Intensive care unit environment

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Key points

The intensive care unit (ICU) is a potentially hostile environment for the vulnerable critically ill patient.

Adverse environmental factors can contribute to delirium.

Delirium is associated with an increased length of hospital stay and increased mortality.

Frequently reported stressful *environmental factors* are noise, ambient light, restriction of mobility, and social isolation.

Improving the ICU environment involves education of critical care staff, modification of equipment, and careful consideration to future ICU design.

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The speciality of intensive care medicine was developed as a consequence of the poliomyelitis epidemic of the 1950s, when widespread mechanical ventilation was required. Since then the technology available to support the critically ill patient has become more sophisticated and complex, and the importance of intensive care units (ICUs) in today's healthcare system is without question. In 1994, Critical Care Medicine reported that nearly 80% of all Americans will experience a critical illness or injury, either as the patient, family member, or friend of a patient, and that ICUs occupy only 10% of inpatient beds, but account for nearly 30% of acute care hospital costs. However, the ICU is a potentially hostile environment to the vulnerable critically ill patient. In addition to the physical stress of illness, pain, sedation, interventions, and mechanical ventilation, there are psychological and psychosocial stressors perceived by these patients. One of the additional factors is the ICU environment, which is also thought to contribute to the syndrome known as ICU psychosis/delirium.[1] Frequently reported stressful *environmental factors* are noise, ambient light, restriction of mobility, and social isolation.

Noise levels

Noise can be defined as any unwanted or undesirable sound which is subjectively annoying or disrupts performance and is physiologically and psychologically stressful. It is subjective and influenced by several factors such as individual sensitivities, cultural and social factors, the sense of having control over the sound, and whether it is appropriate to the situation. Noise can be continuous, fluctuating, or intermittent.[2] Sound is usually measured in decibels (dB) which is a logarithmic scale expressing the ratio of a sound pressure to a reference level. A doubling of sound pressure results in an increase of 6 dB. However, to the human ear, an increase of 10 dB is perceived as a sound twice as loud.[3] Noise is usually measured on the dB(A) scale, which is a frequency-weighted scale applied to reflect the relative sensitivity of human hearing to mid- and higher frequencies and corresponds closely to the subjective impressions of the loudness or intensity of acoustic noise.[4]

The World Health Organization recommend that the average background noise in hospitals should not exceed 30 A-weighted decibels [dB(A)], and that peaks during the night time should be <40 dB(A).[5] Noise in ICUs frequently exceeds these values. Studies have reported average noise levels of 60–70 dB(A) with peaks over 90 dB(A). In addition, some researchers found that sound pressure levels did not significantly reduce at night.

The generation of noise is multifactorial and generally down to behaviour and equipment. Items falling onto the floor have been recorded as 92 dB(A) and nebulizers at 80 dB(A). The loudest noise appears to be the hood used for continuous positive airway pressure where sound pressure levels of above 100 dB(A) have been measured. Table 1 places ICU noise in the context of commonplace noises.

How does noise affect patients in ICU?

Sleep

In the past, ICU noise has been considered an important environmental cause of sleep disruption. Sound pressure levels of below 40 dB(A) are generally required to enable sleep, although the auditory threshold for waking may increase when individuals are continually exposed to a noisy environment.[6] However, a few studies investigating polysomnography and environmental noise measurements found that although environmental noise was in part responsible for sleep–wake abnormalities, it was not responsible for the majority of sleep fragmentation (Fig. 1). Despite this, patients still perceive noise as a common cause of disrupted sleep on the ICU and may find it difficult to get to sleep because of the continuous background noise.[7] It has been suggested that the disruption to

doi:10.1093/bjaceaccp/mkp036

Table 1 Examples of commonplace noise levels

Example of noise	Sound pressure level [dB(A)]
Jet aircraft taking off at 50 m/ship's engine room	120
Loud music in a disco	100
Lawn mower at 1 m	90
Vacuum cleaner at 1 m	70
Average ICU sound level	60–70
Conversation at 50 m	55
Soft whisper in a library	40

sleep caused by noise may become more important as a patient begins to recover from critical illness.[2]

Research has shown that there are two distinct stages of sleep: non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. NREM sleep is further subdivided into four stages, where the progression of sleep from stage 1 through to stage 4 is accompanied by a progressive increase in the arousal threshold.[8] Stages 3 and 4 represent a deeper sleep and are also known as delta or slow-wave sleep (SWS). REM sleep is a very active stage with a high degree of physiological activity such as irregularities in respiration and heart rate (Fig. 2). Most normal individuals spend 13–23% of their total sleep time (TST) in stage 3 or 4 sleep and 20–25% of their TST in REM sleep, although this varies markedly with age. Although the brain is very active during REM sleep, it is also considered to be restful sleep with a variable arousal threshold.

