Guidelines for intensive care unit design*

Dan R. Thompson, MD, MA, FACP, FCCM (Co-Chair); D. Kirk Hamilton, FAIA, FACHA (Co-Chair);
Charles D. Cadenhead, FAIA, FACHA, FCCM; Sandra M. Swoboda, RN, MS, FCCM;
Stephanie M. Schwindel, MArch, LEED; Diana C. Anderson, MD, MArch; Elizabeth V. Schmitz, AIA;
Arthur C. St. Andre, MD, FCCM; Donald C. Axon, FAIA, FACHA†; James W. Harrell, FAIA, FACHA, LEED AP;
Maurene A. Harvey, RN, MPH, MCCM; April Howard, RN, CCRN, CCRC; David C. Kaufman, MD, FCCM;
Cheryl Petersen, RN, MBA, CCRN

Objective: To develop a guideline to help guide healthcare professionals participate effectively in the design, construction, and occupancy of a new or renovated intensive care unit.

Participants: A group of multidisciplinary professionals, designers, and architects with expertise in critical care, under the direction of the American College of Critical Care Medicine, met over several years, reviewed the available literature, and collated their expert opinions on recommendations for the optimal design of an intensive care unit.

Scope: The design of a new or renovated intensive care unit is frequently a once- or twice-in-a-lifetime occurrence for most critical care professionals. Healthcare architects have experience in this process that most healthcare professionals do not. While there are regulatory documents, such as the *Guidelines for the Design and Construction of Health Care Facilities*, these represent minimal guidelines. The intent was to develop recommendations for a more optimal approach for a healing environment.

Data Sources and Synthesis: Relevant literature was accessed and reviewed, and expert opinion was sought from the committee members and outside experts. Evidence-based architecture is just in its beginning, which made the grading of literature difficult, and so it was not attempted. The previous designs of the winners of the American Institute of Architects, American Association of Critical Care Nurses, and Society of Critical Care Medicine Intensive Care Unit Design Award were used as a reference. Collaboratively and meeting repeatedly, both in person and by teleconference, the task force met to construct these recommendations.

Conclusions: Recommendations for the design of intensive care units, expanding on regulatory guidelines and providing the best possible healing environment, and an efficient and cost-effective workplace. (Crit Care Med 2012; 40:1586–1600)

KEY WORDS: architecture; construction; critical care medicine; design; environment; healing; intensive care unit

Most healthcare providers have little experience designing and constructing an intensive care unit (ICU). These ICU Design Guidelines can make the process easier and the finished project more efficient, effective, safe, and patient centered. These ICU Design Guidelines are *performance guidelines* rather than *prescriptive guidelines*. A prescriptive guideline quantifies, as in the case of minimum square footage for a patient room, whereas a performance guideline describes functions to be accommodated. As an example, the space required for a patient room and medical equipment in a community hospital will be less than what may be required in a major tertiary care institution. In the case of a patient room, clinical protocols and equipment may evolve, rendering a prescriptive guideline obsolete (1). On the other hand, the prescriptive guidelines will describe things that must be done in the design of such space that may not be understood by the clinician, such as space for cleaning supplies and storage. This document proposes to describe *optimum* conditions rather than minimum requirements. The bibliography includes many tools that will round out the document and the process, and should be used in connection with this document.

The intent of these Guidelines is to offer a best practice approach as an alternative to the prescriptive minimum standards of The Facility Guidelines Institute (FGI) 2010 *Guidelines for Design and Construction of Health Care Facilities* (2). Other organizations, such as the National Health Service in the United Kingdom, have published guidelines to assist in the design of new ICUs, and these should be referred to in conjunction with these performance Guidelines (3, 4). Optimal design

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ideally requires knowledge of both clinical best practice and building codes (5, 6).

Due to the global nature of intensive care, these Guidelines are written with the intent to be used by healthcare organizations around the world. While the FGI provides healthcare guidelines that could be accepted globally, many of the standards set forth in the FGI Guidelines were born from policies and regulatory standards developed in the United States (2).

These ICU Design Guidelines are based on the concept of form follows function and that the configuration and performance of a critical care unit should be driven by the function and place it serves. As such, these ICU Guidelines must adapt to a range of facilities, from a rural or community hospital to a teaching hospital. These Guidelines are intended to apply to adult medical/surgical ICUs. Other patient populations, such as pediatric, neonatal, and subspecialty, may have additional or different requirements that may not be mentioned in these Guidelines (2, 7, 8). Some issues are changing so rapidly, such as information technology, they are referred to only briefly. During the design process, experts in information technology may be helpful along with the architects and engineer involved in construction.

Why Build a New ICU or Renovate an Old One?

Hospitals undertake ICU construction for many reasons: to adapt to changing patient demographics or disease patterns; to upgrade or add services; and to accommodate changes in the flow of information, materials, or patients. New construction may become cost effective when an older ICU requires expensive repairs or upkeep to remain viable, or simply ceases to function well (9).

Changes in performance standards and new issues in reimbursement and risk management may suggest alterations. Designing for infection control – by separating patients, adding isolation facilities, adding hand hygiene stations, upgrading mechanical ventilation and filtration, revising provisions for disposal of human waste, or introduction of antimicrobial materials – can lower infection rates and therefore morbidity and mortality, cost per case, and length of stay (10, 11).

Changes in the model of care delivery may drive ICU design. Advances in technology have led to miniaturization of equipment, and have increased the amount of equipment needed to care for patients.

Persistent shortages of skilled staff and aging of the critical care staff (12) have added new criteria for selecting technology and for making ICU design decisions (13, 14).

The Design Team

ICU design is complex and should include both clinically oriented and design-based multiprofessional team members. Each team member will bring specialized skills and knowledge to focus on the project at hand, which might be a remodeling, an expansion, or a completely new ICU. It is likely that design team members will have been involved in healthcare and ICU projects; it would be less likely for the clinical team members to have been part of such an effort. However, it is helpful for the clinical team to become familiar with the design regulations to help with interdisciplinary team communications. Learning to communicate clearly with those outside of your field may be a challenge. The ultimate ICU design – in cost, size, and details – will most likely be a compromise that balances various, sometimes competing interests (15).

Project team members and their primary roles will likely include: 1) hospital administration – unit sizing based on utilization, finance, and budgets; 2) the clinical team – a multidisciplinary group, including physicians, nurses, infection control specialists (16), pharmacists, therapists, and ancillary staff; 3) the design team – the architect, engineers (mechanical, electrical, structural), and technology planners (medical equipment, information technology, others); and 4) other hospital service representatives (materials management, environmental services, food service, others) (2, 10). The contractor, or construction manager, may or may not be included in the early stages of planning and design, but will be an essential team member. Environmental issues should be addressed both in the functional program and the final design. These may be relevant in the shell of the building and therefore might be addressed elsewhere in the design or in the actual design of the unit. Architects with LEED (Leadership in Energy and Environmental Design) certification may be helpful in this part of the process.

