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Developing acoustical policies around in EU countries

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According to research, noise levels in hospitals worldwide are perceived to be very high. At the same time, the awareness of the negative effects of noise on patients and healthcare staff has grown. Standards and policies are a great help to manage or eliminate noise in hospitals. An overview of international standards will be presented, showing various parameters and angles of approach, e.g. based on activity or room type. To further optimize the content, and stimulate the use of the standards, some countries have even defined healthcare specific standards. These can support the planning and the evaluation of the sound environment in those premises. New insights from research and case studies, as well as emerging laws, provide opportunities or even force us to improve the existing content of standards to meet future demands. Suggestions for that are based upon the subjective experience of people and could include the use of additional room acoustic parameters, such as reduction of sound pressure level and parameters addressing privacy. Finally, revision of standards provides opportunities for all stakeholders in the building project to understand the importance of room acoustics in relation to the quality of care and the well-being of patients and staff in health care environments.

1 Summary

Noise in hospitals is among the top complaints of medical staff [1]. Negative effects of high sound levels on staff include burnout and depression, increased number of medical errors and increased chances of hearing loss. A well planned acoustic environment enhances the feeling of privacy, safety and comfort. The stakeholders have a shared interest and therefore challenge to find effective noise control approaches.

Building codes show limitations in securing the quality of the sound environment. Standards and guidelines however are providing measures to plan for good room acoustics in the context of supportive healthcare design. A look at room acoustic standards across Europe shows several recent revisions. This paper provides an overview of several European standards and exclusively focuses on those parts that deal with room acoustics within healthcare buildings. When it comes to defining room acoustics, it is mostly about how sound behaves in a room. This paper deals with all basic concepts (sound absorption, sound reflection and sound diffusion) except for sound transmission

A comparison between the standards demonstrates differences in use of room acoustic parameters and accompanying values. In combination with recent acoustic case studies and non-European policies, inspiration is provided when planning for local standardization processes. These might heavily affect the future quality of care provided in health care premises.

2 Sound in healthcare

Over the last years sound levels in hospitals have increased dramatically. Recent research by James West and Ilene Bush at Johns Hopkins University has shown an increase of 15 dB over the last 40 years [1]. Noticing that an increase of 10 dB is perceived as a doubling of the sound level, the situation is far from ideal. Background noise levels are typically 45 dB to 68 dB, with peaks frequently exceeding 85 dB to 90 dB.

Noise in hospital is one of the biggest complaints of those occupying the buildings. Several investigations and research projects have pointed out clear links between sound levels and the quality of care. Healthcare not only is stressful for patients but also is a physically and emotionally demanding service to deliver. Changes to the room acoustic environment have shown many benefits. A study conducted at Karolinska University Hospital demonstrated benefits of acoustical interventions on both patients and staff [3].

The study showed following benefits to patients and staff:

- Lowered readmission rates
- Improved patient satisfaction with services provided
- Reduced blood pressure, lowered stress levels
- Improved team-spirit and work satisfaction.

Other benefits of improved room acoustics found in studies:

- Less sleep deprivation [4]
- Reduced need for pain medication [5]

Taking all studies into account, the focus when planning for new buildings or refurbishments should be to:

- Make hospitals quieter
- Provide circumstances for good communication between staff and patients and between staff
- Support the need to control privacy

3 Room acoustics in building codes and laws is limited

Regulations, standards and guidelines are the tools provided to manage the sound environment. To safeguard occupational health in healthcare premises, local governments issue laws that have to be complied with. Some local building regulations address acoustics in building by setting for example minimum or maximum requirements for the construction. Local building regulations generally do not provide very detailed instructions or guidance to develop a supportive acoustical environment. Standards and guidelines can be used to further specify and optimize the required acoustical environment.

4 Room acoustic standards and guidelines

Conditions ensuring the comfort, well-being and effectiveness of staff and patients can be assessed through standards and guidelines. This paper will focus on the content of standards and guidelines issued in European countries [6,7,8,9,10,11,12].

4.1 The approach

The table below provides an overview of several standards and guidelines relevant to healthcare premises.

Country	Sweden	Germany	Finland	Norway	United Kingdom	Denmark	The Netherlands
Document	SS 25268	DIN 18041	SFS 5907	NS 8175	HTM 08-01	SBi 216	NPR 3438
Name	Acoustics - sound classification of spaces in buildings	Acoustical quality in small to medium-sized rooms	Acoustic classification of spaces in buildings	Acoustic conditions in buildings - Sound classification of various types of buildings	Acoustics Health Technical Memorandum	SBi 216, guidelines for building regulations 2008	Noise at the workplace - Determination of the amount of disturbance of communication and concentration.
Standard/ guidelines	Standard	standard	standard	standard	guideline	guideline	guideline
Date of issue	2007	2004	2004	2008	2006 (draft)	2008	2006
Segment of application	•Healthcare premises •Other types of workplaces	•All types of workplaces up to 5 000 m^3	•Healthcare premises •Other types of buildings	•Healthcare premises •Other types of buildings	•Healtcare premises	•Healthcare premises •Other types of buildings	•All types of workplaces
Approach for acoustic quality	A: room type B: activity C: comfort	A: room type B: - C: comfort	A: room type B: - C: comfort	A: room type B: - C: comfort	A: room type B: - C: -	A: room type B: - C: -	A: - B: activity C: comfort
Use of sound comfort classes	4 classes for reverberation time and installation noise	3 classes for building generated noise	2 classes for reverberation time and installation noise	4 classes for reverberation time and installation noise	-	-	3 classes for intelligibility 5 classes for SPL

