

Critical care organisation and management

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Critical Care Unit layout

The Critical Care Unit should be easily accessible by departments from which patients are admitted and close to departments which share engineering services. In a new hospital, all critical care facilities should ideally be proximal to operating theatres, emergency department, laboratories, and imaging suites.

It is desirable that critically ill patients are separated from those in the recovery phase or needing coronary care where a quieter environment is needed. Providing intensive care and high dependency care in the same Critical Care Unit allows flexibility of staffing, although the differing requirements of these patients may limit such flexibility.

Size of unit

Requirements depend on the activity of the hospital with additional beds required for regional specialties such as cardiothoracic surgery or neurosurgery. Very small (<6 beds) or very large (>14 beds) units may be difficult to manage, although larger units may be divided operationally and allow better concentration of resources.

Patient areas

- Patient areas must provide unobstructed passage around the bed with a floor space of 26m² per bed and bed centres of at least 4.6m. Curtains or screens are required for privacy.
- Floors and ceilings must be constructed to support heavy equipment (some may weigh >1000kg).
- Doors must allow for passage of bulky equipment as well as wide beds.
- A wash hand basin with elbow-operated or proximity-operated mixer taps, soap, and antiseptic dispensers should be close to every bedspace.
- The specification should include 50% of beds as isolation cubicles. Air pressure control in cubicles should ensure effective patient isolation.
- Services must include adequate electricity supply (at least 28 sockets per bed) with an uninterruptable power supply for essential equipment. Oxygen (4), medical air (2), and high (2) and low (2) pressure suction outlets must be available for every bed.
- The bed areas should have natural daylight and patients and staff should ideally have an outside view.
- Communications systems include an adequate number of telephones, intercom systems to allow bed-to-bed communication, and a system to control entry to the department.
- Computer networks should enable communication with central hospital administration, laboratory and radiology systems, and the internet.

Other areas required

Other areas include adequate storage space, separate clean-treatment and dirty utility/sluice areas, offices, laboratory, seminar room, cleaners' room, staff rest room, staff change and locker room, toilets and shower facilities, relatives' area including a quiet area for grieving family, and an interview room.

See also:

Infection control—general principles, p544.

Critical Care Unit staffing (medical)

Critical care has evolved from its early success in simple mechanical ventilation of the lungs of polio victims to the present day where patients usually have, or are at risk of developing, failure or dysfunction of one or more organ systems requiring mechanical and pharmacological support and monitoring. The unit should have dedicated consultant sessions allocated for direct patient care with additional sessions for management, teaching, and audit activities. These sessions should be divided between several critical care-trained specialists who should be supported by trainee doctors providing round-the-clock cover on a rota which provides adequate rest.

Required skills of critical care medical staff

Management

Senior medical staff, assisted by senior nursing and pharmacy colleagues, command the primary responsibility for the structural and financial management of the unit. It is through their actions that treatment of the critically ill is initiated and perpetuated; they are ultimately responsible for the activity of the unit and patient outcome.

Decision-making

In the Critical Care Unit, most decisions are made by team consensus. Clinical decisions fall under three categories: (i) decisions relating to common or routine problems for which a unit policy exists; (ii) decisions relating to uncommon problems requiring discussion with all currently involved staff, and (iii) decisions of an urgent nature taken by critical care staff without delay.

Practical skills

Expertise in the management of complex equipment, monitoring procedures and performance of invasive procedures are required.

Clinical experience

Medical staff require experience in the recognition, prevention and management of critical illness, infection control, anaesthesia, analgesia, and organ support.

Technical knowledge

The critical care specialist has an important role in the choice of equipment used in the unit. Advice should be sought from non-medical colleagues.

Pharmacological knowledge

Drug therapy regimens are clearly open to the problems of drug interactions, while pharmacokinetics are often severely altered by the effects of major organ system dysfunction, particularly involving the liver and kidneys. Adverse reactions are common.

Teaching and training

The modern critical care specialist has acquired skills that cannot be gained outside the Critical Care Unit. Therefore, it is necessary to impart this knowledge to doctors training in the specialty.



Critical Care Unit staffing (nursing)

Critically ill patients require close nursing supervision. Many will require high-intensity nursing throughout a 24h period while others are of a lower dependency and can share nurses. In addition to the bedside nurses, the department needs additional staff to manage the day-to-day running of the unit, to assist in lifting and handling of patients, to relieve bedside nurses for rest periods, and to collect drugs and equipment. These additional nurses (or nurse assistants) can be termed the 'fixed nursing establishment' and the nature of their duties is such that they will usually include the higher grade nurses. The bedside nurses are a 'variable establishment' and their numbers are dependent on activity such that more patients require higher numbers. Most departments fix part of their variable establishment by assuming an average activity.

Fixed establishment

Providing one nurse per shift requires a rota of 5.5 nurses. In addition, staff handover, annual leave, study leave, and sickness are usually calculated at 22% such that one additional nurse is required. Thus, the provision of one nurse in charge of each shift and one nurse to support the bedside nurses requires 11 nurses in those two roles alone. In larger units, there may be a need for additional nurses supporting the nurse in charge.

