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Rx for Improving Patient Outcomes:

Enhance Acoustics and Aesthetics



Rethinking Hospital Design Creates Healing Environments

Healthcare construction in the United States exceeded \$70 billion in 2011. In addition to providing more patients with care and access to new medical technologies, this boom in construction also presents an opportunity to transition from the traditional view of how to construct a hospital to a new philosophy that utilizes evidence-based design strategies that link a hospital's physical environment to healthcare outcomes.

Like evidence-based medicine, where clinical choices are informed by research, evidence-based design uses research to connect design decisions to an improved healing environment. A landmark study issued by the Center for Health Design titled, *"The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity"*, provides guidance.

The study compiled data from more than 600 evidence-based design related studies and concludes that "Evidence-based design is not about hospitals that are simply nicer or fancier than traditional hospitals. Rather, the focus of evidence-based design is to create hospitals that actually help patients recover and be safer, and help staff do their jobs better."

Included in a list of actions healthcare executives and design teams should take when building new healthcare facilities is this counsel: "New hospitals should be much quieter to reduce stress and improve sleep. Noise levels will be substantially lowered by the following combination of environmental interventions: providing single-bed rooms, installing high performance sound-absorbing ceilings, and eliminating noise sources."

A similar report titled, *"Healthcare at the Crossroads: Guiding Principles for the Development of the Hospital of the Future"*, from the Joint Commission Public Policy Initiative concurs.



This report notes that the hospital building boom currently underway is fueled by increasing demand for healthcare services and increasingly obsolete hospital facilities. This boom once again offers the opportunity to remake the hospital to better meet the needs of patients and families and those who provide the care.

DID YOU KNOW?

- In 35 published studies, not one hospital complied with World Health Organization guidelines for maximum noise levels in patient rooms.
- Compared to patient rooms, the emergency departments tend to exhibit sound levels nearly twice as loud.
- With the 2009 American Recovery & Reinvestment Act, penalty fines of up to \$1.5 million can now be imposed for HIPAA privacy violations, including oral privacy violations.

As this report notes, "Building more of the same will freeze into place persistent problems with which hospitals must already contend that otherwise could be mitigated through the application of evidenced-based design."

As a result, included as one of its "Principles to Guide Design" is this recommendation: "Incorporate evidence-based design principles that improve patient safety, including single rooms, decentralized nursing stations, and noise-reducing materials, in hospital construction."

Rising Noise Levels in Hospitals

Hospitals are inherently noisy for two primary reasons. First is the plethora of noise sources, ranging from paging systems and patient monitoring equipment to staff conversations and the clamor of visitors. Second, walls, floors, and ceilings tend to be hard surfaces that are designed for durability and cleanliness, but which also create excessive reverberation in a space. Consequently, they are more sound reflecting than sound absorbing. Moreover, hospital noise levels have been rising since the 1960s. And, high noise levels in hospitals have implications for patient and staff health and well-being.

Quieting Spaces Promotes Patient Healing By...

1. IMPROVING SLEEP QUALITY

Numerous research studies validate the belief that noise is annoying to patients, largely because of its impact on sleep. Loud noises in hospitals have been linked to sleep disturbance and arousals among patients, both of which can lead to increased pain perception and, consequently, patient

medications. One such study* evaluated the effect of reduced reverberation time on sleep by exposing subjects to sound stimuli, with and without sound-absorbing ceiling panels.

The study found that EEG-arousals following specific sound stimuli were significantly reduced when reverberation time was reduced with sound-absorbing panels. Subjects evidenced far better sleep quality (less sleep fragmentation) in patient rooms with shorter reverberation times compared to those with longer reverberation times.

2. LOWERING PULSE AMPLITUDES AND REHOSPITALIZATION RATES

For example, a recent study assessed the effect of room acoustics on patients admitted to the Intensive Coronary Care Unit (CCU) at Huddinge University Hospital.

As part of the study, room acoustics were altered by changing ceiling panels throughout the CCU from sound-reflecting panels to sound-absorbing panels of similar appearance. Patients were monitored with regard to blood pressure including pulse amplitude, heart rate, and heart rate variability.

The study indicated significant improvements after the changeover, especially in regard to pulse amplitude, with lower values during the night after the changeover.