The Goal: A Healing Environment

Evidence shows that the physical environment affects the physiology, psychology, and social behaviors of those who experience it (17). The goal of the design process is to create a healing environment – the result of design that produces measurable improvements in the physical or psychological states of patients, staff, physicians, and visitors (18). Elements of a healing environment include: materials and finishes that reduce noise levels, minimize glare, and support infection control; floor plans, equipment, and other features, such as human engineering principles, may enhance efficiency and effectiveness of patient care and minimize workplace injury; stress-reducing furnishings and décor, incorporating natural light and views of nature; and thoughtful provision for the creature comforts of patients, families, and staff (17, 19, 20). Optimal ICU design can help to reduce medical errors, improve patient outcomes, reduce length of stay, and increase social support for patients, and can play a role in reducing costs (21, 22).

Optimal design requires knowledge of best practices, design standards, and building codes (5, 6). A design based on the functional requirements of the critical care unit and the consensus opinion of experts should enhance patient, family, and staff satisfaction (23, 24), and in doing so, help to protect the institution's bottom line. Staff satisfaction with the work environment has been shown to correlate with patient satisfaction and to improve retention and staff commitment (25).

One of the first pieces of work is the development of a functional (requirements) program. This should predate the actual design process and should attempt to determine what function and functions are necessary for the design to accomplish. This will include some discussion and understanding of workflow that is usually done in the unit and its environment. Developing a functional program is frequently lost in the process, but the design will of necessity be different for different functions. An example of the functional design may be: do you need isolation facilities and how often do you need them? By recognizing this need before the design process, the design can incorporate these items in the final product. Another additional task that in some way parallels the early process is the development of an Infection Control Risk Assessment. This will entail a thorough look at the risk of infection both during the construction and the utilization of the facility (26).

Of necessity for the healthcare team, an educational process may need to occur before the actual design, and perhaps at the same time a functional program is

being prepared, and will lead into working with the process. In addition to this document, articles and reading in the bibliography may be the basis for a large part of the educational process.

Evidence-based design allows design teams to benefit from the accumulated and ever-changing experience of others (18), just as evidence-based medicine identifies best practices in health care (27, 28). Evidence-based design is defined as "a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project" (29–31). One pathway to best practice design is to study or visit award-winning units, such as winners of the annual design contest jointly sponsored by the Society of Critical Care Medicine, American Association of Critical Care Nurses, and American Institute of Architects. Video recordings and floor plans of these units are available in a package from the Society of Critical Care Medicine (32).

THE CRITICAL CARE UNIT

The critical care unit consists of four major zones, each housing a primary function or set of interrelated functions.

1) The **Patient Care Zone** consists of patient rooms and adjacent areas; its primary function is direct patient care.
2) The **Clinical Support Zone** consists of functions closely related to direct patient care; not only inpatient rooms but also in other areas of the unit.
3) The **Unit Support Zone** refers to areas of the unit where administrative, materials management, and staff support functions occur.
4) The **Family Support Zone** refers to areas designed to support families and visitors.

Design for the Future

Design for an optimally functioning unit will consider the requirements of daily workflows. Designers must also look to the long term. An effective ICU design must be flexible enough to accommodate changing care practices and advances in technology over the unit's lifespan (33).

Size and Arrangement of the Unit

For prescriptive descriptions of the ICU, the most current edition of the FGI Guidelines provides square footage requirements for selected rooms (2). Several Society of Critical Care Medicine members have consistently participated in the development of the FGI Guidelines over the course of its numerous additions. The National Fire Protection Association code defines specific limitation on exiting and smoke compartment size (34).

The traditional design of critical care units has been influenced by reliance on a single paper medical record, central monitors, and regulations promoting a single, centrally located workstation from which all beds within the unit can be observed. These conditions are changing as information systems allow the digital record to be in multiple places at once, interdisciplinary care teams become more prevalent, nursing moves closer to the bedside, families become more involved in patient care, technology advances, and functions that had been centralized become decentralized.

Unit design begins with an in-depth analysis of patient care and support functions, workflow, and hospital policies (for example, those governing visitation and family involvement in care). An inventory of equipment and supplies, both current and future, will help to determine space requirements. The Clinical and Unit Support Zones are those spaces within the unit that directly support clinical and administrative staff. The design should reduce travel distances for staff, placing frequently needed spaces, equipment, or materials as close as possible to the site of use. The Family Support Zone should meet the needs of families and visitors while avoiding disruption to care processes.

The efficient unit is small enough for care providers to be fully aware of all activities on the unit or pod, yet large enough to permit efficient staffing. Whether a centralized or decentralized design is chosen, caregivers must be able to observe patients from many points within the unit (11). Research of the Society of Critical Care Medicine Design Competition-winning units suggests that there is no single ideal geometry for ICU layout (35). Published suggestions have proposed units or patient room groupings ranging from a minimum of six beds, for reasons of efficiency and economy, to a maximum of eight to 12 beds for reasons of observation (36). If

there is a need for >12 beds, consider arranging them in multiple pods.

PATIENT CARE ZONE

The Patient Care Zone refers to areas where direct patient care is provided – patient rooms and the immediately adjacent areas. Designers must consider the needs of patients and visitors, and direct care performed by staff. As critical care has evolved to integrate families into daily patient care, family needs and care functions must be incorporated into ICU design.

Single- vs. Multi-Bed Rooms

Research has demonstrated that single rooms are superior to multi-bed rooms in terms of patient safety (11, 37–40). They also enhance privacy. Rooms providing full enclosure have been shown to increase sleep quality (41).

Clear Floor Area

Clear floor space is space not occupied by the patient, fixed room furnishings, and equipment. It excludes other defined spaces, such as anterooms, vestibules, toilet rooms, and closets, as well as built-in equipment, such as lockers, wardrobes, and fixed casework (2). Clear floor area dimensions must allow room for services that are brought to the bedside, such as portable imaging, echocardiology, transcranial Doppler examination equipment, electrocardiogram, nuclear medicine, dialysis equipment, and more (42).

Single-patient rooms should have an optimal clearance of not less than 4 ft at the head and foot of the bed and not less than 6 ft on each side of the standard critical care bed (2). This clearance does not include space needed for staff and family support functions (43).

Medical Utility Distribution System

The choice of system(s) for mounting and organizing electrical, medical gas, and other medical utility outlets has a major impact on patient and staff satisfaction (6, 44). The design team should consider the patient type, functional plan, staff preferences, technology trends, and potential future needs. Options for mounting and configuring medical utility outlets include the flat headwall system, fixed column, suspended column, and boom configurations. Combinations or

hybrids of these systems may be appropriate. The medical utility distribution system will have an impact on patient room layout and size.

Flat (or Headwall) Configuration. The flat headwall configuration is mounted on the wall at the head of the bed. This configuration is widespread. It allows outlets to be easily arranged according to patient needs. This configuration can also create problems during a crisis or "code" situation by forcing the staff member responsible for keeping the airway clear to step over a tangle of lines, tubes, and cords.

Column Configuration. The column configuration has an array of outlets on a nonmovable vertical column attached to the floor and to the ceiling. The nonmovable suspended column variant hangs from the structure above. Distribution of the outlets can vary depending on the needs of the purchaser.

Boom Configuration. The boom configuration consists of a movable articulated arm(s). Ceiling-mounted booms offer maximum flexibility in positioning and accessing medical gas, electrical, and data outlets. There is a wall-mounted version best suited for renovations. Accessory shelves, brackets, and poles may be mounted on these devices, allowing optimal positioning of all support devices, such as monitors, computers, communication devices, and intravenous (IV) pumps. The use of booms permits maximum flexibility in bed placement. Pendant-mounted boom configurations offer immediate and unrestricted access to the patient's head during a crisis (44), but may be confusing to the patient.