Variable establishment

The same principles apply for the provision of bedside nurses. Thus, to provide 1:1 nursing for a bed requires 5.5 nurses and to provide 1:2 nursing requires 2.75 nurses. The total number required depends on the occupancy and the nurse-to-patient ratio for each occupied bed. One of the difficulties in staffing a Critical Care Unit relates to the variable dependency and occupancy. An average dependency weighted occupancy (average occupancy \times average nurse-to-patient ratio) should be used to set the establishment of bedside nurses with additional nurses being drafted in from a bank or agency to cover peak demands.

Skill mix

Nursing skill mix is the subject of much controversy as the need for economy is balanced against the need for quality. As stated above, the fixed nursing will usually be of higher grade since the role incorporates the administration of the unit and supervisory nursing. The bedside nurses will be made up of those who have received post-qualification training in critical care and those who have not. The ratio of trained to untrained critical care nurses should be of the order of 3:1 to facilitate in-service teaching.



Outreach support

Critical care outreach aims to augment the effectiveness of Critical Care Units by utilising their expertise at all stages in the evolution of critical illness. Outreach teams typically support patient care outside the Critical Care Unit to prevent admission or readmission. However, the outreach team will also expedite timely admission to a Critical Care Unit for those that need it. Outreach teams work in collaboration with staff in general ward areas and should be utilised following the identification of a deterioration in the patient's condition to provide advice, support, education, and a link to the critical care facility. Many outreach teams in the UK are developed around critical care nurses, but they also depend on support from critical care medical staff and other members of the multidisciplinary critical care team such as physiotherapists. In other countries such as Australia, the model of a medical emergency team, staffed by intensivists or trainees, is more commonplace.

The outreach team should support and facilitate the ability of ward staff to:

- Identify patients who are at risk of developing life-threatening acute illness. Patients suffering cardiorespiratory arrest in hospital usually show gradual deterioration over several hours (especially in conscious level and respiratory rate) rather than an abrupt collapse.
- Initiate immediate resuscitation.
- Make appropriate referral, documentation, and communication.
- Provide psychological support and physiological surveillance to patients after discharge from the Critical Care Unit.
- Educate and train general ward staff in the identification of deteriorating vital signs, the use of appropriate early warning scoring systems, and the institution of appropriate management.
- Though no study has specifically shown mortality reduction through the use of outreach or medical emergency team, ward staff and patients greatly value their support. The outreach teams can prompt decisions regarding resuscitation status and this has led to a reduction in inappropriate cardiac arrest calls.

Outreach team calling criteria

These are usually defined locally based on breaching limits of vital signs.

Early warning scoring systems

Simple risk assessment tools are available to aid the identification of patients at risk of deterioration. These are based on weighted scores given to routinely available vital sign data.

Typical outreach calling criteria

- Respiratory rate >25 or <8/min.
- Oxygen saturation <90% on $\text{FIO}_2 >0.35$.
- Heart rate >125 or <50 beats/min.
- Systolic blood pressure <90 or >200mmHg, or a sustained fall of >40mmHg from the patient's normal value.
- Sustained alteration in conscious level.
- Patient looks unwell or you are worried about their condition.

Early warning scoring system

	3	2	1	0	1	2	3
HR		<40	41–50	51–100	101–110	111–129	≥130
BP	<70	71–80	81–100	101–199		>200	
RR		≤8	9–14		15–20	21–29	≥30
Temp		<35.0		35.0–38.4		≥38.5	
CNS				A	V	P	U

A = alert; V = responds to voice; P = responds to pain; U = unconscious.

Key paper

Morgan RJM, Williams F, Wright MM (1997). An early warning scoring system for detecting developing critical illness. *Clin Intensive Care* 8: 100.

See also:

Survivor follow-up, p12; Communication, p18.

Critical Care Unit admission criteria

The Critical Care Unit should be seen as the hub of critical care provision throughout the hospital. In the UK, critical illness is now defined according to patient dependency levels (see table opposite), ranging from those suitable for ward care through to true intensive care requirement. Thus, admission to the Critical Care Unit is not necessary for all of those with a critical illness, particularly where a well-functioning outreach team can support care in the general ward environment. While dependency levels do not necessarily define the need for admission to a Critical Care Unit, it is generally those requiring level 2 or 3 care who are considered for admission.

Admission criteria may be set on a priority basis related to patient dependency levels, their specific diagnosis, physiological or biochemical abnormalities, or investigational findings.

Local policies for critical care admission should:

- Identify who has day-to-day responsibility to make admission decisions.
- Include a mechanism for reviewing difficult cases and difficult ethical decisions.
- Identify those who are too well or too sick to benefit from critical care admission (in the context of other facilities available locally).
- Identify priorities for admission during times of high utilisation of beds, e.g. level 3 patients admitted as a higher priority than level 2.
- Identify when, who, and how to transfer patients to other units.
- Identify categories of patients who should or should not be admitted to Critical Care Units, including conditions where admission is mandatory.
- Identify any age criteria below which admission is precluded.
- Clarify the links with local incident management policies, contingency plans, and triggers for the implementation of these plans.