In addition, the study found the incidence of rehospitalization was lower for patients after the changeover compared to those before it. Patients after the changeover also exhibited higher levels of satisfaction with the care provided by the staff.

The study concludes that a poor acoustical environment during acute illness may, therefore, have important detrimental physiological effects on rehabilitation.

Loud noise levels are also a key concern in healthcare settings such as neonatal intensive care units (NICU) where premature infants have a high sensitivity to both noise and light. Studies show that loud noise levels in NICU environments decrease oxygen saturation (increasing the need for oxygen support therapy), elevate blood pressure, increase heart and respiration rates, and worsen sleep.

3. PROMOTING PATIENT PRIVACY

Research shows that when a patient either hears conversations about other patients, or feels their own information may be overheard, it impacts their trust and ability to freely discuss health issues with their physician, which could seriously impact their care. It is critical, therefore, that private conversations with or about a patient are not overheard.

* *"Impact of Reduced Reverberation Time on Sound-Induced Arousals During Sleep,"*
Soren Berg MD, PhD, SLEEP, Volume 24, Number 3, 2001.

CASE STUDY

To demonstrate the effect sound-absorbing materials can have on lowering noise levels, Johns Hopkins researchers conducted a study titled *"Quieting Weinberg 5C: A Case Study in Hospital Noise Control"*.

Weinberg 5C is a hematological oncology unit with reflective, hard surfaced floors, walls, and ceilings. No sound-absorbing materials were anywhere in the unit. The center of the unit houses the nursing station and service rooms, while patient rooms are located on the outside of the unit.

The nursing staff mentioned that any conversation at the nurses' station was audible throughout the entire unit. Acoustical measurements showed the noise level was 55 dBA, and reverberation times ranged between 0.2 seconds and 1.2 seconds.

To help control noise within the unit, sound-absorbing panels were installed high on the corridors' walls and on half of the corridors' ceiling areas.

Following installation of the panels, noise levels dropped more than half. An immediate impact of the sound-absorbing panels and their sound-reducing properties was to permit patients, staff, and visitors to lower the level of their speech while still being understood. In addition, reverberation time dropped by a factor of more than two.

The study also notes an important measure of the effectiveness of noise control in a hospital setting is the judgment of patients and staff regarding the noisiness of the unit. To determine staff and patient perceptions, the Johns Hopkins researchers also conducted a short survey before and after noise intervention.

Prior to panel installation, nearly two-thirds of the patients and staff viewed the unit as noisy, with the majority of patients viewing it as very noisy. After installation of the panels, over 90% of the staff and patients viewed the unit as quiet or very quiet.

Following the final analysis, the study concludes: "Our results suggest that new hospital buildings, particularly those with in-patient units, would do well to incorporate sound-absorbing materials wherever possible in their designs."

Quieting Spaces Promotes Staff Effectiveness By...

1. REDUCING STRESS

Noise can also be a source of annoyance and stress to hospital staff, and interfere with their ability to work effectively. A poor acoustical environment makes it difficult for healthcare staff to understand patients with different languages, accents, and speech patterns. In addition, research has found that noise-induced stress is related to emotional exhaustion and burnout.

To help determine the influence of acoustic conditions in the work environment, a similar study to that conducted to examine its effect on patients in the Coronary Care Unit at Huddinge University Hospital was conducted to investigate its impact on staff.

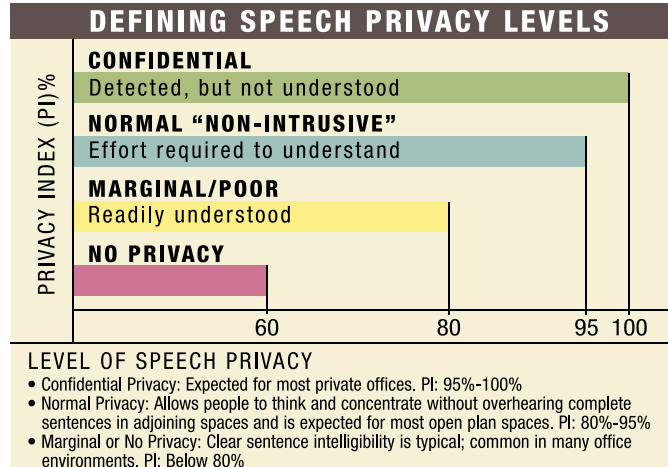
QUIET AND CLEAN

Airborne pathogens can be transmitted by dust in the air and settle on interior surfaces and survive for weeks or months. As a result, such surfaces can act as pathogen reservoirs and become the source of possible infection outbreaks. Selection of interior finishes that are easily cleaned and disinfected is thus a key consideration in preventing the spread of infection. Recommendations for the selection and cleaning of interior finishes are included in the AIA Guidelines and the *CDC Guideline for Disinfection and Sterilization in Healthcare Facilities*.

