



# Structure and function: planning a new ICU to optimize patient care

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## Purpose of review

To survey the recent medical literature reporting effects of ICU design on patients' and family members' well being, safety and functionality.

## Recent findings

Features of ICU design linked to the needs of patients and their family are single rooms, privacy, quiet surrounding, exposure to daylight, views of nature, prevention of infection, a family area and open visiting hours. Other features such as safety, working procedures, ergonomics and logistics have a direct impact on the patient care and the nursing and medical personnel.

## Summary

An organization structured on the needs of the patient and their family is mandatory in designing a new ICU. The main aims in the design of a new department should be patient-centered care, safety, functionality, innovation and a future-proof concept.

## Keywords

design, environment, ICU, patient-centered care

## INTRODUCTION

In 1852, Nightingale [1] observed the importance of keeping critically ill patients together in one separate place for special nursing care. One hundred years later, the polio epidemics of the 1950s and parallel developments in organ support technologies and monitoring made colocation of critically ill patients a necessity, leading to the establishment of ICUs [2,3] staffed by doctors, nurses and allied health professionals with special expertise in critical illness. During the years of evolution and institutionalization, the nursing and medical care were focused mainly on the improvement of the patient's illness and less on care of the family or concepts of patient and safety [4]. As intensive care medicine has become a specialty in its own right, a more holistic approach has developed, with research insights into the need to improve human factors [5] including the safety, reliability and compassion with which care is delivered, particularly to mitigate the mental stress of being an intensive care patient or a next of kin [6,7]. Moreover, the physical and psychological well being of the ICU nursing and medical personnel and the safety of the procedures in patient care have been carefully documented, especially during the last decade [8,9]. Whereas previously it was

common practice for ICUs to have been designed and built according to local or individual preference, we now recognize that a different approach is necessary, focusing on ergonomics and the special needs of patients and their families to create therapeutic and restorative environments in ICUs as part of the wider emphasis on better hospital design [9,10,11].

## WHERE TO BEGIN?

The first step in designing an ICU is to define a vision in order to create the best possible environment for critically ill patients and their relatives and which enables doctors and nursing staff to deliver safe, reliable and compassionate care (Table 1)

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**Curr Opin Crit Care** 2012, 18:688–692

DOI:10.1097/MCC.0b013e328358d4bd

## KEY POINTS

- An organization structured on the needs of the patient and the family is mandatory in designing a new ICU.
- Patient-centered care, safety, functionality, innovation and future-proof concepts should be the main aims in the design of the new department.
- Key to the concept's success is prior testing using full-scale models.
- Healthcare equipment must be simple and easy to use, with minimal alarms.

[9<sup>11</sup>,12,13]. Concepts can be developed in two domains: first, patient-centered care dictating structural considerations focused on architecture and interior design; and, second, functionality, processes of care and safety. The entire exercise should be underpinned by interviewing patients and their family members with experience of intensive care, as well as ICU staff, to evaluate the present condition and shortcomings they have experienced. A crucially important element in determining the final design is to create life-size models of a patient room or an area in the proposed unit in order to test the developed concepts [14]. It is not sufficient to see floor plans, as this provides a misleading perspective from which walls, impediments, poor lighting and inefficient or unsafe relationships between staff and structures are invisible.

## PATIENT-CENTERED CARE

Patient-centered care involves not only the needs of the patient but also of the family and the staff delivering that care.

## Needs of the patient

Single-patient rooms are needed to fulfill some of the needs of ICU patients. Results of several trials have shown that patients can suffer from sleep disturbance and restlessness due to high level of noise in ICUs [15–18,19<sup>12</sup>]. Single rooms with closed doors can provide a quiet environment. Dennis *et al.* [15] have shown that patients were significantly more likely to be observed sleeping when noise and light was reduced. Drouot *et al.* [16] and Ugras and Oztekin [18] confirmed these findings and identified noise as a cause of sleep disturbances.