A critical care consultant should consider the nature and severity of the patient's illness, the potential reversibility of their condition, the long- and short-term probability of survival, and the wishes of the patient when deciding on Critical Care Unit admission.

Although patients with 'do not attempt resuscitation' orders or terminal illness for palliative care may fit the criteria for level 2 or 3 care, a clear assessment needs to be made on how they would benefit from admission. Admission may be justified if there is benefit to the patient in terms of avoiding cardiac arrest or better provision of palliation. However, many such patients will clearly not benefit from admission to the Critical Care Unit or from continuation of treatment once admitted. Management of such patients can be difficult. Local guidance needs to ensure decisions are reviewed regularly. Mechanisms to share decision-making between several senior members of the team (sometimes with senior staff uninformed with the patient's care) should be in place given the potential of legal challenge of clinical decisions.

Critical care levels of dependency

Level 0

Patients are appropriately cared for in ordinary hospital wards such as are available in all acute hospitals and all general departments of surgery and medicine. Patients may need administration of medication, patient-controlled analgesia, intravenous maintenance fluids, blood transfusion, and other simple treatments. Observations would usually be required less frequently than every four hours.

Level 1

Patients are at risk of their condition deteriorating, e.g. recently relocated from higher levels of care, requiring additional monitoring or input from staff with specific expertise. In addition to level 0 requirements, patients may need administration of intravenous fluids at rates in excess of 3,000mL/d, and regular but infrequent tracheal suction via a tracheostomy. Observations would be required at least every four hours.

Level 2

Patients require single-organ monitoring and support, e.g. inotropic support for the cardiovascular system, renal replacement therapy or non-invasive ventilatory support, patients with major uncorrected physiological abnormalities, patients classified as American Society of Anaesthesiologists' 3 or 4 following minor or major surgery, patients requiring preoperative optimisation but not requiring post-operative ventilation. In addition to level 1 requirements, patients may need frequent tracheal suction via a tracheostomy tube or rapid blood transfusion (perhaps up to six units in 24h).

Level 3

Patients require advanced respiratory monitoring or support, or monitoring and support for two or more organ systems (or one organ system with chronic impairment of at least one other).

Survivor follow-up

Recovery from a critical illness continues for a prolonged period after discharge from hospital, particularly after a severe critical illness involving a long stay. Mortality after hospital discharge is up to three times higher than that of the general population for two to three years after hospital discharge. Patients often experience a variety of physical and psychological symptoms after prolonged critical illness (see table opposite). If not recognised as a sequel to critical illness, this can lead to unnecessary treatment and investigation, contributing further to their morbidity.

Many hospitals are now running critical care follow-up clinics to provide multidisciplinary support to patients after critical illness. These clinics allow patients to gain an understanding of their illness. There are usually gaps in the patient's recollection of events. They may suffer hallucinations or delusions, or misinterpret events they have patchy knowledge of. This can lead to frustration and anger. Explanations to complete their knowledge are very helpful in helping patients come to terms with what happened to them and this is usually reassuring. Provision of information that helps the patient understand a realistic timeframe for their recovery overcomes any unrealistic expectations they may harbor.

The whole family dynamic often changes as a result of a critical illness. Close family members experience anxiety and depression during the critical illness. This changes to a state of overprotection after the illness which can often be frustrating for the patient.

A follow-up clinic also gives an opportunity for patients and relatives to provide feedback on areas of care that could be improved to the benefit of subsequent patients.

Typical problems post-critical care discharge

Weakness	Stress
Weight loss	Irritability
Fatigue	Depression
Poor appetite and taste changes	Anxiety
Voice changes	Amenorrhoea
Insomnia	Lack of confidence
Skin and nail changes	Guilt
Itching	Poor concentration
Hair loss	Poor memory
Painful joints	Social isolation
Peripheral neuropathy	Sexual problems (Impotence/libido)

See also:

Outreach support, p8.

Patient safety

The nature of critical illness makes patients particularly vulnerable. They often cannot communicate or react normally to protect themselves. Normal defence mechanisms are breached by various tubes and catheters, increasing the risk of infection. Complex drug treatment regimens increase the risk of adverse reactions. Immobility increases the risk of muscle wasting or thromboembolism. It can be unclear whether deterioration in a patient's condition is a result of the disease or the treatment.

Protection in a complex environment

The critical care team must deal with an increasing array of data on multiple organ systems, support devices, monitors, treatment, and evidence on which to make decisions. Without some decision support aids, it is easy to miss some issues, with patient harm as a possible consequence. Decision support in its simplest form includes aide memoires to remind the team of what they should be doing. The Fast Hug mnemonic described in the table opposite is one such tool to ensure some of the basics of critical care are not forgotten. Other aides include communication sheets and structured record systems.

One of the most common causes of treatment error relates to drug prescription and administration. Electronic prescribing from templates will reduce errors associated with poor handwriting but these are not foolproof.