Many high performance ceilings that meet the acoustical needs of healthcare facilities can be readily cleaned. In addition, there are now ceilings that offer even greater infection control protection by providing both clean room performance and a smooth, soil-resistant, water-impervious surface capable of being easily washed with disinfecting cleaners.

Acoustically, these fine-textured ceiling panels feature excellent sound-absorbing and sound-blocking properties with an NRC of 0.70 – 0.90 and a CAC of up to 35. This combination helps promote privacy and enhances the healing environment.

To meet the hygienic requirements of a space, ceilings that feature a broad spectrum anti-microbial treatment on both the face and back to inhibit the growth of mold, mildew, and Gram-positive and Gram-negative odor/stain-causing bacteria are recommended.



In this case, the study noted staff members were surprised by the improved speech intelligibility after the installation of the new ceiling as well as the perceived noise level. They reported that they also felt more relaxed and irritability decreased.

Thus, the study raises the possibility that important gains in the psychosocial work environment can also be achieved by improving room acoustics.

2. REDUCING MEDICAL ERRORS

Speech intelligibility is key in healthcare settings because nurses and physicians must constantly comprehend and act on many types of auditory information in a high-stress environment. High levels of noise can lead to distractions and a loss of focus. Consequently, a major concern is patient safety in the form of medical errors caused by less than perfect oral communication.

3. REDUCING VOCAL FATIGUE

Researchers also noted that it is likely staff members are raising their voices in order to be understood above the background noise. Medical staff fatigue is an issue since speaking in a raised voice is tiring.

Solving the Healthcare Acoustics Challenge

REDUCING REVERBERATION

Hard sound-reflecting surfaces typical of older hospital designs cause sounds to linger and have long reverberation times. When acoustic conditions are characterized by long reverberation times, sounds will overlap, resulting in reduced speech intelligibility.



Reverberation time is largely determined by the presence of sound-absorbing materials in the room. Research has shown that installing high performance sound-absorbing ceiling panels results in reduced noise levels and perceptions of noise. The ceilings also resulted in improved speech intelligibility and reduced perceived work pressure among the staff.

To help reduce noise levels and reverberation time, acoustical ceiling panels should have a Noise Reduction Coefficient (NRC) of 0.70 or greater. However, the actual NRC required for a ceiling in a particular healthcare space will depend on the space's function, size, and NRC of other materials in it.

In general, if ceiling heights are approximately 10 feet, the best and most cost effective method of reducing reverberation time is to place most, if not all, of the sound-absorbing material on the ceiling in the form of a suspended acoustical ceiling.

If ceiling heights are approaching 12 feet, some sound-absorbing material may have to be placed on the walls to help attain the desired reverberation time. Acoustical wall treatments frequently take the form of vinyl, fabric, or perforated wood-covered panels with either a mineral fiber or fiberglass backer board. If ceiling heights are 14 feet or greater, acoustical wall treatments are recommended to reach sound control goals.

Protecting Privacy

In current healthcare settings, patients are often exposed to situations where they overhear conversations about other patients. Or, they have their own private information communicated in an environment where it can be heard by others. To help ensure confidentiality, the Health Information Portability and Accountability Act (HIPAA) mandates that all individually identifiable patient

information, including information communicated orally, be kept private. In 2009, the American Recovery & Reinvestment Act (ARRA) established a tiered penalty structure for oral HIPAA violations. Penalty fines can reach up to \$1.5 million for oral privacy infringements.

The level of speech privacy achieved in a particular space is denoted by its Privacy Index (PI), an indicator of how well a private conversation can be overheard by an unintended listener. The commonly recognized levels of speech privacy are confidential, normal, marginal or poor, and no privacy.

AIA Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities recommend confidential speech privacy between closed spaces such as examination rooms, treatment rooms, consultation rooms, and areas where patients discuss their personal health, psychiatric, and psychological conditions, and in open spaces where patients discuss those same issues.

