



KEY POINT SUMMARY

OBJECTIVES

The objective of this study was to investigate the physiological and clinical impact of a healing environment. The hypothesis was that modifications of an ICU patient room led to a decrease of SPLs.

Feasibility of Noise Reduction by a Modification in ICU Environment

Luetz, A., Weiss, B., Penzel, T., Fietze, I., Glos, M., Wernecke, K. D., Bluemke, B., Dehn, A. M., Willemeit, T., Finke, A., & Spies, C.. 2017 | *Physiological Measurement Volume 37, Issue 7, Pages 1041-1055*

Key Concepts/Context

Noise can adversely affect sleep quality, which is important to the recovery of ICU patients. Two ICU rooms in a German hospital were re-designed with the objective of reducing noise. The authors conducted a study wherein they examined the impact of these modifications on sound pressure levels (SPL) in these rooms.

Prior to the start of the study, two of seven ICU rooms underwent the following modifications aimed at reducing noise levels:

- A corridor was designed behind the patient's head (separated by a sound-protective wooden wall) – this carried medical equipment like breath delivery units of ventilators, the connections for compressed air and oxygen, and vacuum and syringe infusion pumps;
- Noise-shielding between patients in the two-bed patient rooms;
- An observation room separating the patient room from the main corridor and serving as entrance to the patient room – with windows for patient observation, work space for computers, and syringe-pump alarm system;
- The main door of the patient room had an automatic closing mechanism whose purpose was only for movement of beds and large equipment and for emergencies;
- A screen above the patient extending from the head to the feet comprised of an LED light-emitting grid placed on an acoustic foam.

Analyses of the SPL measurements showed that the above interventions were effective in reducing noise levels by almost 3 decibels in an ICU patient room.



Methods

This was an experimental study that took place in the ICU of a tertiary hospital in Germany eight months after modifications were made to two of seven patient rooms. One standard (unmodified) and one modified room were examined for the study. Both rooms had the same medical equipment operating for 20 hours or more; both rooms were fully occupied for 20 hours or more; when measurements were being taken, no admissions or discharges took place in either room. SPLs were recorded in 24-hour periods between June 2014 and August 2014 – four measurements (referred to as M1, M2, M3, and M4) were made; corresponding night-time measurements were also made (referred to as N1, N2, N3, and N4). The night-time measurements were made between midnight and 5 a.m.

Sound recorders were placed at the door and window-side beds of both rooms for M1. For M2-M4 the sound recorders were placed at the door-side bed for the modified room and at the window-side bed for the standard room. Additionally, research staff documented all sounds they heard in both rooms during M1. Clinical data was obtained from electronic patient records – the Acute Physiology and Chronic Health Evaluation II (APACHE II) score was used to quantify the severity of the patient's illness and the Therapeutic Intervention Scoring System (TISS) 28 was used to score the level of nursing care. The statistical analyses included (1) comparisons of SPLs for both rooms – Welch's t-tests for LAeq (A-weighted energy equivalent SPL) and LAFmax (A-weighted SPL with fast time constant) differences between both rooms; Fisher's exact test to compare frequencies of threshold overruns; (2) time series analyses of SPLs – Bartlett's test to test null hypothesis (data was from white-noise process of uncorrelated random variables) and comparison of differences between both rooms using standard statistical methods.

Findings

The analyses found:

M1:

- LAeq (A-weighted energy equivalent SPL) was significantly lower in the modified room than in the standard room, particularly at the window-side bed.
- LAFmax (A-weighted SPL with fast time constant) values were lower in the modified versus the standard room. Although the LAFmax values at the door side was much lower than at the window-side bed, it was not significant statistically.

M2-M4:

- LAeq (A-weighted energy equivalent SPL) was significantly lower in the modified room than in the standard room during M2 and M4. M3 recorded



a significantly higher LAeq in the modified room than in the standard room – this was attributed to a water-chamber sealed chest drain.

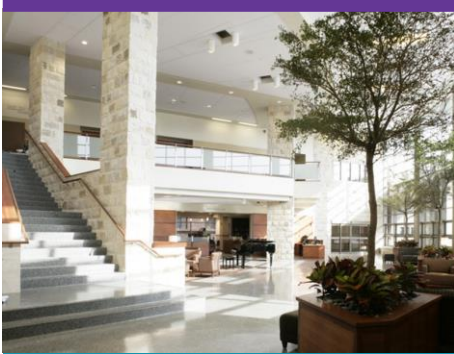
- LAFmax (A-weighted SPL with fast time constant) values were significantly lower in the modified versus the standard room during all three measurements.

Night-time measurements:

- N1 SPLs were significantly lower in the modified than in the standard room. Comparing measurements at the door-side beds, the standard room exceeded the 50 decibel LAeq threshold by 65.5%, whereas the modified room exceeded the threshold by 39.9%. With regard to the window-side bed SPLs, the modified room exceeded the threshold by 10.5%, whereas the standard room exceeded the threshold by 50%.
- N1 measurements showed that the LAFmax threshold of 60 decibels was exceeded by 62% at the door-side bed and 59.3% at the window-side bed of the standard room; in the modified room measurements exceeded the threshold by 26.7% at the door-side bed and 30.3% at the window-side bed. The differences between the two rooms were statistically significant ($P < 0.0001$).
- N4 measurements were similar to N1.
- N2 measurements – there were no significant differences in LAeq; the modified room had a significantly lower LAFmax ($p < 0.001$).
- N3 measurements – LAeq was significantly higher in the modified room as compared to the standard room ($p < 0.001$).

Day/night patterns:

- M1: Irrespective of where measurements were made (door-side or window-side bed), LAeq values were significantly higher during the day than at night in both rooms. The door-side bed in the standard room recorded the lowest day-night difference, while the window-side bed in the modified room recorded the highest day-night difference, the latter being significant. With regard to the LAFmax values, sound levels were significantly higher during the day at the window-side bed compared to night than at the door-side bed.
- M1-M4: There was a significant decrease in SPLs between midnight and 5 a.m. during all four measurement periods in the modified rooms, with very distinct day and night LAFmax values. In the standard rooms the day and night variations in LAFmax values were not as distinct. There was very little difference in the average LAFmax values for M2 and M4.



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Sound sources:

During M1 the researcher made the following observations:

- Of the 497 sound and sound combinations documented, 274 were heard in the standard room and 223 in the modified room.
- In the standard room 54% of the sounds were heard at the door-side bed, whereas in the modified room 37% of the sounds were recorded as heard on the door-side bed.
- ICU staff members' conversations occurred 128 times in the standard room and 104 times in the modified room. At night there were 16 conversations in the standard room, four in the modified room.

Limitations

The authors identified the following limitations for this study: The clinical impact of the study findings is hypothetical as data pertaining to patients' sleep was not obtained. Secondly, the study was able to provide a control only in the first measurement – M1, during which patients were prospectively allocated to rooms. A third limitation was that there were few comparable sound recordings.

Other limitations – the study did not indicate the impact of individual design interventions.

Design Implications

This study indicates that design interventions targeted at reducing noise levels do contribute to lower SPLs. Although more studies are needed to arrive at more robust conclusions, the study indicates the following implications for design:

- Provision of redirecting foot traffic through a buffer room (an observation-cum workroom as demonstrated in this study)
- Placing sound-making medical equipment within a soundproof enclosure
- Provision of a separate entrance/doorway for bed and equipment traffic

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