Medical Gas, Vacuum, Data, and Electrical Outlets. Medical gas, vacuum, data, and electrical outlets need to be accessible from each side of the patient bed and arranged to provide enough room for multiple, simultaneous procedures. The design team should consult the minimal recommendations for gas, vacuum, data, and electrical outlets in the most current edition of the FGI Guidelines (2, 45), but the unit's functional program may require more than the prescribed minimum. It is recommended that 50% of the electrical outlets in the patient room should be connected to the hospital emergency power system.

The oxygen system must also be easy to access during intubation or extubation procedures. Face and aerosol masks should be accessible from either side of the bed. Because several devices use compressed air, including ventilators and pneumatic percussion devices, adequate space is needed for additional medical compressed air outlets.

Rooms may need at least five vacuum (suction) outlets for bronchoscopy, *esophagogastroduodenoscopy*, and other bedside procedures, and to accommodate patients with multiple drains (such as chest tubes and wound drains).

In an effort to embrace electronic point-of-care documentation, patient rooms may be designed to accommodate computer terminals and mobile computing solutions. If a wireless system is not provided, data ports for in-room computer terminals should be located so that clinical staff can view the patient while documenting or accessing patient information. Placement of computers should protect the confidentiality of patient data.

IV Pumps. Designers must provide adequate electrical outlets, as well as space, for pumps and IV bags for administering IV fluids and medications, as indicated by the interdisciplinary care team. Most pumps connect electronically to patient monitoring or data acquisition systems.

Medications. Medication needed on a frequent or emergency basis must be readily available either within or near patient rooms. A computer-controlled dispensing system will fulfill this requirement (See Preparing and Dispensing Patient Medications in the following section). Bedside medication storage should be secure and able to accommodate large or odd-sized articles, such as IV bags and large syringes. To reduce staff travel, consideration may be given to placing a small refrigerator in patient rooms for medications that must remain cold, or provide a central refrigerator for staff to access medications.

Supplies. In-room storage and handling of patient care supplies must minimize on-hand inventory and waste while economizing efforts of the bedside staff. Infection control is an important consideration and storage for clean and soiled items must prevent cross contamination by visitors and staff, and between the patient's gastrointestinal and pulmonary tracts. The design should provide adequate, convenient space to handle linen during changes, a clean, dry surface (fixed or portable) for stacking clean linen, and a hamper for soiled linen. Separate storage should be provided for clean and used gloves, gowns, hair coverings, shoe covers, and eye protection.

Doors

The door system should be sized to permit rapid movement of patients, bariatric beds, equipment, and personnel into or out of patient rooms in the event of a crisis. Sliding glass doors with breakaway capacity may provide beneficial additional width as well as increased visibility to the patient.

Windows

Natural light is essential to the well-being of patients and staff (17), and is required by most codes. Each patient care space should provide visual access to the outdoors, other than skylights, with not less than one window of appropriate size per patient bed area (46). Window coverings should be easy to clean, in accordance with infection control guidelines.

Providing patients an outside view (47) – preferably overlooking a garden, courtyard, or other natural setting – may help relieve anxiety and stress (17), improve care, enhance patients' comfort, and improve patient orientation. In cases where a patient's bed must face the interior of the unit to permit close observation by staff, an adjustable mirror mounted on the wall or ceiling may provide the patient a view of the outdoors.

Patient Room Furnishings

Critical care patient rooms, at a minimum, contain the following: a hospital bed designed for the critically ill patient; one chair suitable for use by the patient and one additional chair for visitors (both with cleanable upholstery); soiled linen collection hamper or similar device; containers to collect trash and waste products; and containers to collect hazardous waste products, such as needles and syringes (48). The use of specialty and special-sized beds should be remembered when calculating required bed space (49).

To create a comfortable environment for patient healing, rooms should include a clock, a calendar, and tack boards or similar devices to permit patients and families to personalize the room. Whiteboards should also be provided to allow patients and their families to be aware of their care team. Horizontal surfaces should be provided for greeting cards, photos, and other creature comforts, and placed where patients can see them.

The unit's functional design may allow for, or require, patient and family education. Appropriate materials should

be provided to serve this purpose and to communicate general information about the institution. Each patient room may be equipped with a television and educational/entertainment system, controllable by the patient or family, to support patient education goals and also to provide positive distraction and entertainment.

Clothing and Personal Effects. The design should include secure storage of patient and family clothing and limited personal effects.

Family Accommodations

Workflow and clear-space requirements will drive design decisions about how best to meet family needs and integrate families into patient care. Families may be accommodated in a designated Family Support Zone in or near the unit, in patient rooms, or in some combination of the two. For in-room overnight stays by family members, a variety of fold-out furniture options are available. Another option is to design hotel-type patient suites, where a family space adjoining the patient room might provide a desk, Internet and telephone access, and secure storage for a limited number of personal possessions.

Room Décor

Pleasant surroundings for patients and staff promote increased comfort, and in some cases, improved outcomes (50–53). Color schemes can affect mood and stress levels. Scenes of nature in greens and blues have been shown to decrease stress levels for patients (54) and are probably helpful for families and caregivers. Pictures and artwork can be selected and placed appropriately for patients, families, and caregivers (55). For bed-ridden patients, the ceiling is most often what is seen. Attention early in the design process will ensure the implementation of positive distractions in addition to required ceiling-mounted medical equipment, such as a selection of images that can be incorporated into ceilings.

Critically ill patients often suffer from delirium (56) and there is evidence that pictures and images featuring geometric designs or abstract art should be avoided (55). Similarly, avoid the use of bold patterns on horizontal surfaces, window coverings, and furniture upholstery.

Temperature Control

In consultation with the care team, patients and families should be able to control patient room temperature (57).

Lighting

Patients exposed to increased intensity of natural sunlight have been shown to experience less perceived stress, use fewer analgesics, and have improved sleep quality and quantity (58, 59). Bright light, both natural and artificial, has been shown to reduce depression among patients (22). Artificial light for general illumination and specific tasks is essential. Consult recommendations for lighting levels developed by the Illuminating Engineers Society of North America, outlined in the Illuminating Engineers Society of North America Handbook (60).

A high-intensity light source for clinical procedures should be readily accessible. This light source may be portable, or wall or ceiling fixed. To prevent burns, incandescent and halogen light sources should be avoided, or if used, covered by a lens or diffuser. Flexible arms, if used with this light source, must be mechanically controlled to prevent the lamp from contacting bed linen. Each patient bed should also have a reading light that can be easily controlled by the patient.

General illumination should feature adjustable lighting levels, designed to minimize glare within the patients' sightline. Indirect lighting is preferred. Adjustable low-level illumination should support observation and movement around the patient at night or whenever the patient requires rest. It is recommended that emergency lighting and light intensity for tasks, such as charting or data entry, comply with the Illuminating Engineers Society of North America recommendations (60).

If space is provided to accommodate the family, appropriate lighting should be provided. This may include a reading light source designed not to disturb a sleeping patient.