Learning from mistakes

Learning from mistakes is fundamental to the improvement of patient safety. Incident reporting systems are now widespread amongst Critical Care Units to:

- Ensure action is taken to prevent similar incidents in the future.
- Fulfill legal duties to report certain kinds of accident, violent incidents, dangerous occurrences, and occupational ill health.
- Ensure accurate information is collected to identify trends and take steps to prevent similar incidents from re-occurring.
- Provide evidence in pursuance of litigation claims, both for and against the hospital.
- Record incidents of particular interest for quality assurance, including the ability to demonstrate accident reductions, as part of a risk management strategy.

It is essential that confidentiality is maintained and disciplinary action avoided, except where acts or omissions are malicious, criminal, or constitute gross or repeated misconduct.

Deliberate harm

Because critically ill patients are vulnerable, the possibility of deliberate harm should be borne in mind. In order to protect patients, staff must undergo pre-employment health and criminal records' checks. Staff must be vigilant to ensure visitors are left with no opportunity to harm the patients. There must be clear record keeping and review by all members of the multidisciplinary critical care team to ensure unexpected changes in condition are recognised. Because deliberate harm is uncommon, recognition requires a high index of suspicion.

Fast Hug

Feeding	Oral or enteral preferred to parenteral
Analgesia	The minimum amount to avoid pain
Sedation	The minimum amount to achieve a calm patient
Thromboprophylaxis	Low molecular weight heparin
Head of bed elevated	30° head up if not contraindicated
Ulcer prophylaxis	In patients in whom evidence of benefit
Glucose control	Tight glycaemic control protocol

Key paper

Vincent JL. Give your patient a fast hug (at least) once a day (2005). *Crit Care Med* 33: 1225–9.

See also:

Fire safety, p16; Clinical governance, p22; Infection control—general principles, p544; Infection control—dangerous pathogens, p548.

Fire safety

Fires affecting the Critical Care Unit are rare but are particularly difficult in that patients are not easily evacuated; yet their lives depend on services which fire may disrupt. Smoke, while dangerous to staff and the less sick patient who may be breathing spontaneously, is less of a problem to those receiving mechanical ventilation since their fresh gas supply is from outside the affected environment. Therefore, it follows that in the event of fire, the priority is to ensure safety and means of escape for the staff first.

Control of smoke

Smoke and toxic gases are a common association with fire and may, in themselves, be flammable, particularly in association with high concentrations of oxygen. The main techniques for control of smoke include containment (e.g. fire-resisting walls, doors, and seals) and dispersal (e.g. positive pressure air supply), the latter being used in patient areas. The possibility of flammable or toxic fumes should be considered when equipping and furnishing the Critical Care Unit.

Escape from fire

- Escape routes should be well marked and unobstructed.
- The nature of critical illness is such that not all patients can be evacuated.
- The staff should escape first by proceeding to the nearest exit away from the fire.
- Patients should be evacuated in the order of the least sick first.
- Evacuation of patients should be managed by someone trained in the use of breathing apparatus; in most cases, this will be the fire brigade.
- If patients are to be evacuated, they should be moved to a place of safety on the same floor as the Critical Care Unit. Patients should not be moved downstairs (or lifts used) unless first approved by a Fire Officer.
- In the majority of fires, containment will reduce the need for full evacuation.

Preventing fire

- Automatic smoke or heat alarms should be provided in all areas.
- Cooking areas and laboratory areas must be separated from patient areas by fire doors.
- Fire doors are provided to protect staff and patients, and should not be wedged open.
- If a closed door would compromise the care given to patients but is essential to separate fire compartments, then an electro-mechanical device should hold the door open and be disabled by the fire alarm.
- Fire extinguishers and blankets of the appropriate types should be readily available and staff should be properly trained in their use.



Communication

Good communication is essential to the smooth running of the Critical Care Unit. This includes communication between staff, patient, visiting professionals, and relatives.

Patient communication

Critically ill patients may still be able to hear bedside conversations despite sedation or apparent unconsciousness. All procedures should be explained to the patient in simple terms before starting, even if they appear to be unconscious. The patient who is not competent to consent to treatment may still appreciate verbal discussion or explanation.

Multidisciplinary team communication

The multidisciplinary approach to critical care involves medical and non-medical staff in decision-making. Ward rounds are a forum for such interdisciplinary communication, and the specialist leading the round should ensure all present are both truly involved and understand the day's plan. The plan for the day is more likely to succeed if those effecting the plan are involved in setting it. All changes from the plan, whether due to unforeseen emergencies or failure of the patient to respond, should be fully discussed and documented.

Communication with visiting teams

The critical care staff should be responsible for the day-to-day care of critically ill patients, including coordinating the input from various non-Critical Care Unit professionals. The admitting team should be involved in major strategy decisions and should be accompanied to the bedside or relatives' area by a member of the critical care medical staff. They should be encouraged to write a clear note of their thoughts and proposed management plans in the patient records.

Communication with relatives

Relatives are often overwhelmed by the environment of a Critical Care Unit, are worried about the patient, and are easily confused by the information given. Most communication should be face to face, avoiding lengthy discussions on the telephone. Where several people are imparting information, differences in emphasis or content serve to confuse.