Critically ill patients do not sleep well. In general, patients in critical care units may spend 30–40% of their sleep time awake, sleep may be highly fragmented and distributed throughout the day and night, and there is a reduction in slow wave and REM sleep.[9] There may even be a complete absence of definable sleep or wake states in septic patients. Sleep deprivation is associated with mental changes and delirium in the ICU and may have a detrimental effect on recovery. Lack of SWS may impair memory formation and the consequent amnesia may contribute to delirium. In healthy subjects, sleep deprivation is associated with impaired immune function and the development of a catabolic state.

Other effects of noise on patients

Exposure to noise can be annoying, ranks highly among causes of ICU stressors, and is clearly an individual, subjective, and variable response. Perceived lack of control over noise, for example, may contribute to noise-induced stress.[10, 11] Noise exposure may trigger a response by the sympathetic nervous system, thereby increasing cardiac work and may also have adverse effects on respiratory muscle function. Excessive noise may increase sedation requirements in critically ill patients, may impair communication, and may contribute to hearing loss. Hearing loss is an additional risk factor for the development of delirium.

Light and temperature

It is recognized that the human sleep–wake cycle is closely linked to the environment and, along with social cues and sounds, the light–dark cycle is probably the most powerful linking factor.

Fig 1 Polysomnography with four channels (C3, C4, O1, and O2) of EEG, right and left electrooculagrams (EOG), chin and limb (EMG), EKG, and continuous environmental noise recording (mean noise). The EEG represents stage 1 sleep with an arousal caused by a burst of ambient noise measuring 69 dB(A). (Reproduced with permission from Freedman and colleagues.[7])

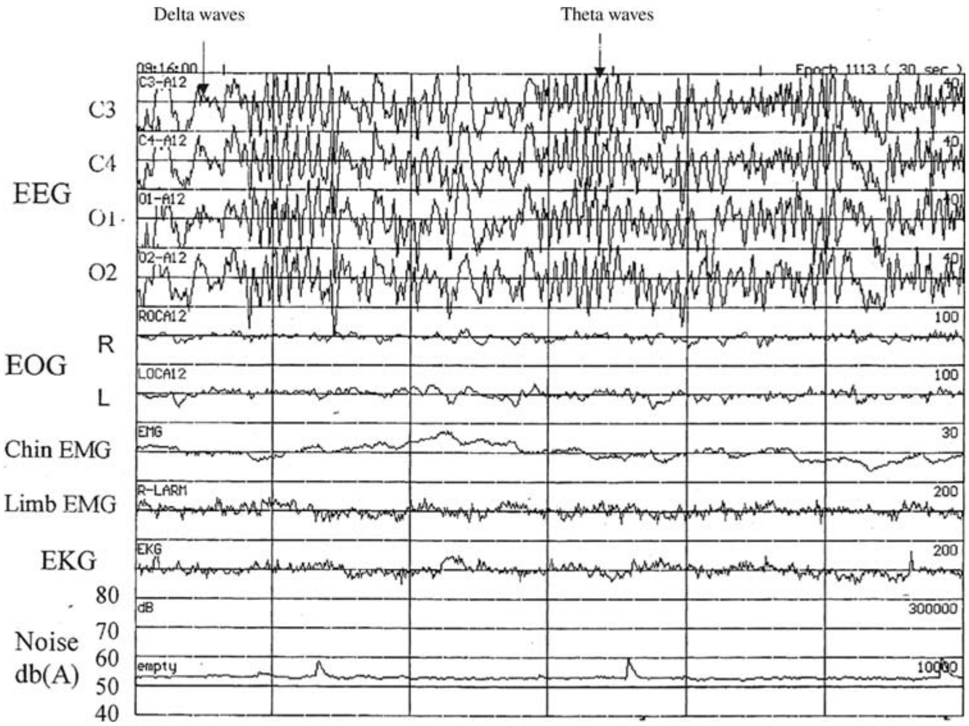

Fig 2 Polysomnographic representation of septic encephalopathy. This EEG pattern demonstrates a baseline of low-voltage mixed-frequency waves with intermittent theta and delta waveform activity. (Reproduced with permission from Freedman and colleagues.[7])