Lifting Devices

Several studies have found that work-related injuries have become a major problem on critical care units, and lifting is one of the most common causes of injury (61, 62). To enhance patient and caregiver safety, mechanical lift devices can be built into the ceiling, or mobile lifts can be provided (63, 64). If mobile lifts

are provided, storage space must also be provided in close proximity to the patient room.

Hand Hygiene, Toilet Facilities, and Fluid Disposal

A variety of fixtures and options are available for fluid disposal, hand washing, and toilet facilities in patient rooms.

Hand Hygiene. Evidence suggests that the presence of both soap and water and alcohol gel systems are required for maximum performance and hand hygiene adherence (65, 66).

Sinks. Sinks in patient rooms should be placed near the entrance and near disposal systems (2, 66, 67). Dispensers for soap should be located near the sink. A paper towel dispenser and trash receptacle should be next to the sink to minimize dripping of water onto adjacent surfaces. Sinks should enable hands-free operation (68). Foot-controlled devices are not recommended, since the design and mounting methods for these devices create difficult housekeeping and infection control conditions.

Alcohol gel dispensers. Alcohol gel dispensers with effective disinfectants should be located for convenience in the patient room as well as in other staff locations around the unit. In the patient room, this can include locations proximate to a handwashing sink and near the head or foot of the bed. Placement of devices at the threshold or place of entry of each room allows for ease of access and a visual reminder for hand hygiene.

Toilets. Relatively few intensive care patients are expected to use a conventional toilet. Exceptions may include patients under observation, or before discharge. Shared toilets can be a source of cross contamination.

Toilet options for patients with limited mobility. Room design should afford privacy in the use of mobile commode chairs, or bedpans for patients who cannot get out of bed. Swing-out or fold-down commodes are not recommended because they create infection control concerns and may not be rated for bariatric patients. A fluid-disposal or bedpan flushing device should be available in each patient room or as part of an adjacent toilet. Some bedpan washers can create aerosol sprays with biological contaminants (69). If used, barriers that protect the staff member from exposure, or sealed models, should be part of the design. A closed macerator system in conjunction with disposable bedpans

and basins or a sealed bedpan cleaner is a desirable substitute for a bedpan washer attached to a conventional toilet (70).

Toilets for bariatric patients. Designers should consider the needs of bariatric patients, such as providing floor-mounted fixtures that have greater bearing capacity (71).

Fluid Disposal. Each patient room should have direct access to a fixture for the disposal of fluids. Closed systems that do not spread aerosols are preferred. Options include macerators, bedpan washer/sterilizers, or clinical sinks placed within the room or between two rooms. A toilet (water closet) fixture may also satisfy the requirement for fluid and waste disposal. If fluid disposal is not made available in the room or in a connecting room, it should be provided in close proximity via the corridor, although this option is not optimal.

Dialysis Equipment

If the design requirements include bedside renal dialysis or continuous renal replacement therapy, appropriately conditioned water and drain facilities must be provided, with the capacity to deliver deionized water if necessary. Water and drain connections should be separate from handwashing sinks and located so that dialysis equipment can be placed on either side of the patient's bed.

Sharps and Device Disposal

Management of sharps, such as needles, blades, wires, and devices soiled with body fluids, feces, and urine, necessitates serious design consideration. Sharps containers must be placed within patient rooms where they are visible and within reach, be placed in an area free from obstruction, and in some cases, be portable. Large sharps containers allow easy and safe disposal of sharps from invasive procedures (72). Smaller bedside containers often cannot hold larger items, such as guide wires and catheters.

Isolation

For infectious patients, formal isolation facilities must be available when the functional program dictates (2, 73). Negative pressure, relative to adjacent spaces, can be used to prevent the spread of airborne pathogens from an infected patient. If an anteroom or alcove is provided, it should afford space for staff to don protective (universal precaution) garments and equipment before entering the isolation room (74). The number or percentage of isolation rooms in a critical care unit is dependent upon circumstances of the institution (2).

For patients who require protection from infection, positive pressure in the room's air handling system ensures that airborne external contaminants will not enter the room's environment. When determining the percentage of isolation rooms in a unit, infection control personnel should be involved to define the number of isolation rooms.

Pet Visitation

Pet visitation has been shown to be therapeutic. This may be of particular value to long-term patients. If the functional program includes pet visitation, then the unit design must accommodate it. Infection control protocols must be carefully followed (75–79).

CLINICAL SUPPORT ZONE

Clinical support functions include all unit functions related to diagnosis and treatment of patients. Some of these functions may take place within patient rooms and adjacent areas, while others may happen elsewhere on the unit or the hospital, or even in remote locations.

Careful analysis of workflow and patient care processes is needed to optimize design of the Clinical Support Zone. Certain clinical support functions meet immediate or emergency needs. For these, it is critical to consider both proximity to patients and ease of access for staff. The intermittent need for some services lends themselves to greater centralization.

Emergency Eyewash Station

Workers in the ICU are exposed to many hazardous fluids. Despite universal precautions, splashes of chemicals/bodily fluids can occur. The institution will need to determine whether an emergency eyewash station may be used to address the issue.

Team Work Areas

The quality of patient care has been shown to improve when delivered by a multidisciplinary team of clinician specialists, pharmacists (80, 81), respiratory and other therapists, dieticians, social service professionals, chaplains, and other health professionals (12). This document uses the term "Interdisciplinary Team Center" (ITC) to describe a central location for supporting team interaction and certain centralized activities. Additional work areas, both general and function specific (such as an imaging room, or a space for preparing and dispensing patient medications), may be placed around or near the ITC as the functional program dictates. All work areas should provide adequate, convenient storage for reference manuals, policy or procedure manuals, hospital formularies, telephone lists and other paper resource materials needed by users, as well as sufficient computer, data, and telecommunications ports.

Physiologic Monitoring

There is perhaps no better way of monitoring a patient than by direct visualization. There is a link between poor visualization of patients by nursing staff and physicians and patient mortality (82). To achieve direct visualization, each patient's face and body position should be easily seen from the main ICU corridor or from the ITC. A decentralized unit design should provide a clear view of patients from decentralized work areas. For safety reasons, each patient should be visible from more than one workstation if possible.

Centralized Monitoring. The ITC will usually house centralized monitoring devices. Designers should consider available space and the ratio of staff to patients. Space should be allocated not only for monitoring devices, but for printers and other support equipment. Monitoring functions should not infringe upon clerical functions. Monitors should be positioned to enable medical staff to easily see and hear patients from multiple vantage points. New technology, including text messaging, allows unique alarms to alert staff to changes in patient parameters, malfunctioning devices, or life-threatening situations, and the design should accommodate this technology (83).

Remote Monitoring (Electronic ICU) (84–86). ICUs may want to send physiologic and patient trend data to specialists at remote locations in the hospital or elsewhere. To support the electronic ICU model, robust video observation, physiologic monitoring, and communications links must be provided in every patient room. Remote monitoring locations must include adequate space for video monitors, physiologic parameter monitors, computer workstations, desks, and chairs, as well as telephones and other devices to communicate with ICU staff. The

lighting and environment of remote monitoring rooms should promote concentration. If the remote monitoring location is isolated, a staff toilet should be considered as part of the suite.