- All communication with relatives should be fully documented.
- It is essential the bedside nurse is present when relatives are spoken to since there are often questions and concerns which crop up later that may be directed to that nurse. Relatives have greater contact with the nurses and often build up a relationship with them.
- Where admitting teams need to communicate with relatives about a specific aspect of the illness, the bedside nurse and, ideally, a member of the Critical Care Unit medical staff, should be present.
- Most interviews with relatives should be away from the bedside although it is often helpful to impart simple information at the bedside, particularly to demonstrate particular issues. Again, it must be remembered that the patient may hear the conversation.
- While it is preferable to interview all relatives together, this is not always practical. Information changes when delivered second-hand so it may be better to communicate directly with various relatives separately in these circumstances.

Key paper

Pronovost P, Berenholtz S, Dorman T, et al. (2003) Improving communication in the ICU using daily goals. *J Crit Care* **18**: 71–5.

Medicolegal aspects

The Critical Care Unit is a source of many medicolegal problems. Patients are often not competent to consent to treatment. They may be admitted following trauma, violence, or poisoning, all of which may involve a legal process. Admission may also follow complications of treatment or medical mishaps occurring elsewhere in the hospital. The nature of critical illness is such that complications are common and litigation may follow.

Consent and agreement

Many procedures in critical care are invasive or involve significant risk. The patient is often not competent to consent for such treatment and, in many countries, surrogate consent or assent cannot be legally given by the next of kin. Nevertheless, it is important that the risks and benefits of any major or risky procedure are explained to the next of kin and that this discussion is documented in the case records. For major decisions, particularly those involving withdrawal or withholding of life-prolonging treatments, the patient should ideally be involved in discussions. If not feasible, relatives should be asked to give their view of what the patient would want in this situation although their views should not necessarily dictate decisions, responsibility for which lies with medical staff.

Research presents consent problems in the critically ill and requires close ethical committee supervision.

Note-keeping

It is impossible to record everything that happens in critical care in the patients' notes. The 24h observation chart provides the most detailed record of what has happened but summary notes are essential. Such notes must be factual without unsubstantiated opinions about the patient or about previous treatment. All entries must be timed and signed. Records of ward rounds must include the name of the consultant leading the round. These notes may be used later in legal proceedings; they may be used against you but, if well kept, will usually form the best defence.

Errors and mishaps

In the event of an error or mishap, the episode should be clearly documented after witnessed explanation to the patient and/or relatives. An apology is not an admission of liability but is usually much appreciated, as is explanation in an open and transparent manner.

Dealing with the police

Most police enquiries relate to patients who are admitted after suspicious circumstances. While there is a duty to maintain patient confidentiality, it may be in the patient's interests to impart information about them. This may be with the consent of the patient or the next of kin. Written statements or verbal information may be requested. Any information given should be strictly factual, avoiding opinion.

Dealing with the Coroner

The Coroner must be informed of any death where a death certificate cannot be issued. Death certificates can be issued where the death is due to a natural cause and the patient has been seen professionally by the doctor within 14 days prior to death. The table opposite documents the conditions requiring the Coroner to be informed. Where there is any doubt, the Coroner should be consulted.

Deaths which must be notified to HM Coroner in the UK

No doctor attending within prior 14 days

Death without recovery from anaesthesia

Suicide

Sudden or unexplained death

Medical mishap

Industrial accident or disease or related to employment

Violence, accident, or misadventure

Suspicious circumstances

Alcoholism

Poisoning

Death in custody or shortly after detention

Clinical governance

Clinical governance is a framework through which health care organisations are accountable for continuously improving the quality of their services and safeguarding high standards of care by creating an environment in which excellence in clinical care will flourish. For critical care, clinical governance requires the culture, systems, and support mechanisms to achieve good clinical performance and ensure quality improvement is embedded into the unit's routine. This includes action to ensure risks are managed, adverse effects are rapidly detected, openly investigated, and lessons learned, that good practice is rapidly disseminated and that systems are in place to ensure continuous improvements in clinical care. There must be systems to ensure all clinicians have the right education, training, skills, and competencies to deliver the care needed by patients. There must also be systems in place to recognise and act on poor performance.

The Critical Care Unit interfaces with most of the rest of the hospital and its clinical governance arrangements must contribute to patient care throughout the hospital. Some aspects of critical illness are managed outside the Critical Care Unit, yet the critical care team retains responsibility for ensuring quality and safety of this care.

Essential components of clinical governance

Clear management arrangements

Everyone must know who they are accountable to, the limits of their decision-making, and who must be informed in the decision-making process.

Quality improvement

Through the process of clinical audit, the standard of practice is monitored and changes effected to improve quality.

Clinical effectiveness

Evidence-based practice is essential where sound evidence exists to support clinical decisions. Protocols and guidelines standardise practice.

Risk assessment and management

A register of clinical risks should be kept, to which new risks are appended as they are assessed. An action plan should be developed for managing each risk and its implementation monitored.

Staff and organisational development

Including continued professional education, clinical supervision, and professional regulation.

Patient input

Complaints monitoring should be used to learn lessons and improve practice within Intensive Care Unit (ICU). Patients' and relatives' suggestions and surveys can be used to adapt quality initiatives to the needs of patients.