Sleep–wake cycles can be prolonged if these linking factors are altered, and in some ICUs, patients are not exposed to any natural light. Patients may then become unable to distinguish night from day and this can contribute to disorientation. Although light intensity on ICU usually reflects a 24 h circadian rhythm, bright lights from the nurses' station, lights that are not dimmed, and lights that are turned on at night can be very disrupting to patients' sleep.

Ambient temperature exerts a prominent influence on sleep. Low ambient temperatures generally impair sleep, whereas higher temperatures tend to promote sleep. As with noise, there are marked individual differences in sensitivity to temperature variation and in an individual's optimal sleeping temperature. TST is maximal in thermoneutrality, where temperature regulation is achieved by control of insensible heat loss, without regulatory changes in either metabolic heat production or heat loss.

Restricted mobility, communication, and social isolation

The limitation in communication, eating, and movement all add to the stress experienced by the ICU patient. The inability to speak appears to be a large problem in mechanically ventilated patients and not understanding why they cannot speak and a fear of never being able to speak again compounds the issue. Mechanically ventilated patients describe 'not being understood' as extremely stressful. They expend a significant amount of energy in unsuccessful efforts to communicate, and the accuracy of the message received is not certain.

Maintaining privacy in hospital is notoriously difficult and it has been suggested that while in an ICU patients regress to infantile standards of behaviour and a state of dependency, having to rely on strangers to perform formerly simple tasks such as hygiene, feeding, or even changing position in the bed. Restricted mobility secondary to illness, drugs, and equipment, together with impaired communication means that patients feel they have a lack of control over what happens to them.

Social isolation is frequently associated with the nature of the ICU experience. The physical layout of the ICU or the condition of the patient (e.g. infection) may mean that an individual side room is required and there is also the possibility of restricted visiting by family and friends. Separation from the patient's usual social activities may create an emotional response that hinders weaning from the ventilator.

Delirium in the ICU

Delirium is currently very topical and has received much interest in the critical care literature. According to Ely and colleagues,[11] the diagnosis of delirium requires the presence of 'acute onset of changes or fluctuations in the course of mental status' and 'inattention', and either 'disorganized thinking' or an 'altered level of consciousness'. Some of the physiological changes that occur with delirium include peripheral vasoconstriction, increased arterial pressure, epinephrine release, and muscle tension.

Delirium is more common in the elderly population, and although dementia and delirium can coexist, dementia is usually found among elderly people who are not necessarily acutely ill. Dementia does not usually cause clouding of consciousness, which is common among patients suffering with delirium. In addition to age, physiological and psychological factors are implicated as risk factors for the development of delirium. Physiological factors include administration of drugs such as benzodiazepines or narcotics, cardiogenic or septic shock, hypoxia, renal failure, presenting illness, and metabolic or thermal disturbance. Psychological factors include visual or hearing impairment, pre-existing psychological problems, and environmental factors such as sleep deprivation, noise, separation, communication, and immobilization.[1]

Delirium in the ICU has an incidence of 15–80%[1, 8] and, in the past, has been notoriously difficult to quantify. Ely and colleagues[11] have recently provided a four-feature confusion assessment method for the ICU (CAM-ICU) which is valid and reliable. A subsequent study of 275 patients using this method found ICU delirium to be extremely common with 81.7% patients developing delirium at some point during their ICU stay.[8] The study also found that delirium was an independent predictor of a longer length of stay and mortality at 6 months in ventilated ICU patients. Delirium is also associated with increased length of hospital stay.[1, 11]

Delirium in the ICU should be prevented if at all possible. Non-pharmacological interventions that encourage orientation of patients to their surroundings and maintain normal physiological function are vital. Suggestions for improving the ICU environment are discussed below. If all preventative measures fail then additional treatment will be required. Medical management consists of diagnosing the syndrome, removing the underlying causes, and treating the signs and symptoms. Medication used to treat a patient's primary condition may be contributing to the delirium and so consideration should be made to either reduce the dose or find an alternative. However, pharmacological therapy may ultimately be required. Haloperidol is the agent of choice for patients who are agitated. A dose of 0.5–10 mg orally or i.v. is recommended, depending on the level disturbance, age, and cardiovascular status. Benzodiazepines are recommended for withdrawal states.[9]

Suggestions for improving the ICU environment

How to minimize the impact of noise?