Order Entry

Clearly organized workspace for unit staff and patient care coordinators should be located in the ITC to help improve communication, facilitate ordering, and expedite care. This area should include dedicated computers, telephone, paper forms, pneumatic tube, fax machine, and digital technology used for order entry within easy reach of staff. Computer-based order entry systems are powerful emerging technologies (87). If such a system is not in current use, provisions should be made for its future use.

Documentation and Review

Medical rounds provide healthcare professionals with the opportunity to develop integrated care plans (88). In the ICU, multidisciplinary rounds often occur in various formats (89). Studies have documented the benefits of multidisciplinary rounds, such as reductions in cost and length of hospital stay (90), reduced mortality rates (89), and an association between multidisciplinary care teams and a lower risk of death among patients in the ICU (91). Staff physicians often develop a preference for either bedside or conference room rounds (90), implying that unit design and layout should be able to accommodate various rounding preferences and styles. Physical multidisciplinary rounding in teaching hospitals can become an event including a dozen people or more, many utilizing portable computers. The impact of a large number of people moving through the ICU influences corridor width and acoustic needs. Mobile data entry devices, such as workstations on wheels, are being increasingly used on rounds. Overall unit configurations can place limitations on how and where these devices are used and on the mobility of clinical work. Consideration should be given to types and numbers of devices used, the nature of their use, and the physical layout of the ICU (92).

The number of staff who may be rounding or consulting with the patient at one time should help define the amount of work surface space required for documentation and review of patient records. Areas supporting documentation and review should be located and designed to minimize distractions and potential errors.

Pharmacy Services

The design of the unit must consider the pharmaceutical delivery functional process (93). Whether the ICU relies on the hospital pharmacy or a satellite pharmacy within or near the ICU, pharmacy services should be readily accessible, available 24/7, and provide all medications needed. Space in the unit should be designated for point-of-care pharmacist activity and may include a dedicated computer terminal and work station. Pneumatic tube systems may be used to transport pharmaceuticals to and from the main pharmacy.

Satellite pharmacies within or near the ICU can allow for immediate access to medications prepared by a pharmacist, decreasing medication delivery time. These spaces may also be sized for larger equipment. If a satellite pharmacy serves the unit, medication prep and storage may be less extensive than for units that rely on a main hospital pharmacy.

Preparing and Dispensing Patient Medications

Receiving and organizing prescriptions prepared elsewhere can occur in a central location in the ICU, or can be decentralized closer to the patient, and in some cases may be both centralized and decentralized. For mixing IV fluids and other preparations, if done within the ICU, a location close to the ITC, or easily accessible from decentralized work stations, is recommended.

Medication delivery systems may be automated. Automated medication dispensing systems should be easily accessible in life-threatening clinical situations. Larger ICUs should consider more than one automated delivery system. Some systems may require additional electrical outlets or data port connections.

Medication Rooms. Secured medication rooms should provide adequate space for medication storage, a refrigerator restricted to pharmaceuticals, space for an automated dispensing machine or a secure lock system for controlled substances and patient-specific medications, and a hands-free hot/cold sink. Ample countertop space and disposable sharps containers should be provided. Windows should allow visualization of the patient area during medication retrieval and preparation. Medication rooms should provide computer access to medication references and electronic patient records. A telephone is beneficial for communication with the pharmacy. An intercom or other device will permit communication with patient rooms and the rest of the unit.

Wall space should be available for posting information on drug interactions or specialized instructions. Cabinets or drawers should also be available for stock supplies of one-time use vials and storage of equipment, such as syringes, alcohol pads, and needles.

Interruptions, noise, and poor lighting may negatively affect accuracy of medication dispensing. Proper illumination, including task lighting without shadows or glare, can help to minimize medication errors (94, 95). The Illuminating Engineering Society of North America has published recommended illumination levels for medication dispensing areas (60). To control for noise and distractions, the medication room may be enclosed to assist in concentration (96).

The medication room should be large enough to accommodate at least two staff, a nurse and a colleague who is double checking accuracy, without disruption or interruption. It should be proximal to the ITC or easily accessible from decentralized work stations.

Laboratory

ICUs must have access to 24-hr clinical laboratory services. These can be provided by the central hospital laboratory or a satellite laboratory within or near the ICU. If satellite facilities are implemented, they must provide minimum chemistry and hematology testing, including arterial blood gas analysis and mixed venous blood gas analysis. Space on the unit may be allocated for point-of-care bedside testing equipment. If blood gas analysis is frequent in the unit, consideration of space for a blood gas analyzer, including co-oximetry, may be included in the overall design. With the increasing prevalence of drug-resistant pathogens, care should be taken to provide for separate storage and handling of specimens from patients in isolation rooms. Pneumatic tube systems may be used for rapid transport of specimens to and from the laboratory.

Imaging

Imaging services should be readily accessible to the ICU. The unit should provide adequate storage for portable imaging

machines. The patient archive communication system and a reading room with film-view boxes and/or digital access with high-resolution screens should be available within or adjacent to the unit.

Respiratory Therapy

A respiratory therapist is frequently a part of the critical care team and respiratory equipment and supplies are constantly in use (6). A respiratory therapy office, department, or support space within or near the ICU provides storage for supplies and equipment, such as ventilators and oxygen tanks, including separate storage for soiled equipment.

Specialized Procedure Areas

The patient room should be designed to accommodate certain imaging or invasive procedures. Areas for specialized medical procedures may be developed adjacent to or near the ICU, such as a cardiac catheterization laboratory adjacent to a cardiac ICU. The functional requirements for the unit will dictate the need for procedure rooms. Due to equipment and staffing costs, a cost-benefit analysis should assess the probable number of cases requiring these highly specialized rooms, currently and over the lifespan of the unit.

Emergency Equipment and Supplies

Provisions should be made for storage and rapid retrieval of one or more "crash carts" with emergency life-support equipment and supplies containing equipment, such as "difficult airway" carts, central venous access carts, and fiberoptic bronchoscopy carts (2). Institutional policies governing the ratio of crash carts to patient beds will dictate how much space to allocate. Emergency carts can be located in visible alcoves along a corridor with an uninterrupted power supply to charge the equipment's batteries. They should not be stored in a room or behind a door where they may be hard to find in a crisis. There should be sufficient storage for other emergency equipment and supplies. The design should consider space needed for an emergency oxygen tank and extension cords.

Nonemergency Equipment

Multiple areas should be allocated for storing nonemergency equipment, such as specialty beds, stretchers, wheelchairs, isolation carts, traction devices, diagnostic equipment, bronchoscopy carts, and other specialty carts. Some ICUs may stock duplicates of equipment used daily at the patient bedside, such as Doppler machines – one for patients in isolation, and one for other patients. The unit must provide adequate – and separate – storage for such equipment.

Storage locations for electrical devices (such as transport monitors, IV pumps, and monitoring equipment) should provide adequate electrical outlets for charging. Horizontal storage (shelving) should be planned, and space allocated for other support equipment specific to the ICU, such as blanket warmers, blood transfusion refrigerators, patient cooling devices, and equipment to house products that enhance patient bathing, such as chlorhexidine-impregnated cloths. Several studies have shown the benefit of these products for infection prevention (97–99).

Hazardous Waste. Storage space for hazardous materials, such as "red bags," sharps, and radioactive materials, should be planned. Prompt removal of these items from the bedside to a separate location reduces risk to the patient and medical staff personnel. Policies and procedures for the institution should direct disposal and storage of such items. This function can be co-located with the soiled utility space.