Table 1. Standards and guidelines addressing healthcare premises

Standard/guideline
The overview differentiates standards from guidelines, standards being official standard issued by the local standardization institutes. Those mentioned as guidelines are practiced but not issued by the standardization institutes, with the exception of the Dutch one.

Explanation of table 1
The general approach of most standards is to aim for "comfortable room acoustics". The German standard shows a more specific approach; to ensure audibility and speech intelligibility over large, medium and small rooms. The Dutch standard is aiming to provide target values to avoid disturbance of communication and concentration.

Segment of application:
Most standards mentioned in the overview, are addressing room acoustics for a variety of building types. The UK guideline HTM08-01 differs from the ones from other countries, since it is a healthcare specific document. This means that it can uniquely focus and provide relatively more information on the challenges one is faced with when planning acoustic environments in this type of premises.

Approach for acoustic quality:
The overview shows differences in how to address the acoustics in healthcare premises. The desired room acoustic values can be found either by choosing a room type or an activity, or defining the desired level of comfort. The Swedish standard is most advanced in this matter, integrating all three.

Use of sound comfort classes
With the exception of Denmark and United Kingdom, comfort classes are mentioned in all standards and guidelines. Comfort classes enable to define a certain level of comfort. They provide mainly values of acoustic parameters, such as reverberation time and noise from installations. The Dutch guideline however, aims to give guidance by providing speech comfort and therefore use STI. At the same time the level of concentration is given bu total sound pressure level in a given room.

4.2 Room acoustic parameters

For many years, the acoustical properties of a building have been rated in terms of reverberation time. This review of standards shows that this is still the case, but an interesting change is taking place in some countries. The guideline that was recently published by the Dutch standardization institute actually does not use reverberation time at all. The guidelines provide target values other than reverberation time to tackle the issue of reducing the disturbance of communication and concentration at the work place.

Country	Sweden	Germany	Finland	Norway	United Kingdom	Denmark	The Netherlands
Document	SS 25268	DIN 18041	SFS 5907	NS 8175	HTM 08-01	SBi 216	NPR 3438
Target values of reverberation time	X		X	X		X	
Amount of sound absorption: area to be covered		X	X		X (no amount given)		X
Target values of noise from technical installations	X	X	X	X	X	X	X
Target values of Speech Transmission Index (STI)							X

Table 2. Room acoustic parameters

A certain reverberation time in a room requires a certain amount of absorption. By using the Sabine method (which assumes a diffuse sound filed), some countries present tables of amount of absorption needed to fulfil a certain reverberation time.

The standards in this overview can be divided in three groups:

- Standards which include reverberation time values, but no estimation of amount of absorption material required (Norway, Denmark, Sweden).
- Standards which include reverberation time values, and estimations of amount of absorption material required (Finland)
- Standards which include no reverberation time values, but estimations of amount of absorption material required (Germany, Netherlands)

In the United Kingdom (HTM 08-01), the recommendation is that acoustically absorbent ceilings should be provided in circulation/public (i.e. non-medical) areas, atria and in rooms where speech intelligibility is a requirement. The guidelines do not include amount of absorption required or values of reverberation times.

Furthermore variances occur in addressed room types and use of room acoustic parameters to characterize the sound environment. The German and the Dutch standard give suggestions of areas to be covered with sound absorbers in different room types, e.g. operating theatres and treatment rooms.

To protect the people in a building from too high continuous back ground sound levels all standards in this overview contain guidelines of maximum permitted sound levels caused by technical installations (such as ventilation appliances, cooling and heating appliances).

5 Need for control measures

Creating or refurbishing an environment, to enable staff to perform to their best abilities and patients to recover, requires good planning.

To plan for Room Acoustic Comfort™ one has to specifically look at the interaction between the room, the person and the activity.

Within the hospital environment we can define a number of activities that are influenced by following acoustical quality aspects:

- **Reverberance:** This aspect is linked to the speed at which sound energy disappears in a room
- **Speech Clarity**: This concerns the quality of speech transfer to the listener
- **Auditory Strength:** This is the level at which we experience sound
- **Spatial Decay:** The sound level decreases as the distance to the sound source increases

All of the above mentioned aspects should be taken into consideration when planning the room acoustics. Looking at the activities performed one should create possibilities for good communication, create possibilities for privacy and create a tranquil environment.