Behaviour

A large proportion of noise generated in the ICU seems to result directly from behaviour, for example, from talking or television.[12] Loud voices are generally louder than the telephone or alarms. To minimize noise disruption, it would seem logical to implement a behaviour modification programme to raise awareness of the problem followed by measures to limit noise, for example, from talking. It comes as no surprise that bed spaces opposite the nurses' station and tea trolley are exposed to the most noise. The nurses' station represents a focus of activity and is undoubtedly required as a place for staff to sit down, write in notes, discuss patients, look up results, etc. However, it is also an area of social gathering and chatter. When patients are sedated and ventilated, or appear to be sleeping, it is very easy to forget that they might still be able to hear what is going on around them. However, staff morale has to be considered and a total ban on all non-medical talk could prove to be counter-productive.

Rest periods on the ICU have been tried but with varying success. Although noise levels have not been found to be significantly reduced during these periods, dimmed lights and reduced interventions may also be beneficial.

Equipment

Noise from alarms and equipment is ever present on the ICU. Reducing the volume of alarms, telephones, and intercoms should help to improve noise pollution. Perhaps some of the equipment, for example, the telephones or intercom, could have a flashing light or vibrating system rather than a ring tone. Alarm volumes could be reduced, particularly at night. It may even be possible to provide staff with individual vibrating devices that could replace some of the alarms and could even replace the nurse call system. Oiling squeaky doors and trolleys could help to reduce sound pressure levels, as could the use of bins with cushioned, automatic slowly closing lids.

ICU design

The design of an ICU may influence noise pollution. Strategies for noise reduction include double-glazed windows, floors, walls, and ceilings constructed of materials with high sound absorbing capabilities, offset doorways to reduce sound transmission, ceiling soffits and baffles to help reduce echoed sounds, and surrounding the nurses' station with clear glass (Fig. 3)

The Health Building Note (HBN) 57 states that a single room for each patient should be the long-term strategy as this preserves privacy, dignity, and confidentiality. Single rooms help to decrease noise levels in most instances, although they may also inhibit dispersal of sound from within, and may promote infection control issues. There are concerns from some clinicians regarding such a development because of issues regarding patient safety and provision of an overview of every patient from the nurses' station/communication area. Providing video telemetry or using glass to construct the single rooms (with blinds for privacy) may be an alternative option. Noise sensitivity and annoyance is very subjective. Some patients might find background noise and chatting reassuring and in these patients, a side room may not be the best option. It has been suggested that single rooms may be useful in patients who have stabilized from their critical illness and are trying to re-establish normal circadian rhythm.

Fig 3 Polyvision glass demonstrating glass that switches from opaque to clear at the touch of a button. Top image: opaque (power off). Bottom image: clear (power on). Side rooms could be constructed using this glass. (Reproduced with permission from www.polytron.com.tw, December 2008.)

Additional suggestions

Earplugs have been found to produce a significant decrease in REM latency and an increase in the percentage of REM sleep in healthy volunteers exposed to recorded ICU noise. Despite the lack of studies on ICU patients, this may be a viable option. However, staff must remember to remove earplugs from sedated or immobile patients at appropriate times, or they may worsen disorientation and confusion. Music has helped to decrease noise annoyance, heart rate, and systolic arterial pressure in cardiac patients and so this may be an option on the general ICU. Finally, noise cancellation devices have been shown to reduce the subjective assessment of noise in caregivers from an adult and paediatric ICU. Their use on patients may have similar problems as earplugs.

Suggestions to minimize the effects of adverse lighting and ambient temperature

There seems to be little doubt that light levels reflecting a circadian rhythm are beneficial and that reducing light intensity at night will help to promote sleep. Artificial lights are required for a variety of reasons, such as looking at observation charts, reading drug cards, and effective cleaning. However, ceiling-mounted fluorescent lighting directly over the bed space is felt to be unacceptable, as patients cannot avoid the glare. Dimmable, flexible, multidirectional lighting should be used. A patient reading light is desirable. HBN 57 recommends the maximal use of natural light, glazing to allow patients to see out but prevent anyone else from seeing in, and a view if possible. Natural light may help to reduce disorientation. Views can act as a positive distraction, reducing stress.