Protecting Privacy with Balanced Acoustical Design

An architectural design strategy known as “balanced acoustical design” can be one of the most effective, and often, the least costly method to achieve proper levels of speech privacy within open spaces and between closed spaces. It consists of three techniques that are often referred to as the “ABCs of Balanced Acoustical Design”.



A: Absorb sound in a space with high performance acoustical ceiling and wall treatments that prevent unwanted sound from building up due to reflections.

B: Block horizontal sound transmission between spaces with a combination of high performance ceilings and effective wall and furniture design/layout.

C: Cover the remaining intruding sound with an evenly distributed, comfortable sound masking system adjusted to meet the Privacy Index level desired in the space.

Proper acoustical design has been shown to improve patient sleep, increase patient satisfaction, increase patient confidentiality, improve the healing environment, reduce staff stress, and improve speech intelligibility among staff members.

Selecting the Right Ceiling

The attainment of speech privacy is dependent on good acoustical design and the proper selection of interior systems and materials used in the space. In that regard, the proper choice of a ceiling can serve to both limit the sound intrusion between spaces, and affect the quality of sound within a space. The ceiling is, therefore, a key element in creating an acoustical environment that can maintain speech privacy.

ACOUSTICAL PERFORMANCE INDICATORS

A balanced acoustical design can help ensure speech privacy. To better understand the elements of that design and other acoustical solutions, it's important to be familiar with the main indicators of acoustical performance. They are:

NOISE REDUCTION COEFFICIENT (NRC). Indicates the ability of a surface, such as a ceiling, to absorb sound from all angles. It is expressed as a number between 0.00 and 1.00, and indicates the average percentage of sound the ceiling absorbs. The higher the number, the better the surface acts as a sound absorber.

ARTICULATION CLASS (AC). Indicates the ability of a ceiling to absorb sound that is reflected off the ceiling between two adjacent open spaces, such as office cubicles. The higher the number, the better the ceiling performs with respect to speech privacy between adjacent open plan spaces.

CEILING ATTENUATION CLASS (CAC). Indicates the ability of a ceiling to block sound in one room from passing up into the plenum and transmitting back down into an adjacent closed space that shares the same plenum. The higher the number, the better the ceiling acts as a barrier to sound intrusion between closed spaces.

SOUND TRANSMISSION CLASS (STC). Indicates the ability of a wall or furniture panel to block the transmission of sound through it and into an adjacent space. The higher the number, the better the construction acts as a barrier to sound transmission.

PRIVACY INDEX (PI). Indicates the degree of speech privacy in open or closed spaces. It is expressed as a percentage, and takes into account the acoustical performance of everything in the space. The higher the percentage, the better the speech privacy.

Speech privacy refers to how well a private conversation can be overheard by an unintended listener. The commonly recognized levels of speech privacy are:

CONFIDENTIAL. PI rating of 100% to 95%. Means conversations in a space may be partially overheard, but definitely not understood beyond the confines of the space.

NORMAL OR NON-INTRUSIVE. PI rating of 95% to 80%. Means nearby conversations can be overheard, but only partially intelligible to an unintended listener.

MARGINAL OR POOR. PI rating of 80% to 60%. Means most nearby conversations will be overheard and most likely be fully intelligible to unintended listeners.

NO PRIVACY. PI rating of 60% or less. Means all conversations can be entirely heard and clearly understood.

When selecting ceilings for a healthcare facility, use of the same acoustical ceiling throughout the entire facility is not always the best choice. In terms of speech privacy, there is a difference in the acoustical requirements of open and closed spaces. As a result, different areas require different ceilings, and different applications of balanced acoustical design.

OPEN SPACES Open plan spaces are usually spacious areas that house a large number of people. Examples in healthcare facilities include reception areas, waiting rooms, recovery wards, open plan offices with cubicles, and call centers (provided the calls include private health information).

Lack of speech privacy can be a salient problem in these spaces. That's because overheard conversations can lead to unintentional confidentiality breaches. Fortunately, achieving speech privacy in open areas is not difficult as long as the ABCs of balanced acoustical design are followed.

CLOSED SPACES Closed spaces are typically smaller areas consisting of four walls and a door, and housing one or more people. Examples in a healthcare facility include examination rooms, consultation rooms, treatment rooms, patient rooms, meeting rooms, conference rooms, and physicians' private offices.