The quantity and placement of sound-absorbing material is the key factor for good room acoustics in healthcare facilities. Room acoustics relate to the sound environment in a restricted space. The most common measurement is reverberation time, but in many instances it is of even greater importance to measure the reduction in sound pressure level. In rooms where transmission and communication of information is of great importance, other measurements can be used to gauge speech intelligibility or privacy.

Several studies indicate that it is important to not only focus on reverberation time, but also to consider other descriptors as well, to express the acoustic in a room. A study at the Thorax ICU at Karolinska Hospital in Sweden [13] was conducted to clarify how room acoustics in a patient ward affects the staff's perception of the noise situation. The change that was made in the ward involved increasing the amount of sound absorbing material in the room, thus altering the room's acoustics. The practical absorption factors for the products used in the study are presented in figure 1, where the red line shows the initial ceiling's ability to absorb sound and the yellow line shows the performance of the new ceiling that was installed.

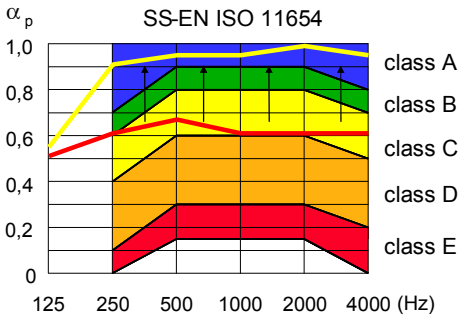

Figure 1. According to the classification standard SS-EN ISO 11654, the existing ceiling is classified as a class C absorbent and the new ceiling as a class A absorbent.

Acoustic measurements were performed in order to determine how the ceiling surface could change the sound environment in the ward. An omni directional loudspeaker with constant sound power level was used for the SPL measurements. The measurement procedure follows the guidelines in ISO 3382:1.

When comparing the different ceiling solutions, the measurements showed that reverberation time was not particularly affected by the absorption factor of the ceiling, as shown in figure 2. However, it did show a sound pressure level difference of 3,1 dB(A), in favour of the absorption class A ceiling.

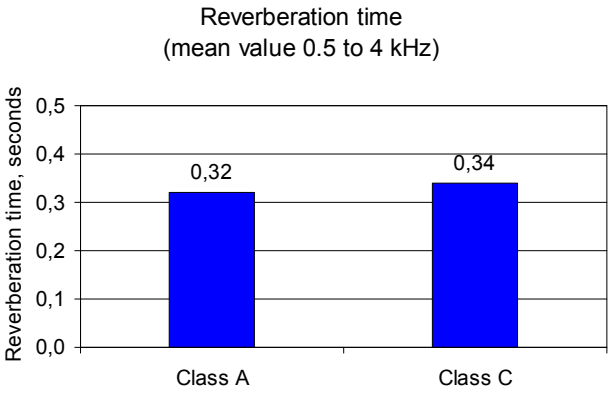

Figure 2. Reverberation time

A sound level reduction of 3,1 dB(A) can be regarded as a considerable reduction and interviews with staff confirmed that the new sound environment was perceived better than the initial sound environment. This shows that the reverberation time does not on its own express the subjective experience of the acoustic in a room.
Within the field of room acoustics, there is normally assumed to be a direct link between the added amount of absorption and the reverberation time of the room. In this case, the measurements do not support this assumption.

5 Conclusion

New insights from research and case studies, as well as emerging laws, provide opportunities or even force us to extend the existing content of our standards and guidelines.

Today, we have a scientific understanding of the relationship between noise and the health of patients and staff. From research, we also have an improved understanding of the limitations in using one single acoustic parameter to express the acoustic in a room.

In a hospital, it is important to create possibilities for good communication, create possibilities for privacy and create a tranquil environment. This means that additional acoustic parameters could be considered to be included in the standards.

In some standards this is already the case, but they deal with premises other than healthcare. In Finland for example, the standard for classrooms and open plan offices include requirements of STI. In Denmark and France, the standards include requirement of DL2, to secure a certain level of privacy in open plan offices.

In USA, the HIPAA (Health Insurance Portability and Accountability Act), protects the privacy of speech in healthcare facilities. In Europe it is the EU Privacy Directive 95/46/EC that protects individuals with regards to the processing of personal data and their right to privacy. Privacy and confidentiality are given more and more importance in Europe and the USA. This might in future require new ways to deal with privacy in standards.

The standards and guidelines we have today are a help to manage noise. In order to further optimize the standards, it will be necessary to proceed to link acoustical parameters and values to the subjective experience of patients and staff. This will have a positive impact on the well-being of those occupying the building and the quality of care provided.

References

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