Noise causes sleep disruption
for critical care patients

Ecophon SAINT-GOBAIN
A SOUND EFFECT ON PEOPLE

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Patients are vulnerable
to sound

At the Intensive Care Unit of Borås Hospital, Sweden, a group of researchers studied how critically ill patients are affected by sound. They found that the high sound pressure levels and noise peaks make the patients stressed and less able to sleep. And sleep is one of the most important aspects of recovery.

The study also showed that there is a lack of knowledge regarding how sound and noise affect patients and staff. Further, the study confirms the importance of not only considering reverberation time, but also including acoustic parameters such as sound pressure level and speech clarity when choosing an appropriate acoustic solution.

Background

When we are sick we seem to forget that just opening the door to a hospital takes us out of our comfort zone. Our system is already stressed and our senses are therefore alert. We are more sensitive to sound and noise than normal – and in hospitals this can be a challenge.

> *Unnecessary noise is the most cruel absence of care which can be inflicted upon either the sick or well!*

Florence Nightingale in Notes on Nursing, 1859[1]

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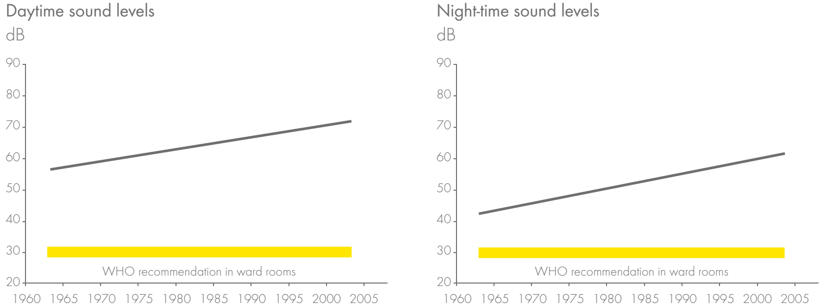
Actual sound levels in hospitals



Patients are affected by sound levels in hospitals – and over the years sound levels have been increasing dramatically[2]. The reason for this can be a combination of more people in the buildings, more equipment, more complex tasks – and in general more sound sources.

High sound levels in healthcare facilities are known to: impair sleep, increase stress, delay post-illness rehabilitation, aggravate agitation, cause psychiatric symptoms, escalate restlessness, increase respiratory rates and increase heart rates[3].

At the same time long-term research shows that a proper room acoustic environment will:

- reduce sleep disruption[4]
- reduce medication intake[5]
- improve speech communication[6]

WHO recommends 30–35 dB in hospitals

World Health Organization recommendation for hospitals[7]

- For ward rooms, the equivalent sound levels should be 30 dB
- The noise peaks during the night should not exceed 40 dB
- Since patients have less ability to cope with stress, the average sound levels should not exceed 35 dB in most rooms in which patients are being treated or observed

Patients' reactions and perceptions

To investigate how the patients experienced the sound environment of the ICU, they were interviewed 2–35 days after their discharge.

All of the interviewed patients shared rooms with one or two other patients and the space was divided only by thin fabric curtain which made it possible for speech to be heard from one bed to another.

> *... but it was so annoying, this noise all the time, and I couldn't sleep to escape the noise, it was impossible, it was so loud it was impossible* [8].

Some of the patients also described the sounds as being scary and frightening and they felt like they had no way to shut off the unwanted and unpredictable sound.

Understanding of sound and noise

To investigate and document the awareness of staff about the sound environment in an ICU, questionnaires were distributed to 1,047 staff members at nine ICUs. The researchers also performed 20 interviews with physicians, nurses and enrolled nurses. At the interviews, staff were also asked to give suggestions for improvements[9].

The results of the questionnaires showed that none of the respondents knew all the answers, and in most areas the number of correct answers was low. Since sound is a complex matter this isn't strange. Most people have never learned how sound affects us, and when it comes to physicians and nurses, their education and profession is about saving lives. Most respondents were convinced that management plays the most important role when it comes to securing a good sound environment.

Questions answered correctly per profession, percent[10]

Theme of question	Physicians	Nurses	Enrolled nurses	Whole group
Chronic physiological changes related to noise.	14%	1%	2%	3%
Maximum levels according to WHO.	7%	17%	23%	17%
Acute physiological changes related to noise.	48%	27%	10%	26%
Noise levels related to physiological changes.	21%	37%	40%	35%

Acoustic intervention at the ICU

The patient rooms at the ICU were two-bed patient rooms with different sound conditions (modified or not). The walls were made of gypsum/concrete and the two rooms were mirror images of each other but identical in size:

- height 2.70 m
- floor area 29 m^2
- volume 77 m^3

The ceiling in the control room had a 13 mm gypsum board with a 20 mm fibrous absorbent, while the ceiling in the modified room was changed to an acoustic class A ceiling with an extra absorber on top. The chosen acoustic ceiling met all hygiene demands.

Control room

Modified room

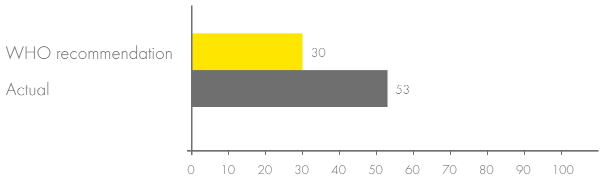
Sound pressure level

The average sound pressure level in the ICU was 53 dB. It is of course debatable whether 53 dB really is loud or not. Or whether it is possible to sleep if the background noise is 53 dB? But the problem with analyzing an *average* SPL is that people react more to peaks – and it is the peaks that will wake patients up when they try to sleep. The average value actually doesn't tell us much in regards to human perception.