Patient Nourishment

Dedicated spaces should provide food, drink, and ice for patients, with minimal facilities for preparation. A sink with hot and cold water must be available. Some ICUs may need to accommodate dietary carts; such carts should be stored away from clinical areas. Automated dispensers for ice, coffee, and water should be conveniently located. Facilities must be readily accessible to personnel.

Additional nourishment spaces may be provided for family or visitors – many ICUs place these facilities in or near the family/visitor lounge. Such facilities should provide adequate refrigerator/freezer and storage space. A microwave oven may be useful. For more information, refer to the Family Care Zone section.

Patient Transportation

ICU design must consider both vertical and horizontal transport paths. Patient elevators should be deep and wide enough to accommodate patient beds, support equipment, and transportation staff. Some elevators have electrical power supplies for emergency use. Separate elevators for service traffic are recommended. Other considerations include corridor widths, door-swing directions, and timed hold-open hardware. Emergency power sources should be available in the event of medical equipment battery depletion during patient transport.

UNIT SUPPORT ZONE

The unit support zone encompasses areas where administrative, logistic, and staff support functions are performed.

Administrative Functions

A variety of offices and conference spaces can be located within the unit but somewhat remote from the Patient Care Zone. This will reduce cross traffic with patients and family members yet provide an administrative area conducive to concentrated work.

The ICU may include a dedicated space for the interdisciplinary team to prepare "change-of-shift" reports. Some members of the interdisciplinary team may require office space for management, education, and clinical specialty purposes. If offices must be shared, consideration should be given to the need for occasional privacy. Office spaces should be large enough to include necessary equipment and comfortable furnishings. The unit should contain spaces for staff meetings and consultation with families. Many of these needs may occur simultaneously.

Multipurpose Conference Room. There is a need for larger meetings than can occur in individual offices. A large conference room or classroom proportionate with staff size can accommodate a variety of needs, including educational/training conferences, multidisciplinary staff meetings, formal didactic rounds and impromptu meetings, in-service education, or debriefings.

This room should have audiovisual equipment capable of upgrade and high-speed Internet connections. It should include an erasable marker board and "flipcharts," flexible (expandable) table options, and comfortable seating, including a supply of stackable chairs for the occasional larger group. It should contain access to the hospital/health information system and picture archiving and communication system monitors, emergency cardiac arrest alarms, and a telephone or other intercommunication system linking

to the ICU. It is preferable to designate a separate space for the staff lounge.

Materials Management and Housekeeping Functions

The design must consider how supplies will be delivered from central supply processing and bulk stores. Some institutions use satellite materials management locations dedicated to serving the ICUs. Dispensing machinery can track per-patient use of materials and thus help with billing. Floor space for this equipment needs to be provided. These spaces can include utility rooms, work rooms, supply rooms, and holding functions.

Supplies. Supplies of all kinds – whether linen, paper goods, patient care items, or administrative forms – are typically delivered to the unit immediately if required for patient treatment daily, or weekly. These may be transported via dedicated lifts. Supplies may arrive on carts or pallets. To control infection, boxes and containers should be opened outside the unit, and transferred to on-unit storage. If possible, circulation paths for supply carts should be segregated from clinical zones and family areas, both vertically (via elevators) and horizontally (via corridors or passageways).

Clean Utility/Workroom. A place is needed for storing all clean and sterile supplies, both disposable and reprocessed. It should be centrally located, easily accessed by multidisciplinary staff, segregated from the soiled utility room, and large enough to accommodate rolling carts (such as linen carts and IV medication pumps). The primary clean utility room may be supplemented by satellite work locations proximal to patient beds. If the unit is large or in a pod format, designers may want to provide multiple clean utility rooms and/or allocate dedicated linen storage space per pod. Providing alcoves for mobile bedside carts within rooms can reduce clutter outside rooms.

Clean utility/workrooms should contain a work counter and handwashing station. Easy-to-clean shelving and storage cabinets should be off the floor and within easy reach. Security is a consideration, since syringes and sharps may be stored there.

Soiled Utility/Workroom. The soiled utility room should be physically separated from, and have no direct connection to, the clean utility/workroom. They may provide temporary storage for carts containing patient meal trays not yet collected by dietary personnel, and for used and soiled items that will be reprocessed or disposed of elsewhere. Holding spaces should be sized according to anticipated soiled materials volume, and organized to accommodate several categories of waste, including hazardous materials. Steps should be taken to reduce overall waste. Disposal procedures will vary by hospital.

The soiled utility room should include a hot and cold running water sink and clinical sink with a flushing rim feature, adequate countertop space, and space for cleaning supplies. A variety of containers, such as cans, bins, bags, and hampers, may be required to hold different categories of soiled materials, including linen, trash, and hazardous (red bag) waste. Because disposal of hazardous materials is becoming increasingly expensive, steps should be taken to reduce its volume.

Housekeeping. The unit should provide adequate storage space for housekeeping equipment and supplies, such as housekeeping carts, vacuums, buffers, mops, buckets, and ladders. To secure equipment, consider implementing a keypad or other control system.

Staff Support Functions

ICU staff members need places to sleep, eat, relax, take care of personal needs, and store their belongings.

On-call Rooms. Short naps or sleep breaks may enable medical staff to function better and reduce errors (100–102). On-call rooms for members of the interdisciplinary team should be available as dictated by the functional program, preferably within or adjacent to the unit, or at a minimum, on the same floor. Separate rooms should be provided for men and women. Telephones or intercoms should link on-call rooms to the ICU, and cardiac arrest/emergency alarms must be audible. Computer access to patient medical records and picture archiving and communication systems would be ideal. Toilet and shower facilities should be provided, and these facilities should be accessible.

Staff Lounge. A staff lounge in or near the ICU should provide a private, comfortable, spacious, and relaxing environment. The lounge should include comfortable seating, a table with chairs for dining, and food storage and preparation facilities, including a large refrigerator, microwave oven, and coffee dispenser or coffee maker (52). Computer access is desirable, and an area for staff mailboxes should be included. Critical information for staff members may be displayed on a bulletin board in the lounge or near staff restrooms.

The staff lounge should be linked to the ICU by telephone or intercom, and emergency cardiac arrest alarms must be audible. The room should be separated from public areas. If possible, windows to the outdoors should provide a view of nature. The lounge should be ventilated to remove food smells from patient care and public areas.

There are pros, cons, and precautions needed for including televisions for staff (53). Televisions may serve not only as entertainment, but also as a source of critical information during a public crisis or emergency situation. Televisions, if provided, should feature cable or satellite access.

Staff Restrooms. Restrooms clearly designated for staff and designed to meet accessible requirements should minimize time away from duty, yet ensure privacy (103). Toilets should not open directly into the staff lounge. If the unit is large or contains several pods, multiple staff restrooms should be considered. Separate male and female restrooms are recommended and should include a toilet, handwashing sink, dispensers for soap and waterless hand cleaner, hand drying means, waste receptacle, and mirror. A storage cabinet and shelving would be helpful.