It would seem sensible to accommodate a patient's preferable temperature range, particularly at night, in order to promote sleep. Single rooms may make this easier to achieve. Bed areas should be mechanically ventilated and cooled, with other areas naturally ventilated where possible.

Suggestions to improve communication and prevent social isolation

While some of the treatments and interventions that a patient on ICU is exposed to are unavoidable, staff should be sympathetic to the needs of their patients. Pain should be alleviated and interventions kept to a minimum. An atmosphere in which rest is possible should be provided. In patients who are weak and who have a critical illness polymyopathy or neuropathy, patience and understanding will be vital to reassure and comfort. Communication and understanding can be improved by the use of pen and paper, letter/word charts, and computer voice synthesizers. Hearing aids should be switched on, glasses worn, and families consulted regarding problems with communication in the past. Where possible, patients should be given more information by the multidisciplinary team, participate in their own clinical treatment, and feel involved in the process.

Although single rooms may preserve dignity and allow privacy, they may compound the problem of social isolation. If not constructed in glass, rooms can be painted in colours that promote rest and have a calming effect. In order to improve sensory orientation, a clock, calendar, bulletin board, and access to a television (with earphones) could be provided. It is important to allow friends and family the time and space to visit. There may be little room for relatives to sit and the layout and acoustics of the ICU may make privacy impossible. Therefore, provision should be made for this and also overnight facilities, an interview room, a sitting room, and snack making area.

Maintenance of the patient's normal routine, particularly at bedtime, may help to reduce anxiety and promote sleep. Families can bring in items from home that may help the patient feel more relaxed and less frightened.

Conclusion

There are a wide variety of environmental factors that affect patients on ICU. They all interact with each other and can have significant effects on the health, well-being, and outcome of critically ill patients. A lot of time, effort, and money are invested in the technological and pharmacological advances of intensive care medicine. Improving the ICU environment is also important and involves a dedicated, sympathetic, multidisciplinary team, education of critical care staff, modification of equipment, and careful consideration to future ICU design.

References

1. Ely EW, Gautam S, Margolin R *et al.* The impact of delirium in the intensive care unit on hospital length of stay. *Intensive Care Med* 2001; **27**: 1892–900
2. Pugh RJ, Jones C, Griffiths RD. The impact of noise in the intensive care unit. *Yearbook of Intensive Care and Emergency Medicine*. Berlin and Heidelberg: Springer, 2007; 942–9
3. Meyer TJ, Eveloff SE, Bauer MS *et al.* Adverse environmental conditions in the respiratory and medical ICU settings. *Chest* 1994; **105**: 1211–6
4. Pugh RJ, Griffiths R. Noise in critical care. *Care Crit Ill* 2007; **23**: 105–9
5. Berglund B, Lindvall T, Schwela DH. *Guidelines for Community Noise*. Geneva: World Health Organization, 1999
6. Cooper AB, Thornley KS, Young GB *et al.* Sleep in critically ill patients requiring mechanical ventilation. *Chest* 2000; **117**: 809–18
7. Freedman NS, Kotzer N, Schwab RJ. Patient perception of sleep quality and etiology of sleep disruption in the intensive care unit. *Am J Respir Crit Care Med* 1999; **159**: 1155–62
8. Ely WE, Shintani A, Truman B *et al.* Delirium as a predictor of mortality in mechanically ventilated patients in the intensive care unit. *J Am Med Assoc* 2004; **291**: 1753–62
9. Borthwick M, Bourne R, Craig M *et al.* Detection, prevention and treatment of delirium in critically ill patients. Intensive Care Society 2006. Available from www.ics.ac.uk
10. Freedman NS, Gazendam J, Levan L *et al.* Abnormal sleep/wake cycles and the effect of environmental noise on sleep disruption in the intensive care unit. *Am J Respir Crit Care Med* 2001; **163**: 451–7
11. Ely EW, Inouye SK, Bernard GR *et al.* Delirium in mechanically ventilated patients. validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU). *J Am Med Assoc* 2001; **286**: 2703–10
12. Kahn DM, Cook TE, Carlisle CC *et al.* Identification and modification of environmental noise in an ICU setting. *Chest* 1998; **114**: 535–40

Please see multiple choice questions 4–6