See also:

Audit, p24.

Audit

Audit has become an essential part of medical practice. The main purpose is to improve quality of care. In the Critical Care Unit, this should involve all members of the multidisciplinary team. Change in practice in one discipline will inevitably have a knock-on effect in others. Audit may involve a review of activity, performance against pre-determined indicators or cost-effectiveness. Audit may focus on specific topics or may encompass the performance of several Critical Care Units. A successful audit requires commitment from senior staff to ensure practice is defined, data are collected, and change is effected where necessary. Where change is suggested by audit, a further review is required to ensure that such change has occurred.

Data collection

Ideally, a basic dataset should be common to all Critical Care Units nationally to allow meaningful comparisons to be made. This requires a dataset detailed enough to answer questions posed, but not so detailed that collection becomes unsustainable. Resources must be provided in terms of computer databases and staff to collect and analyse data. This is a skilled task that should not be delegated to junior team members. The data collector should be familiar with the fundamentals of critical care medicine, and be provided with regular summary reviews to ensure enthusiasm continues and quality control is maintained. Methods of data entry should consider the time involved and that most of those collecting data are not keyboard experts. Typographical mistakes destroy the value of collected data so error trapping and data validation must form part of the housekeeping in any database used. Some audit topics require data collection outside the basic dataset. Collecting appropriate data requires clarity in setting the question to be answered and care in choosing data items that will truly answer the question.

Audit meetings

Regular audit meetings should follow a pre-defined timetable. This helps to ensure maximum staff attendance and also sets target dates for data collection and analysis. Audit meetings should be chaired and have defined aims. Discussion of the topic being audited must lead to recommended changes in practice and these must be followed through after the meeting. It is clear that all staff cannot attend all meetings. Dissemination of information prior to implementing proposed changes is necessary to stand some chance of carrying them through.

See also:

Clinical governance, p22.

Critical care scoring systems

Various critical care scoring systems have evolved to provide:

- An index of disease severity, e.g. APACHE, SAPS.
- An index of workload and consumption of resources, e.g. TISS.
- A means of comparison for:
 - auditing performance—either in the same unit or between units.
 - research, e.g. evaluating new products or treatment regimens.
 - patient management objectives, e.g. sedation, pressure area care.

The Glasgow coma scale apart, no scoring system is practised universally. APACHE is the predominant severity score used in the USA and UK while SAPS is more popular in mainland Europe. Inter-user interpretation of the same scoring system can be highly variable.

TISS (Therapeutic intervention scoring system)

- A score is given to procedures and techniques performed on an individual patient (e.g. use and number of vasoactive drug infusions, renal replacement therapy, administering enteral nutrition).
- Some units use TISS to cost individual patients by attaching a monetary value to each TISS point scored.
- It can be used as an index of workload activity.
- A discharge TISS score can be used to estimate the amount of nursing interventions required for a patient in step-down facilities or in the general ward.
- TISS does not accurately measure nursing workload activity as it fails to cater for tasks and duties such as coping with the irritable or confused patient, dealing with grieving relatives, etc.

SoPRA (System of patient-related activities)

The SoPRA score is intended to indicate the scope of care (medical, nursing, and other) provided to critically ill patients to assess the intensity of the impact that each patient makes on the daily workload of the Critical Care Unit.

Glasgow coma scale

First described in 1974, it utilises eye opening, best motor response, and best verbal response to categorise neurological status (see table opposite). It is the only system used universally in Critical Care Units though limitations exist in mechanically ventilated, sedated patients. It can be used for prognostication and is often used for therapeutic decision-making, e.g. elective ventilation in patients presenting with a GCS <8.

Sedation

A variety of systems gauges and records the level of sedation in a mechanically ventilated patient. They assist staff to titrate the dose of sedatives to avoid either over- or under-sedation. The forerunner, developed in 1974, was the Ramsay Sedation Score. This is a 6-point scoring system separated into three awake and three asleep levels where the patient responds to a tap or loud auditory stimulus with either brisk, sluggish, or no response at all. The main problem lies in achieving reproducibility of the tap or loud auditory stimulus. We currently use an 8-point system developed in-house (UCLH sedation scale) (see table opposite).

Glasgow coma scale

Score	Eyes open	Best motor response	Best verbal response
6	–	Obeys commands	–
5	–	Localises pain	Orientated
4	Spontaneously	Flexion withdrawal	Confused
3	To speech	Decerebrate flexion	Inappropriate words
2	To pain	Decerebrate extension	Incomprehensible sounds
1	Never	No response	Silent

Key paper

Teasdale G, Jennet B (1974). Assessment of coma and impaired consciousness: a practical scale. *Lancet* 2: 81–4.

