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Noise in the intensive care unit: where does it come from and what can you do about it?

Practical measures and interventions to reduce noise levels in the ICU and to improve the patient experience.

The intensive care unit (ICU) is known to be noisy and is getting louder (Busch-Vishniac et al. 2007). Despite several trials, no interventions have been able to reduce noise levels by a meaningful amount (Li et al. 2011; Boyko et al. 2017; Johansson et al. 2017). There tends to be a view that high noise levels are to be expected in the ICU due to the level of care being delivered, and that little can be done to change this (Litton 2019). However, our recent study (SILENCE: NIHR Research for Patient Benefit ref: PB-PG-0613-31034) suggests that sound levels can be lowered if staff can be encouraged to think differently about the problem and given the opportunity to be involved in designing interventions to reduce noise levels.

We used a mixed methods approach (Cresswell 2014) to assess the ICU environment. This involved qualitative analysis of both patient and staff experiences, and quantitative measurement of the ICU soundscape. Patients consistently reported that they were frequently disturbed, unable to sleep, frightened by the unfamiliar surroundings, and, after discharge, they struggled to reconcile their memories with reports of what had happened to them (Darbyshire and Young 2013). Ethnographic observations identified that the environment is somewhat chaotic, and generally organised for the convenience of staff. Nurses strived to deliver care efficiently, but it was apparent that there were discrepancies between ‘work as imagined’ (staff perception of working practice) and ‘work as done’ (the realities in the workplace) (Hollnagel 2016).

We also noticed that these frequent patient interactions contributed to noise and disturbance over and above the sounds directly associated with the task. Alarms, frequently triggered by the staff intervention, were left to run until care activities were completed. This behaviour contrasted with staff reports that they always silenced alarms immediately. It was clearly considered ‘normal’ to allow alarms in these circumstances. Acceptance of practice that would be considered inappropriate in other settings is an example of ‘normalised deviance,’ a term coined by Diane Vaughan in relation to the NASA Challenger disaster (Price and Williams 2018).

When deviance occurs, it is common for actions and behaviours to be defended as necessary and justified. In this case, it might be that the patient needs to be rolled and the alarm is triggered due to physical movement rather than physiological abnormality. Staff therefore correctly recognised that these alerts were false-alarms, but did not obviously consider their contribution to local noise pollution, or the potential effects of this on patients.

Mismatches between staff perception and reality are particularly important when thinking about culture change because if interventions focus on ‘work as imagined,’ the realities of ‘work as done’ are not addressed. Equally, addressing work as done without overt reference to how this differs from ‘work as imagined’ is likely to have limited effect as staff may not recognise the need for change.

Quantitative measurement of overall Sound Pressure Levels (SPL) was revealing, and supported the qualitative reports generated from patient interviews. It demonstrated SPL levels persistently higher than the World Health Organization (WHO) recommendations, with peak values frequently measured over 100dB (Darbyshire and Young 2013). Patterns were observed in the data. Handover periods were consistently one of the louder periods of a shift, and it was obviously quieter overnight, although still well above WHO guideline levels. We also found that simple environmental modifications can facilitate noise reduction strategies. We saw a number of “solutions” to noise problems; for example, wadding placed in a doorway to prevent the door slamming because the soft-close mechanism was broken and the lifting of trolleys in motion to prevent the sound of a squeaky wheel. We particularly noticed that nightshifts were quieter when lights were off except to facilitate care interventions. Darkness, therefore, seemed to be low. We also noticed that whilst it seemed to be common to turn overhead lights out overnight for patients who were...
Below 40 dB, no evidence was found that the biological effects on patients was harmful to health.

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Below 55 dB is overwhelming effective at recreating the noise levels in the ICU, as staff members are given the opportunity to experience the ICU from the patient’s point of view. The course evaluation indicated this teaching is overwhelmingly effective at recreating the feelings reported by real ICU patients. The session could be stopped at any time by the participant, although none did so. After just a few minutes, staff reported feeling uncomfortable, confused, stressed, frightened, and alone; feelings which map closely to how patients describe their time in the ICU. In line with adult education theory (Kolb and Fry 1975), participants were encouraged to reflect on their experience and relate it to their patients who have no control over their situation, and who cannot take ‘time out.’

