency (Dependency Scoring Systems: Guidelines for Nurses, Royal College of Nursing, 1995). A number of systems for assessing nursing workload, e.g. the GRASP methodology, do not give a good index of nursing effort expended in the ICU environment. A Time Oriented Score System (TOSS), which has been developed in Italian ICUs, may give a better indication of nursing workload. The Therapeutic Intervention Scoring System (TISS), and its recent modification TISS 28, include nursing activity, but are not comprehensive enough to be used as a nursing dependency tool. TISS is currently being updated by an ICNARC Working Group, and should reflect ICU practice in the UK. This new System of Patient Related Activities (SOPRA) will include a large number of nursing related elements.

### **Cost**

It is recognised that defining a standard method by which to cost intensive care remains difficult. An ICNARC Working Group on Costings is currently addressing this problem.

## **Bed availability/Refusals/Transfers/Cancelled elective surgery**

To aid local planning, units are encouraged to maintain a register of bed availability on the ICU, and the reason for any bed spaces not in use. A record should be kept of patients referred to the ICU but for whom admission did not follow. This register should include as a minimum the patient's details, reason for referral, why admission did not take place, where and what further care was provided, and the eventual hospital outcome.

## **Augmented Care Periods (ACPs)**

Following the Data Set Change Notice (29/96/P24) issued in September 1996, it will be mandatory for each hospital from 1997 to record, and report centrally, the number of Augmented Care Periods within each patient's hospital stay. This will form a Critical Care Data Set within the Contract Minimum Data Set (CMDS) and Hospital Episode Statistics (HES).

Augmented Care Periods do not include:

- surgical and anaesthetic intra-operative care
- post-operative care within an operating department
- coronary care
- imaging procedures
- endoscopy procedures.

The location of care may not be the same as the type of care being delivered. Data collection will not include, at least initially, general wards, A&E, radiology departments, labour wards and special care baby units. ACPs are being incorporated into the ICNARC dataset.

## **References**

### **GENERAL**

Standards for Intensive Care Units. Intensive Care Society. 1984

Guidelines on Admission to and Discharge from Intensive Care and High Dependency Units. Department of Health. March 1996. HMSO

Report of the Working Group on Guidelines on Admission to and Discharge from Intensive Care and High Dependency Units. Department of Health. March 1996. HMSO

Guidelines for purchasers of intensive care. Royal College of Anaesthetists and The Intensive Care Society, 1994

Health Building Note 27: Intensive Therapy Unit. NHS Estates. 1992. HMSO (formerly Hospital Building Note 27). Department of Health and Social Security, 1974)

Guidelines for utilisation of intensive care units. European Society of Intensive Care Task Force. Intensive Care Medicine. 1994; 20: 163-164

Recommendations on minimal requirements for Intensive Care Departments. P Ferdinande. Members of the Task Force of the European Society of Intensive Care Medicine. Intensive Care Medicine 1997; 23: 226-232

International standards for safety in the intensive care unit. International task force on safety in the intensive care unit. Intensive Care and Critical Digest. 1990; 12: 55-57

Recommendations for critical care unit design. Task Force on Guidelines. Society of Critical Care Medicine. Critical Care Medicine. 1988; 16: 796-806

Recommendations for intensive care unit admission and discharge criteria. Task Force on Guidelines. Society of Critical Care Medicine. Critical Care Medicine. 1988; 16: 807-810

Guidelines for categorisation of services for critically ill patients. Task Force on Guidelines. Society of Critical Care Medicine. Critical Care Medicine. 1991; 19: 279-288

Recommendations for services and personnel for delivery of care in a critical care setting, Task Force on Guidelines. Society of Critical Care Medicine. Critical Care Medicine. 1988; 16: 809-810

Application for Recognition for Training for Intensive Care Medicine. Intercollegiate Board of Intensive Care Medicine, Royal College of Anaesthetists. 1996

Care of the Critically Ill Child. British Paediatric Association. 1993

Standards for Paediatric Intensive Care. British Paediatric Society. 1996

Paediatric Intensive Care. Report from the Chief Executive of the NHS Executive to the Secretary of State. March 1996. HMSO

Intensive Care services in the Northern Region. Report of a Working Party of the Northern Regional Health Authority. 1993

The Intensive Care Service in the UK. Intensive Care Society. 1990

Intensive Care Audit. Intensive Care Society, 1990

Intensive Care Services - provision for the future. Association of Anaesthetists of Great Britain and Ireland. 1988

## NOISE

US Environmental Protection Agency 1974. Report No. 550-9-74-004.