UCLH sedation scale

3	Agitated and restless
2	Awake and uncomfortable
1	Aware but calm
0	Roused by voice, remains calm
–1	Roused by movement
–2	Roused by noxious or painful stimuli
–3	Unrousable
A	Natural sleep

APACHE scoring

- The APACHE (Acute physiology and chronic health evaluation) score utilises a point score derived from the degree of abnormality of readily obtainable physiological and laboratory variables in the first 24h of ICU admission, plus extra points for age and chronic ill health.
- The summated score provides a measure of severity while the percentage risk of subsequent death can be computed from specific coefficients applied to a wide range of admission disorders (excluding burns and cardiac surgery).
- APACHE I, first described in 1981, utilised 34 physiological and biochemical variables.
- A simplified version (APACHE II) utilising just 12 variables was published in 1985 and extensively validated in different countries.

A further refinement published in 1990, APACHE III, claims to improve upon the statistical predictive power by adding five new physiological variables (albumin, bilirubin, glucose, urea, urine output), changing thresholds and weighting of existing variables, comparing both admission and 24h scores, incorporating the admission source (e.g. ward, operating theatre), and reassessing effects of age, chronic health, and specific disease category. Wide acceptance of APACHE III may be limited as its risk stratification system is proprietary and has to be purchased.

Key paper

Knaus WA, Draper EA, Wagner DP, et al. (1985) APACHE II: a severity of disease classification system. *Crit Care Med* **13**: 818–29.

Acute physiology score

+4	+3	+2	+1	0	+1	+2	+3	+4
Core temperature (°C)								
≥41	39–40.9		38.2–38.9	36–38.4	34–35.9	32–33.9	30–31.9	≤29.9
Mean BP (mmHg)								
≥160	130–159	110–129		70–109		50–69		≤49
Heart rate (bpm)								
≥180	140–179	110–139		70–109		55–69	40–54	≤39
Respiratory rate (/min)								
≥50	35–49		25–34	12–24	10–11	6–9		≤5
If FIO ₂ ≥0.5: A–aDO ₂ (mmHg)								
≥500	350–499	200–349		<200				
If FIO ₂ <0.5: PaO ₂ (mmHg)								
				>70	61–70		55–60	≤55
Arterial pH								
≥7.7	7.6–7.69		7.5–7.59	7.33–7.49		7.25–7.32	7.15–7.24	≤7.15
Serum Na ⁺ (mmol/L)								
≥180	160–179	155–159	150–154	130–149		120–129	111–119	≤110
Serum K ⁺ (mmol/L)								
≥7	6–6.9		5.5–5.9	3.5–5.4	3–3.4	2.5–2.9		<2.5
Serum creatinine (μmol/L) (NB. double points score if acute renal failure)								
≥300	171–299	121–170		50–120		<50		
Haematocrit (%)								
≥60		50–59.9	46–49.9	30–45.9		20–29.9		<20
Leukocytes (/mm ³)								
≥40	20–39.9	15–19.9	3–14.9			1–2.9		<1
Neurological points = 15 (Glasgow coma score)								

Age points

Years	≤44	45–54	55–64	65–74	≥75
Points	0	2	3	5	6

Chronic health points

Two points for elective post-operative admission or five points if emergency operation or non-operative admission, if patient has either:

- Biopsy-proven cirrhosis, portal hypertension, or previous hepatic failure.
- Chronic heart failure (NYHA Grade 4).
- Chronic hypoxia, hypercapnia, severe exercise limitation, 2° polycythaemia, or pulmonary hypertension.
- Dialysis-dependent renal disease.
- Immunosuppression by disease or drugs.

SAPS score

- Has a similar role to APACHE II, but more widely utilised in mainland Europe; the Simplified Acute Physiology Score (SAPS) was devised by LeGall *et al.* in 1984 (SAPS I) and modified by the same group in 1993 (SAPS II).
- As for APACHE II, burns and cardiac surgical patients are excluded from analysis.
- The original version used 14 readily measured clinical and biochemical variables while the updated version, SAPS II, comprises 12 physiology variables, age, type of admission (medical, scheduled, or unscheduled surgical), and three underlying disease variables (see table opposite).
- A point score is based on the degree and prognostic importance of derangement of these variables in the first 24h following ICU admission. The point scoring was assigned following logistic regression modelling of data obtained from 8,369 patients in 137 adult ICUs in both Europe and North America and validated in a further 4,628 patients.
- The claimed advantage of this system is that it estimates the risk of death without having to specify a primary diagnosis.

Key paper

Le Gall JR, Lemeshow S, Saulnier F. (1993) A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicentre study. *JAMA* 270: 2957–63.