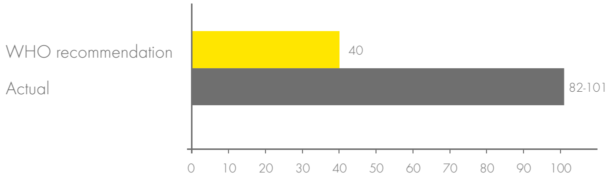
When it comes to the peaks in the investigated ICU – the numbers speak for themselves:

- the actual peak levels were 82–101 dB
- and they exceeded 55 dB 68–79% of the time

Sound levels, average



Sound levels, peak



Room acoustic results

In building regulations around the world reverberation time (T_{20}) is often the only parameter used for guidance, but speech clarity (C_{50}) is crucial when it comes to critical care. Communication must be clear and the sound level should not be allowed to build up. The researchers therefore chose to include speech clarity and sound pressure level as investigated acoustic parameters, as well as reverberation time.

Acoustic descriptors

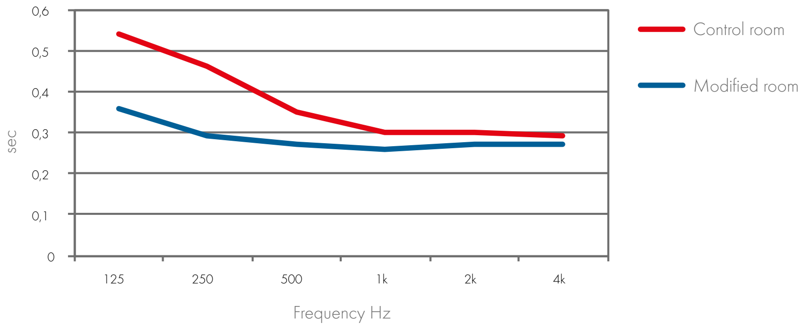
Parameter	Measure	Explanation
Reverberation Time	T_{20} (s)	Measures how fast the sound energy disappears in the space. A shorter reverberation time means the space has less disturbing echoes and feels more calm.
Speech Clarity	C_{50} (dB)	Measures how well speech is perceived in the space. If the value increases, speech clarity is improved.

Noticeable differences according to ISO 3382-1

Subjective listener aspect	Room acoustic quantity	Noticeable difference
Perceived reverberance	Reverberation Time T_{20} in seconds	5%
Perceived clarity of sound	Speech Clarity C_{50} in dB	1 dB

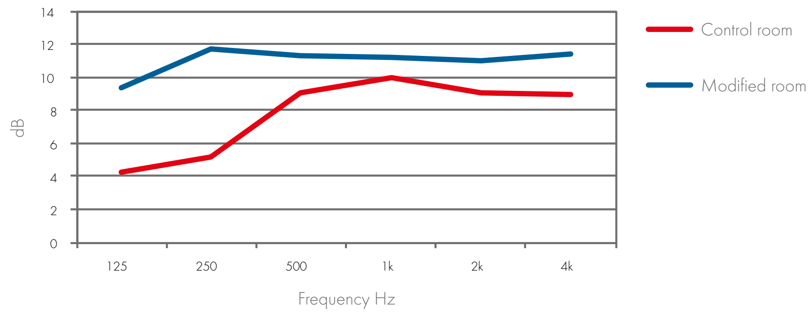
Values for T_{20} in both rooms met the Swedish Standard SS25268 that demands max. 0.5 seconds at (125)250–4,000 Hz[11]. The modified room showed improvements in the low-frequency area but at other frequencies the curve is fairly similar. So, on paper both rooms look ‘good’ when it comes to T_{20}, but the results for C_{50} tell a different story.

Reverberation Time, T_{20}



The measurements show that even when we have rooms with relatively short reverberation times – speech clarity can be bad. In the control room we see values under 5 dB in the lower frequencies which is highly problematic in a sound environment that has to support communication. The mid and high frequencies are considered acceptable in the control room. However, since the noticeable difference of C_{50} is just 1 dB, the modified room is like another world. Above 9 dB in all frequency bands is a great result – and this environment is even good enough to support speech communication for hearing-impaired people[12]. In short – the perceptions of the two rooms are totally different. The result for the modified room is impressive in general.

Speech Clarity, C_{50}



So what did the changes in T_{20} and C_{50} mean for the sound pressure level in general? In this study there was a drop in sound pressure level by approximately 3 dB in the modified room in comparison to the control room[13]. Knowing that the decibel scale is logarithmic, 3 dB means that the sound pressure level was halved. It is therefore very important to recognize the results.

Ecophon solutions used

Ecophon supplied the ceiling products for the room with good acoustics. The ceiling was Ecophon Hygiene™, a wall-to-wall sound-absorbing ceiling that also meets all hygiene demands in this environment. On top of the ceiling additional low-frequency absorbers, Ecophon Extra Bass, were placed.

References

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[8] Johansson L, et al.: Noise in the ICU patient room – staff knowledge and clinical improvements. Intensive and Critical Care Nursing (2016).

[9] Ibid.

[10] Ibid p. 5, table 4

[11] The Swedish standard SS25268 does not include 125 Hz.

[12] R. Plomp and A. J. Duquesnoy: Room acoustics for the hearing impaired, The Journal of the Acoustical Society of America 71, S19 (2005)

[13] Johansson L, et al: Evaluation of a sound environment intervention in an ICU: A feasibility study, Australian Critical Care (2017)

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