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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 et al. 2016). 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.

"almost 90% of alarms are unnecessary; staff (perhaps understandably) employ the precautionary principle and are reluctant to alter alarm volumes or patterns"

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 an indicator to staff that patients should be sleeping and that general activity levels should be low. We also noticed that whilst it seemed to be common to turn overhead lights out overnight for patients who were not sedated, they were often left on above-sedated patients, thus contributing to the disruption of the circadian regulatory system (Bedrosian and Nelson 2017).

After compiling noise data and the qualitative results, an intervention strategy was designed using the principles of experience-based co-design [EBCD] (Locock et al. 2014). Simple solutions such as replacing broken metal bins with soft-close-lid plastic versions removed a key source of noise. The research group also liaised with local staff to write alarm management guidelines, incorporating individualised alerting parameters and suggesting that volume levels should be guided by changing ambient sound levels rather than simply being set to the maximum throughout the shift. We highlighted the lighting effect on night time noise to encourage better day/night differentiation and recommended that switching off main unit lights should become part of policy (Darbyshire and Hinton 2018). Finally, the research team engaged with a medical educationalist to design a teaching module comprising an e-learning package and a simulation exercise (Darbyshire et al. 2018). The experiential aspect of the immersive simulation contextualises the need to reduce 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.

“ 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 ”

'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 4dB between 1am – 4am, 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.

SPL in Oxford were reduced by approximately 4dB in the four months after environmental changes were introduced, and after initial delivery of the teaching sessions.

Table 1. World Health Organization noise level recommendations

- Average patient room noise should remain at 30dB
- Below 30dB, no effects on sleep are observed except for a minor increase in the frequency of body movements.
- Below 40 dB, no evidence was found that the biological effects on patients was harmful to health.
- Noise level above 40 dB resulted in sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives. Vulnerable groups may be more affected.
- Noise level above 55 dB is considered dangerous for patient health. Patients may be annoyed due to lack of proper sleep and the risk of cardiovascular disease may also increase.

Source: Night noise guidelines for Europe (2009). World Health Organization

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 7dB to ~46dB (Young et al. 2018). This drop of 11dB 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. ■

> **auditory and visual distractors have a measurable impact on task performance, and alarm fatigue is a well-recognised source of risk**

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

Bedrosian TA, Nelson RJ (2017) Timing of light exposure affects mood and brain circuits. Translational Psychiatry, 7, E1017.

Beecroft, JM., Ward M, Younes M, Crombach S, Smith O, Hanly PJ (2008) Sleep Monitoring in the intensive care unit: comparison of nurse assessment, actigraphy, and polysomnography. Intensive Care Med, 34: 2076-83.

Bourne RS, Minelli C, Mills GH, Kandler R. (2007) Clinical review: sleep measurement in critical care patients: research and clinical implications. Crit Care, 11: 226.

Boyko Y, Jennum P, Nikolic M, Holst R, Oerding H, Toft P (2017) Sleep in Intensive care unit: the role of environment. Journal Of Critical Care, 37: 99-105.

Bressan, P. & Pizzighello, S. 2008. The attentional cost of inattentional blindness. Cognition, 106, 370-383.

Busch-Vishniac I, West JE, Kwon P, Dunn J (2007) The challenges of noise control In hospitals. 14th international conference on sound and vibration. Cairns, Australia.

Cresswell JW (2014) Research design: qualitative, quantitative, and mixed methods Approaches. Los Angeles, London, New Delhi, Singapore, And Washington Dc, Sage Publications.

Darbyshire JL, Greig PR, Vollam S, Young JD, Hinton L (2016) "I Can Remember Sort of Vivid People...but to Me They Were Plasticine." Delusions on the Intensive Care Unit: What Do Patients Think Is Going On?. PLOS ONE, 11(7).

Darbyshire J, Young J, Bedford J, Redfern O, Hatch R. (2019) Understanding sound Pressure levels in the intensive care unit. 39th International Congress Of Intensive Care And Emergency Medicine, 19-22 March. Brussels.