One aspect of the simulation experience was to demonstrate the patient experience of alarms. As staff were healthy volunteers, the monitors were manipulated to sound an alarm tone while the participant was connected to it. This unexpected alarm was intended to simulate the concern that patients spoke about when they heard alarms. The disturbance caused by a noise such as an alarm is more than a simple function of volume. The intrusiveness of noise is dependent on its frequency. By design, alarms have similar sound qualities to a baby’s cry or a human scream, representing primal triggers of attention in most humans. They are intended to be disturbing so that they attract attention. In open plan ICUs, this means that every alarm can be attended to by any member of staff. It also means that every alarm is heard by every patient. Even where patients are admitted to single rooms, they will be repeatedly disturbed by their own alarms.

‘Loudness’ is a measure of sound that allows the subjective perception of the sound to be quantified (ISO 2017). Sounds of a higher pitch, such as alarms, are more likely to be disturbing. In our study, loudness levels showed a clear reduction of about 4 dB between 1 am – 4 am, although this marked dip is not seen in the average decibel level which remains fairly constant (Darbyshire et al. 2019). This suggests that there were fewer alarm sounds during this period.

Implementing alarm management guidelines was challenging. While it has been reported that almost 90% of alarms are unnecessary (Gorges et al. 2009), staff (perhaps understandably) employ the precautionary principle (UN 1992) and are reluctant to alter alarm volumes or patterns. From a psychological perspective, however, this is an overly simplistic approach as auditory and visual distractors have a measurable impact on task performance (Simons 2000; Bressan and Pizzighello 2008, Molloy et al. 2015), and alarm fatigue is a well-recognised source of risk (Ross 2015; ECRI Institute 2011). Improvements then can be achieved in both patient comfort and safety through better understanding and use of alarms. Specifically, meaningful change is more likely with a wider understanding of the types of noise that are likely to be most disturbing, and better awareness of the consequences for patients of this constant disturbance.

<table>
<thead>
<tr>
<th>Table 1. World Health Organization noise level recommendations</th>
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<tbody>
<tr>
<td>• Average patient room noise should remain at 30dB</td>
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<tr>
<td>• Below 30dB, no effects on sleep are observed except for a</td>
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<td>minor increase in the frequency of body movements.</td>
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<td>• Below 40 dB, no evidence was found that the biological</td>
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<td>effects on patients was harmful to health.</td>
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<td>• Noise level above 40 dB resulted in sleep disturbance,</td>
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<td>environmental insomnia, and increased use of somnifacient</td>
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<td>drugs and sedatives. Vulnerable groups may be more</td>
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<td>affected.</td>
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<td>• Noise level above 55 dB is considered dangerous for</td>
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<td>patient health. Patients may be annoyed due to lack of</td>
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<td>proper sleep and the risk of cardiovascular disease may</td>
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<td>also increase.</td>
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The final phase of the SILENCE project was to design a system to report sound levels and feed this back in real time. The research team consulted with clinical staff throughout this development period. By the end of the SILENCE project, SPL had reduced a further 7 dB to ~46 dB (Young et al. 2018). This drop of 11 dB is a significant change, that is easily noticeable in the environment.

A recent meta-analysis of interventions limiting patient exposure to noise and disturbance through the use of earplugs and eye masks has been shown to reduce the risk of delirium (Litton et al. 2016). It is highly likely that ambient noise levels also have a significant environmental effect on sleep. SILENCE and other similar studies have consistently reported the difficulties with measuring the duration/quality of sleep in the ICU (Jeffs and Darbyshire 2017; Bourne et al. 2007; Beecroft et al. 2008; van der Kooi et al. 2012). Better measures of sleep are therefore needed for routine clinical use if we are to be able to measure the effects of changing noise levels more accurately. Future research will need to focus on patient-oriented outcomes such as sleep and delirium, and their correlation with measures of sound.

We speculate that ‘making a lot of noise about SILENCE’ (without explicitly dictating behavioural change), may have contributed indirectly to the local improvements in loudness and SPL, essentially by activating what is commonly termed the “Hawthorne Effect.” Encouraging staff to be directly involved with practical measures to improve the patient experience of ICU having been through a visceral experience of their own (thus having a personal understanding of the problem of noise in the ICU) seems to have been the key driver for change. In conclusion, mixed methods enable richer interpretation and deeper understanding than is possible through quantitative or qualitative methods alone. Focusing on patient experiences and including those working in the environment to help design change seems key to achieving significant success.

Key points
- Sound levels in the intensive care unit can be reduced
- It is important to consider the quality of the sound as well as the volume
- Including patients and care delivery staff in the development of interventions changes group dynamic and improves engagement
- Immersive, experiential simulation teaching is a powerful learning tool
- Educational interventions need to align with adult educational theory

References

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