Lockers. A secure space for lockers for staff belongings may be allocated within or adjacent to the staff lounge. In larger facilities, these spaces may be designated for different segments of the staff or shared by more than one unit. Because many nurses or other staff may prefer to keep some belongings at the patient bedside or at work stations, designers should consider providing secure drawers or shelves at these locations.

FAMILY SUPPORT ZONE

The Family Support Zone consists of those spaces and functions outside of the patient room to serve family and visitors. Family support has been recognized as a significant factor in patient recovery and reduced morbidity (104), so it is an important element to be considered.

Signage and Wayfinding

Patient room numbers should be clearly marked. Directional signage should be easy to read, understand, and

follow. In many locations, multilingual signage should be considered. Wayfinding techniques, such as landmarks, art, and floor patterns may be considered (105). Clearly worded requests to turn off cellular telephones, explaining the potential of interference with vital life support and telemetry monitoring, should be posted at ICU access points and in waiting rooms or family support areas (106, 107). Signage should also be posted to remind staff to turn their pagers to "vibrate" mode.

Family Lounge

A family and visitor's lounge should be provided adjacent to or near each ICU pod, located so as to avoid disrupting patient, staff, and supply circulation patterns. Family members will tend to cluster immediately outside the patient's room or the unit if the lounge is perceived to be too far from the ICU. Family and visitors' lounges may be decentralized around the ICU, closer to patient rooms.

A lounge must provide for the multifaceted needs of families and visitors, affording a comfortable space to wait, privacy for conversations with healthcare personnel, communications within and beyond the ICU, and basic amenities. Seating quantity can vary substantially with the functional plan, cultural factors, and the unit's location in the hospital. Families tend to rearrange furniture if their needs are not met. Furniture groupings should promote visual and auditory privacy for families. Partial walls and dividers can help (51).

The lounge should provide choice, both in the type of furniture and its arrangement (48). Fold-out chairs or recliners could be considered if these are not provided in patient rooms. Chairs should provide arms to assist guests in sitting and rising, as well as good back support. Some furniture should accommodate obese visitors. The selection and arrangement of furniture should allow adequate clear floor space for feet and legs, and should accommodate wheelchairs. The lounge should include seating and play areas for children.

Families will scatter personal belongings around the lounge if adequate storage is not provided. This could include shelving, closets, or secure lockers (52). Racks for magazines, hospital and ICU information, and educational materials should also be readily available. Accessible toilets for males and females should be reasonably close to, or part of, the lounge

(103). Unisex toilets are sometimes used, although not generally preferred.

Environmental Considerations

Carefully coordinated and selected color palettes, material choices, furniture selections, window coverings, art, positive distractions, exposure to nature (55), and lighting choices (22) can all produce a calming effect (17). Skylights are an option if windows are not feasible. Providing visitors and families with access to a courtyard or patio is recommended. Noise-dampening materials and carefully selected music can contribute to a supportive environment for families (108).

The use of televisions in public spaces is controversial (53). Televisions in lounge areas have been shown to increase stress, especially if viewers disagree over or cannot control programming or volume. Although televisions rarely contribute to a soothing environment, they may nonetheless provide a source of distraction for distraught visitors. Consider separate rooms for televisions. If televisions are included in lounge areas, closed-captioning might be used to keep noise to a minimum, or low-volume speakers placed close to viewers (such as on end tables) to confine television noise to a smaller area. Programming options could be limited to a specific number of channels with appropriate programs for all ages. Nature videos could also be broadcast.

Consultation Rooms

Rooms for private conversations between interdisciplinary team members and families are recommended. Designers should make every effort to protect privacy, although Health Insurance Portability and Accountability Act guidelines do not mandate structural design (11). If possible, consultation rooms should afford direct access from the unit and from the lounge, so that personnel do not need to cross the seating area. This private space can be used for patient updates, and if necessary, for grieving. Financial counseling, pastoral care, social services, and other family support is typically available to ICU families. The ICU must consider whether these functions will occur in family consultation rooms or in departmental suites elsewhere in the hospital (109).

Meditation Spaces

Rooms near the ICU should be provided for meditation, reflection, and spiritual

contemplation. Particular attention should be paid to designing restorative space for multiple cultures and faiths, so that all users feel welcome and comfortable.

Family Communications

Better communication between caregivers and families produces higher family satisfaction ratings (50). If a personal cell telephone number is not available, visitors should be provided with beepers or pagers so they can be contacted if they leave the lounge or unit. Lounges should include public telephones, including TTY (telephone typewriter)-accessible phones. Telephone booths or alcoves can provide a measure of privacy. Access to the Internet for personal and business use is a valuable amenity. Tables and chairs to support laptop computers should be available. If the hospital has a business center available to the public, a notice to this effect should be displayed.

Family Nourishment

Electric drinking fountains or another fresh water supply should be conveniently located within or near the lounge. Some hospitals provide food trays to families at meal times. Vending machines are helpful, particularly at late hours when hospital coffee shops or food services may not be available.

Some programs encourage families to bring or prepare foods familiar to patients. A kitchen or pantry can bring a touch of home to the lounge and provide respite for families and visitors. It should include a microwave, coffee pot, and refrigerator. Infection control measures should apply in this communal area. Recycling should be considered.

Family Sleep Rooms

When possible, families and visitors should return home to rest. Some hospitals negotiate agreements with a nearby hotel to accommodate visitors and families from out of town, or provide in-hospital facilities for this purpose. The ICU may find it useful to create one or more family sleep rooms near the lounge or unit; these may or may not contain toilet and shower facilities. Policies for the use of sleep rooms must be carefully considered to ensure fair and impartial use.

Family Laundry

Washers and dryers for patients' and families' clothes and linens may be housed

in a dedicated room on the unit, near the family and visitors' lounge, or adjacent to family sleep rooms. Institutional procedures should be followed for disinfecting the equipment each day or after use for contaminated items.

DETAILS AND COMMON DESIGN ELEMENTS

Security and Access Control

Dedicated entrances to the ICU may have video camera monitoring capability and telephone or intercom to allow communication between ICU staff and visitors, and a system to control access according to visitation and other hospital policies. Placing a waiting area or family lounge next to or near the unit entrance can be supportive for visitors, and in some ICUs, access to the unit is through the lounge. Ideally, a dedicated staff member receives visitors, supplies information, maintains the lounge environment, and controls access to the unit and patient rooms. If economic constraints place limits on such staffing, acceptable alternatives should be provided to meet the needs of visitors. Card-key access is a possibility for units with an open or "contract visiting" policy. A less satisfactory option is a buzzer system with telephone contact from outside the unit or from the lounge to an access-control desk within the unit.

Safeguarding Patient Privacy

To protect patient privacy, room design that limits obtrusive sightlines during care or procedures is desirable. Windows between rooms may compromise privacy. To address this problem, various window designs permit selective viewing by staff while nonetheless protecting patient privacy. These include curtains, adjustable blinds enclosed between two panes of glass, and systems that turn glass opaque when an electrical charge is applied to the glass pane.

Health Insurance Portability and Accountability Act guidelines prohibit the display of full patient names on room doors to protect patients' privacy (11). The patient list/census board should not display identifiable patient information if the board is visible to the public. Similarly, personal health information displayed on bedside screens or unit workstations should be protected from unauthorized viewing by appropriate placement, as well as by the use of passwords and screen savers.