Darbyshire JL, Hinton L (2018) Using patient narratives to design an intervention to Reduce noise in the intensive care unit. The Journal Of Health Design, 3(2): 109–112.

Darbyshire JL, Hinton L, Young J, Greig P (2018) Using the experience-based co-Design method to design a teaching package. Medical Education, 52: 1198.

Darbyshire JL, Young JD (2013) An investigation of sound levels on intensive care Units with reference to the WHO guidelines. Crit Care, 17, R187.

ECRI Institute (2011) Top 10 health technology hazards for 2012. Health Devices, 40: 1-18.

Gorges M, Markewitz BA, Westenskow DR (2009) Improving alarm performance in The medical intensive care unit using delays and clinical context. Anesth Analg, 108: 1546-52.

Hollnagel E (2016) The nitty-gritty of human factors. In: Shorrock, S. & Williams, C. (Eds.) Human factors and ergonomics in practice: improving system performance and Human wellbeing in the real world. Boca Raton, Fl: CRC Press.

ISO 2017. ISO 532-1-2017: Acoustics - methods for calculating loudness - Part 1: Zwicker Method.

Jeffs EL, Darbyshire JL (2017) Measuring sleep in the intensive care unit: a critical Appraisal of the use of subjective methods. J Intensive Care Med, 885066617712197.

Johansson L, Lindahl B, Knutsson S, Ogren M, Persson WK, Ringdal M (2017) Evaluation of a sound environment intervention in an ICU: A feasibility study. Aust Crit Care.

Kolb DA, Fry R (1975) Toward an Applied Theory of Experiential Learning. In: Cooper C. (Ed.) Theories Of Group Process. London: John Wiley.

Li SY, Wang TJ, Vivienne Wu SF, Liang, SY, Tung HH (2011) Efficacy of controlling night-time noise and activities to improve patients' sleep quality in a surgical intensive care unit. J Clin Nurs, 20: 396-407.

Litton E (2019) Let us apply early goal-directed sleep. 39th International Symposium On Intensive Care and Emergency Medicine, 19-22 March, Brussels.

Litton E, Carnegie V, Elliott R, Webb SA (2016). The efficacy of earplugs as a sleep hygiene strategy for reducing delirium in the ICU: A systematic review and meta-analysis. Crit Care Med.

Locock L, Robert G., Boaz A, Vougioukalou S, Shuldham C, Fielden J, Ziebland S, Gager M, Tollyfield R Pearcey J (2014) Using a national archive of patient experience narratives to promote local patient-centered quality improvement: an ethnographic process evaluation of 'accelerated' experience-based co-design. Journal Of Health Services Research & Policy, 19: 200-207.

Molloy K, Griffiths TD, Chait M, Lavie N (2015) Inattentional deafness: visual load Leads to time-specific suppression of auditory evoked responses. J Neurosci, 35, 16046-54.

Price M, Williams T (2018) When doing wrong feels so right: normalization of deviance. Journal Of Patient Safety, 14: 1-2.

Ross J (2015) Alarm fatigue: are you tuning out? Journal Of Perianesthesia Nursing, 30: 351-353.

Simons DJ (2000) Attentional capture and inattentional blindness. Trends In Cognitive Sciences, 4, 147-155.

UN 1992. Rio declaration on environment and development, ISBN: 9 21 100509 4.

Van Der Kooi AW, Leijten FS, Van Der Wekken RJ, Slooter AJ (2012) What are the opportunities for EEG-based monitoring of delirium in the ICU? J Neuropsychiatry Clin Neurosci, 24: 472-7.

Young J, Darbyshire J, Hinton L (2018) Sleep in the ICU: Limiting elements of noise in the critical care environment (SILENCE). A feasibility study (NIHR RfPB Ref: PB-PG-0613-31034 Final Project Report. NIHR