Several studies have shown lower rate of infection with private rooms compared to multibed environments [20]. On the basis of various studies, Ulrich *et al.* [9<sup>11</sup>,21] extensively discuss effect of single bedrooms in reducing airborne infection and contact transmission. Moreover, Bracco *et al.* [22] found the risk of acquisition of pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA), *Pseudomonas* species and *Candida* species, was lower for those cared for in private, compared with open ward or multibed rooms. Furthermore, single bedrooms appeared to reduce or prevent MRSA infections compared with multibed rooms in various healthcare settings including ICUs [23–25]. Considering the complexity of ICU infections, additional information will be necessary on this matter. However, there is strong suggestive evidence in literature that single rooms limit transmission to roommates.

Single-patient rooms also help to ensure patient privacy. The patients must have visual privacy when needed and must be able to talk to family members and care providers without being overheard or interrupted [26<sup>12</sup>]. Electrostatic glass can be used for this purpose. The patients can normally be observed from outside and at the touch of a button, it

**Table 1. Features mandatory for future ICU design**

Patients-centered care		Functionality and safety		
Needs of patient	Needs of family	Physician/nurse nearby	Ergonomics	Safety
Healing environment	Hospitality	Space for treatment	Ceiling service units	Advanced alarms
Single rooms	Open visiting hours	Remote monitoring		Adequate supplies
Privacy	Bedroom with bathroom for family			Satellite pharmacy at ICU
Quiet surrounding	Clear signage			
Natural daylight	Family area with catering and internet facilities			
Views of nature				
Prevention of infection				

instantly becomes opaque guaranteeing privacy when needed. In a study performed by Fridh *et al.* [27], the relatives of the dying patients who were transferred to a private room were deeply grateful for the privacy. This way it was possible for the family to have their own private sphere, which only the family members themselves were allowed to enter.

Single rooms are also associated with fewer medication errors, improved social support by patients' families, improved communication between patients and staff and an overall increase in patients' satisfaction with care [28<sup>■</sup>]. However, single rooms make it more difficult for nursing staff to care for more than one patient concurrently and when used in the context of isolation (e.g. for infection control), it may result in deficiencies in reliability of and satisfaction with care [29].

In designing the room, well being and orientation of the patient should be the main goals. Therefore, it is important to design the rooms to help re-orientate and maintain a day and night rhythm [19<sup>■</sup>]. Therefore, each patient room should receive natural light. In a review article, Trochelman *et al.* [28<sup>■</sup>] have concluded that natural light in patient care areas reduced agitation in elderly patients, decreased length of stay, lessened the need for pain medication and reduced depression. Access to daylight also contributes to higher satisfaction for the staff [9<sup>■</sup>]. Natural light can be obtained by designing patient rooms with view outside the hospital. Alternatively, the rooms can be looking to an inside garden or patio. It has been stressed that having views of nature or gardens from patients' rooms reduced stress and pain [12,30–32].

The rooms should also be designed to make the patients feel at home [19<sup>■</sup>]. A clock, armchair, fashionable lamp and sideboard, all carefully color-coordinated, can be used for this purpose. A whiteboard in each room with the names of attending personnel is helpful for the patient and their family. A clear glass wall and door can be used to separate the room from the nursing staff replacing old-fashioned curtains. The ceilings in each room should be painted in soft colors with as few irregularities as possible. Delirium often occurs in patients in the ICU and the resulting disorientation is commonplace. Such patients may imagine strange phenomena emerging from the ceiling, whereas in fact it may simply be an air conditioning duct! In a recent study, Zaai *et al.* [33] have shown a shortening of delirium in patients who were admitted to a single-room ICU, designed to reduce noise with improved exposure to daylight in comparison to patients admitted to an open ward ICU.

## Needs of the family

The benefits of visiting relatives should not be underestimated, both from the positive effects they have on the patient and from the importance of their own comfort and peace of mind, and to mitigate the potential for posttraumatic stress. Designing respite areas for relaxation is an important factor [12]. A large area with catering and Internet facilities should be reserved for family use. Personal computers with Internet connection, cable television, telephone and an outside meeting space to their own cafeteria will make the relatives feel as welcome and as comfortable as possible.

Signage and way finding is important for the visiting family [19<sup>■</sup>]. Patient room numbers should be clearly marked. Directional signage should be easy to read, understand and follow. Multilingual signage should be considered if appropriate. Way-finding techniques, such as landmarks, art and floor patterns may be considered in symmetrical multiunit ICUs.