Patient Safety Technology

Space should be designated for patient safety technologies, such as bar-coding and radio frequency identification technology. Patient safety technology assures patient safety in identifying patients, medication and blood product administration, and in the processing of patient samples and supplies (110). Various locations on the unit to house patient safety technology scanners include, but are not limited to, the pneumatic tube system, exit points of the unit, near external laboratory processing stations, in the medication room, in the patient room, or on roaming laptop computer stations.

Communications

Unit efficiency and patient safety depend on effective communication. All ICUs should have an intercommunication system that links workstations, patient rooms or modules, physician on-call rooms, conference rooms, and the staff lounge. Supply areas and the visitors' lounge may be included in the system. When appropriate, links to other key departments, such as blood bank, pharmacy, and clinical laboratories, should be included. The system should be as quiet as possible. Communication equipment may include nurse call (intercom) systems, telephones and pagers, fax machines, and technologies such as pneumatic tube stations and dumbwaiters.

Information Technology. With the increased reliance on information technology in critical care, provision for wireless or wired data ports at the patient bedside and throughout the unit is becoming more important. Adequate data ports and an appropriate number of terminals or workstations must be provided, each with sufficient countertop space, and placed to promote efficiency and protect patient confidentiality. Local area networks, wireless technology, handheld documentation devices, and other technologies may be required.

Rapidly changing technology and styles of interfacing pose formidable design challenges. The design must address workflow, patient confidentiality, future needs, staff preferences, interfaces with the main hospital information system, unit-based information technology needs, and other factors, including the fact that members of the care team may need access to data entry and other information simultaneously, at the patient bedside and in other zones.

Voice Communication. Multiple telephone lines and extensions can eliminate the need to wait for a telephone and provide a more efficient method of routing calls to staff members. Wireless telephone options may enhance communication between administrative and clinical staff. Telephone extensions should be located adjacent to computer workstations, and ringers should employ soft tones. If designated "sound-proofed" areas are provided for telephone use, glass should enable staff to view patients and unit activities. In addition to standard telephone service for each ICU, there should be a mechanism for emergency internal and external communications during power failures.

Personnel Tracking. Voice paging systems raise the noise level on the unit and may add to stress (111). Personnel tracking and nonemergency communications may employ visual displays (numeric or color-coded lights) that eliminate unnecessary noise. The system may include pagers and wired or wireless hands-free phones. Alphanumeric pagers are frequently used to display information rapidly to unit staff. Pagers should be switched to "vibrate" mode to reduce noise, decrease the risk of medical errors, and enhance the healing environment. Wireless earpieces and similar technology may allow medical staff personnel to communicate with one another while working with their hands and without leaving the patient bedside. Mobile technology may increase efficiency by freeing medical staff from the constraints of a fixed location. Studies of cellular telephone interference with medical equipment suggest that cellular telephone use may now be appropriate in most ICUs (106, 107). One option is to designate one or more areas that are safe for cellular telephone use.

Document Transmission. Facsimile machines and Web-enabled scanners are a quick and efficient means of communication. Scanners connected straight to the Internet permit rapid dissemination of vital medical information to other departments or healthcare facilities. Scanners are becoming more common; designers should strongly consider providing dedicated space.

Materials and Finishes

Materials and finishes can help to create a healing environment by controlling noise and reducing the spread of pathogens. Critical care units have been found to be above recommended decibel levels (50, 108, 112). Critically ill patients may be more sensitive to noise than staff, and increased noise levels can disrupt sleep and increase perception of pain (112, 113). Alarms, movement of equipment and chairs, and other unit activities all add to patients' perceptions of noise (114, 115), and conversations conducted at what staff perceive to be an acceptable volume are often disturbing to patients, and may constitute a breach of privacy (116). Select materials that minimize noise (114), not only in patient rooms, but throughout the unit. To enhance infection control, materials and finishes throughout the unit should be easy to maintain and clean, and deter the growth and spread of pathogens (117).

Surfaces. Assume that cleaning processes and standards will not always be followed perfectly, and that surfaces are at risk of accidental spills and high-impact damage. Avoid the use of laminates in clinical areas – they provide sites for mold growth. Avoid surfaces or areas that trap water. Key aspects to achieve desirable surface features include smooth finishes free from fissures, open joints, or crevices that can retain or permit the passage of dirt (118). Select ceiling materials that can be cleaned thoroughly with routine house-cleaning equipment. Acoustical ceilings, if used, should be nonfriable and should conform to the Centers for Disease Control and Prevention and hospital infection control policies (119). When monolithic ceilings are used, they should be smooth and free from fissures, joints, and crevices where dust and particles could lodge. Finish walls with materials that can be easily cleaned. If wall coverings are used, the texture should be consistent with hospital infection control policies. Flooring, made of seamless, resilient sheet goods, should extend up the wall a short distance and be coved to form a smooth junction with the wall. Carpets should be free from edges that create hazards for wheelchairs, walkers, carts, or equipment (117). There is a body of literature discussing infection control considerations as it relates to flooring options (17).

Casework or Millwork. Casework can be either fixed or moveable. Counters and cabinets are either casework (metal) or millwork (wood) and should be constructed to resist damage from the movement of beds and medical devices. Countertops should be made of solid surface materials, and joints should be impervious to penetration by liquids (66). Backsplashes should be high enough to prevent water from splashing on the wall, and designed to prevent moisture from collecting.

Hand Hygiene

Hand hygiene is an important part of infection control, and handwashing stations should be readily accessible throughout the unit. The 2010 FGI Guidelines (2) describe two systems, one that uses water and one that is water-free. The first provides a sink with hot and cold water, a faucet with easy on-off and temperature-mixing capabilities, cleansing agents, and a means for drying hands. The second uses a waterless, antiseptic rub to reduce the number of microorganisms present on the hands. Sinks on the unit may dispense both waterless products and soap. Waterless systems can be used for cleaning hands that are not visibly soiled. Visibly soiled hands must be cleaned with soap and water (120), using handwashing procedures described in current Centers for Disease Control and Prevention Guidelines (119).

Sinks throughout the unit should be free-standing, have an offset drain to prevent splashing of the contents of the plumbing trap, be deep enough to prevent splashing, and designed for excellent drainage; water should not sit on counters or flat surfaces but should drain back into the sink (66). Areas around plumbing fixtures should be sealed, moisture resistant, and designed with splash protection. Dry work areas and counters should be located out of the splash range of the sink (121). Joints at walls and floors should be covered or tightly sealed. There should be no spaces that could harbor pests or allow the growth of pathogens (66).

Storage

The ICU design should provide adequate storage for all equipment, supplies, reference materials, and other items in current use, and plan for future needs. Storage is needed for personal items belonging to staff, patients, and visitors. Corridors should be kept clear to enhance both workplace safety and to present a calm, well-ordered workplace; carts, supplies, and equipment may not be kept in the path of egress or emergency access. Equipment and supplies should be stored as close as possible to where they are used. Separate storage should be provided for equipment used with patients in isolation, and for clean and soiled supplies and equipment.

CONCLUSION

Design of critical care facilities has an impact on organizational performance, clinical outcomes, and cost of care delivery. Organizations involved in design and construction projects are advised to engage experienced consultants who will collaborate with the users and make key design decisions on the basis of best current evidence.

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