Washington. DC,

Noise in the Intensive Care Unit. Balogh D, Kittinger E, Benzer A, Hackl JM. Intensive Care Medicine. 1993; 19: 343-346,

Noise pollution in the anaesthetic and intensive care environment. Kam PCA, Kam AC, Thompson JF. *Anaesthesia*. 1994; 49: 982-986

## FIRE

Hospital Technical Memorandum (HTM) 81. Firecode: precautions in new hospitals. NHS Estates. 1987. HMSO

Hospital Technical Memorandum (HTM) 82. Firecode: alarm and detection systems. NHS Estates. 1989. HMSO

Hospital Technical Memorandum (HTM) 83. Fire safety in healthcare premises. General fire precautions. NHS Estates. 1994. HMSO

Hospital Technical Memorandum (HTM) 85. Firecode: fire precautions in existing hospital. NHS Estates. 1994. HMSO

Hospital Technical Memorandum (HTM) 87. Firecode: textiles and furniture. NHS Estates. 1993. HMSO

Fire safety in the Intensive Care Unit. Intensive Care Society. 1991

## MEDICAL GAS PIPELINES

Health Technical Memorandum (HTM) 2022. Medical gas pipeline systems. Section (b). Design considerations. NHS Estates. HMSO

Note:

HTM 2022 has 4 other sections: (a) legal aspects, (c) validation and verification, (d) operational management and (e) good practice.

## VENTILATION

Health Technical Memorandum (HTM) 2025. Ventilation in healthcare premises. NHS Estates. 1994. HMSO

## ELECTRICAL SYSTEMS

Health Technical Memorandum (HTM) 2011, Emergency electrical services. NHS Estates. 1993. HMSO

NOTE: There are 4 parts to HTM 2011:

- i) Design considerations
- ii) Management policy
- iii) Operational management
- iv) Validation and verification

IEE Regulations for Electrical Installations. Institute of Electrical Engineers. 16th Edition (1991) (and amendments).

BS 5742 (Parts 1 and 2).

## LIGHTING

Health Technical Memorandum (HTM) 1022. Lighting. NHS Estates. 1992. HMSO

CIBSE Lighting Guide. No 12: Hospitals and Health Care Buildings

BS 5266 Part 1 "Emergency Lighting"

## CONSULTANTS' WORKING CONDITIONS

Association of Anaesthetists of Great Britain and Ireland 1993

## PHYSICIAN TRAINING

Training in critical care medicine. Guidelines/Practice parameters committee, Society of Critical Care Medicine. *Critical Care Medicine*. 1995; 23: 1920-1923

Guidelines for training in intensive care medicine. European Society of Intensive Care Medicine. *Intensive Care Medicine*. 1994; 20: 80-83

Guidelines for granting privileges for the performance of procedures in critically ill patients. Task Force on Guidelines. Society of Critical Care Medicine. *Critical Care Medicine*. 1993; 21: 292-293

Guidelines for a training program in intensive care medicine. European Society of Intensive Care Medicine. *Intensive Care Medicine*. 1996; 22: 166

A guide for trainers. Intercollegiate board on training for intensive care medicine. 1997 (in press)

## ADMINISTRATION AND PATIENT OUTCOME

Zimmerman JE, Shortell SM, Rousseau DM et al. Improving intensive care: observations based on organisation case studies in nine intensive care units: a prospective multicenter trial. *Critical Care Medicine*. 1993; 21: 1443-1451

Knaus WA, Draper ED, Wagner DP et al. An evaluation of outcome from intensive care in major medical centers. *Annals of Internal Medicine*. 1986; 104: 410-418

## MANAGEMENT OF EQUIPMENT

Health Equipment Information. 98. Management of Medical Equipment and Devices. 1990. HMSO

The reuse of medical devices supplied for single use only. Medical Devices Agency, MDA DB 9501, 1995. HMSO

## GENERAL TRAINING

Report of the independent inquiry relating to deaths and injuries on the children's ward at Grantham and Kesteven Hospital 1991. The "Allit Inquiry". Sir Cecil Clothier. 1994

Doing no harm. Medical Devices Directorate, 1994.