Strict visiting hours is not an applicable concept in a modern ICU. Twenty-four hours 'open' visiting policy should be applied for the family members and there should be no restrictions on visiting time [34]. This flexibility will result in a quieter atmosphere, as the visits of family members are not concentrated between certain hours.

Bedrooms with bathroom and shower can be built in the unit for those who live far away or for those where the patient is particularly ill. Some ICUs prefer to locate the family rooms next to the patients' rooms [19<sup>■</sup>]. On the contrary, the area chosen for family members can also be situated in a quiet corner of the department. This way, the family is not exposed to the daily activities in the ICU when they are not in the patient room, giving them an atmosphere of privacy, security and trust.

## FUNCTIONALITY AND SAFETY

Purchasing decisions for medical equipment should be based on prior concepts of functionality, safety and innovation, and the interaction between equipment, staff and patients.

## Physician and nurse at the bedside or nearby

In many clinical settings, when patients are perceived to be in a stable condition, nursing staff may tend to congregate at a central station rather than remain at the bedside. Centralized monitoring and observation may be essential when the ICU consists of multiple single rooms and there are limitations on the numbers of nurses [20]. A preferable model is to decentralize nursing care to

facilitate close proximity of the nurse and patient [35]. A compromise position is to design a 'racetrack' configuration with single rooms on the periphery of a common corridor or looking to a patio or inside garden, with workstations and viewing windows in between every two rooms, increased entry of natural lighting and zones of space dedicated for personnel and family [20,35]. Between patient care, the nurses can observe their patients outside the room from their workstations through a glass window, which allows visual access to the patients. Every workstation has access to the hospital and intensive care patient data management systems (PDMS) and Internet. This concept brings the nurse closer to the patient. After examining the patients, the physicians can also go to this workstation and confer with the patient with nurses and other colleagues.

Medical equipment needs to include design considerations of simplicity, ease of use and minimal alarms. Remote control of the monitors from outside the patient's room also means fewer interactions. With a small nurse station outside each pair of rooms, the monitor at each desk will allow the staff to view, control, review and record, without exposing the patients to unnecessary noise and presence of personnel in the room.

## Ergonomics

Headwalls or ceiling service units can be used in designing the patient room. The ceiling service units have the advantage that the medical apparatus, PDMS and the routinely used medical equipments are off the floor. Emergency access to the head of the bed is possible by positioning the ceiling service units. Furthermore, these units allow the flexible positioning of the patient's bed. The bed of the patient can be adjusted for complete sitting position and an awake patient can be positioned easily toward the gardens or the outside view without extensive repositioning of the other equipment. The positioning of ceiling service units is crucial for their functioning. Mock-up patient room setting should be used to test optimal functioning [14].

## Safety

Decentralization of nursing care to facilitate close proximity of the nurse and patient in single rooms reduces contact between staff. Communication may be facilitated with a bleeper or smart phone, which could be adapted to receive specified patient alarms created by mechanical ventilators, infusion or syringe pumps, monitors and other medical devices, and used to call for help in emergency situations. Although the technology is available, a lot of work is

needed to achieve a good functioning system. Further details of such devices are outside the scope of this article.

In a qualitative interview study, Gurses and Carayon [36] reported that the main types of performance obstacles for the nurses were delays in getting medications from pharmacy, inadequately stocked supplies area, as well as patient rooms, and misplacement of supplies in the supplies area. To avoid this, supplies at least for the next 24 h should be prepared and brought daily to the patient's room by the logistics department. A cupboard or mobile cart with drawers can be used for this purpose.

In a recent review article, Hassan *et al.* [13] have stressed the high incidents of medication errors and adverse drug events. Automated dispensing devices and barcode medication administration systems may prevent such incidents. An in-ICU pharmacy store room and an ICU pharmacist as a member of the team are preferable.

## CONCLUSION

An organization structured on the needs of the patient and the family is mandatory in designing a new ICU. Concepts should be developed and tested in large-scale models before finalizing the choice of architecture and equipment. Patient-focused design will ensure that while specific materials, apparatus and infrastructure will age and need replacement, the underlying design and functionalities remain secure for the future.

## Acknowledgements

None.

## Conflicts of interest

*There are no conflicts of interest.*

*Financial support: none.*

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- of special interest
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Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 729).

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