SAPS II score

Age	<40 (0); 40–59 (7); 60–69 (12); 70–74 (15); 75–79 (16); ≥80 (18)
Heart rate (bpm)	<40 (11); 40–69 (2); 70–119 (0); 120–159 (4); ≥160 (7)
Systolic BP (mmHg)	<70 (13); 70–99 (5); 100–199 (0); ≥200 (2)
Body temp (°C)	<39 (0); ≥39 (3)
PaO ₂ /FIO ₂ (kPa) if ventilated/CPAP	<13.3 (11); 13.3–26.5 (9); ≥26.6 (6)
Urine output (L/d)	<0.5 (11); 0.5–0.999 (4); ≥1 (0)
Serum urea (mmol/L)	<10 (0); 10–29.9 (6); ≥30 (10)
White cell count (/mm ³)	<1 (12); 1–19.9 (0); ≥20 (3)
Serum K ⁺ (mmol/L)	<3 (3); 3–4.9 (0); ≥5 (3)
Serum Na ⁺ (mmol/L)	<125 (5); 125–144 (0); ≥145 (1)
Serum HCO ₃ ⁻ (mmol/L)	<15 (6); 15–19 (3); ≥20 (0)
Serum bilirubin (μmol/L)	<68.4 (0); 68.4–102.5 (4); ≥102.6 (9)
Glasgow coma score	<6 (26); 6–8 (13); 9–10 (7); 11–13 (5); 14–15 (0)
Chronic disease	Metastatic cancer (9); haematological malignancy (10); AIDS (17)
Type of admission	Scheduled surgical (0); medical (6); unscheduled surgical (8)
Point score in brackets	

SOFA score

A limitation of the APACHE and SAPS scoring systems is that they were designed and validated on data obtained during the first 24h of intensive care admission. Various systems have been developed to enable daily scoring (e.g. Sequential Organ Failure Assessment (SOFA), Riyadh Intensive Care Program (RIP) score, Multiple Organ Dysfunction Score (MODS), etc.) to allow a better assessment of change in the patient's condition.

As the physiological and biochemical status of the patient is determined in part by the disease severity, but also by the degree of medical intervention, these sequential scoring systems incorporate the use of various therapies and procedures.

The SOFA system was initially designed to improve patient characterisation for multicentre drug trials in sepsis (SOFA initially stood for 'Sepsis organ failure assessment'), but has subsequently been applied to intensive care patients in general, with 'Sequential' being substituted for 'Sepsis'.

Although it has not been validated in the sense that a point score denoting severity of dysfunction in one organ system does not translate directly to an equivalent severity in another organ, it has been used successfully to prognosticate and to follow changes in patient status throughout their intensive care stay (see table opposite).

Key paper

Moreno R, Vincent JL, Matos R, et al. (1999) The use of maximum SOFA score to quantify organ dysfunction/failure in intensive care. Results of a prospective, multicentre study. Working Group on Sepsis related Problems of the ESICM. *Intensive Care Med* 25: 686–96.

SOFA score

	0	1	2	3	4
Respiratory PaO ₂ :FIO ₂ ratio (mmHg)	>400	>400	≤300	≤200*	<100*
Renal Creatinine (mg/dL) or urine output (mL/d)	<1.2	1.2–1.9	2.0–3.4	3.5–4.9 or <500mL/d	≤5.0 or <200mL/d
Hepatic Bilirubin (mg/dL)	<1.2	1.2–1.9	2.0–5.9	6.0–11.9	12.0
Cardiovascular Mean arterial pressure (mmHg)	No hypotension	MAP >70	Dopamine ≤5 or dobutamine (any dose)†	Dopamine >5 or epinephrine ≤0.1 epinephrine ≤0.1†	Dopamine >15 or epinephrine >0.1 epinephrine >0.1†
Haematological Platelet count (x10 ³ /mm ³)	>150	≤150	≤100	≤50	≤20
Neurological Glasgow coma score	15	13–14	10–12	6–9	<6

* With ventilatory support; † Adrenergic agents administered for at least 1h (doses in mcg/kg/min).

Conversion factors

- PaO₂:FIO₂ to kPa: divide by 7.5.
- Creatinine to μmol/L: multiply by 88.
- Bilirubin to μmol/L: multiply by 17.1.

Trauma score

Scoring systems have been developed in trauma for:

- Rapid field triage to direct the patient to appropriate levels of care.
- Quality assurance.
- Developing and improving trauma care systems by categorising patients and identifying problems within the systems.
- Making comparisons between groups from different hospitals, in the same hospital over time, and/or undergoing different treatments.

The Injury severity score (ISS) is a severity scoring for patients based on the anatomical injuries sustained. The Revised trauma score (RTS) utilises measures of physiological abnormality to predict survival (see table opposite). A combination of ISS and RTS—TRISS—was developed to overcome the shortcomings of anatomical or physiological scoring alone. The TRISS methodology uses ISS, RTS, patient age, and whether the injury was blunt or penetrating to provide a measure of the probability of survival.

Injury severity score

Use AIS90 (Abbreviated Injury Score 1990) dictionary to score injury. Identify highest abbreviated injury scale score for each of the following:

- Head and neck.
- Abdomen and pelvic contents.
- Bony pelvis and limbs.
- Face.
- Chest.
- Body surface.

Add together the squares of the three highest area scores.

Revised trauma score

	Measure	Coded value	x Weighting	= Score
Respiratory rate (breaths/min)	10–29	4	0.2908	
	>29	3		
	6–9	2		
	1–5	1		
	0	0		
Systolic BP (mmHg)	>89	4	0.7326	
	76–89	3		
	50–75	2		
	1–49	1		
	0	0		
Glasgow coma scale	13–15	4	0.9368	
	9–12	3		
	6–8	2		
	4–5	1		
	3	0		
Total = revised trauma score				

See also:

Multiple trauma (1), p582; Multiple trauma (2), p584.