The audibility of speech between adjacent closed spaces is not a problem until it becomes intelligible. As a result, the main function of the ceiling in closed spaces is to limit the transmission of sound between adjacent rooms, especially when these spaces share a common plenum.

Speech privacy in closed spaces can be achieved, even at raised voice levels, once again using the ABCs of balanced acoustical design.

Isolating sound in a space through the use of balanced acoustical design not only helps achieve speech privacy compliance with HIPAA regulations, but also increases speech intelligibility in an adjacent space by reducing the amount of noise intruding into it. Adequate sound isolation also results in greater overall acoustic comfort and a reduction in noise-produced annoyance.

Meeting Acoustic Guidelines

When designing for healthcare institutions, the Facility Guidelines Institute's (FGI) *Guidelines for Design and Construction of Health Care Facilities* is the most widely cited design tool referenced by architects, designers, engineers, and facility managers. Updated and published every four years, it is the reference standard cited by numerous federal agencies, states, and local municipalities, and is commonly referred to as the AIA Guidelines.

The subject of sound and noise control has been included in the guidelines, but only on a limited basis. As problems caused by inadequate acoustical treatment in hospitals continued to grow, however, *Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities* were issued in 2007 by AIA and the American Hospital Association through the Facility Guidelines Institute.

The interim guidelines are much more comprehensive, and contain performance-oriented minimum requirements as suggested standards for American healthcare facility design, all of which are evidence-based and/or experience-based, and consistent with best current practices.

Since their issuance, the interim guidelines have been adopted in full as part of the FGI Guidelines. They have also been adopted by the Green Guide for Health Care™ (qualifies for two acoustic credits), and by LEED® for Healthcare (qualifies for two acoustic credits in “Environmental Quality”).

Value of Acoustics

The abundant research compiled over recent years shows the dramatic impact of noise and inadequate privacy in the healthcare environment. As a result, the importance of good acoustics in the design, construction, and operation of healthcare facilities continues to grow.

The reason: proper acoustical design has been shown to improve patient sleep, increase patient satisfaction, increase patient confidentiality, improve the healing environment, reduce staff stress, and improve speech intelligibility among staff members.

INDOOR AIR QUALITY

How can workers be exposed to formaldehyde?

Workers can inhale formaldehyde as a gas or vapor or absorb it through the skin as a liquid. They can be exposed during the treatment of textiles and the production of resins. Besides healthcare professionals and medical lab technicians, groups at potentially high risk include mortuary employees as well as teachers and students who handle biological specimens preserved with formaldehyde or formalin.*

As a result, it is important to consider the indoor air quality in healthcare spaces. Selecting low-emitting, no-added formaldehyde and low-VOC interior finishes that meet or exceed CHPS Section 01350, ASHRAE Standard 62.1-2004 helps earn GGHC and LEED HC credits, as well as limit additional formaldehyde contributions in a space. To further help reduce emissions at the source, it is important to precondition products that do have significant emissions by allowing them to off-gas without any packaging in a dry, well-ventilated space prior to installation.

* Source: *OSHA Formaldehyde Fact Sheet*

ACOUSTICS AND COMFORTING AESTHETICS

The physical design of a hospital environment is an important and integral part of the healing environment. Research indicates that patients and their families respond more positively to attractive environments that connote caring intent. As a result, the design of hospitals needs to portray a “nurturing, non-threatening environment to help put people at ease.”

When designing for a more comforting environment, aesthetics do not have to be compromised when using acoustical ceilings. In fact, many of the highest performing acoustical ceiling panels feature a smooth, fine-textured surface visual. The absence of visible holes and fissures in these panels produces a look that is far less institutional than traditional panels. The lack of visible perforations results in an aesthetic that is more appealing.

POSITIVE DISTRACTIONS. Acoustical ceiling panels that feature a variety of lighthearted designs carved into each panel’s surface are especially effective in pediatric areas, especially those where children must be stationary. These include waiting areas, examination rooms, and treatment bays. Design themes range from “Things That Fly” to “Under the Sea.”

Additionally, the carved elements of many of the panels can be field painted to add color and interest to the ceiling. This provides the opportunity to choose ceiling accent colors that match or coordinate with a space’s color scheme. It also allows the ceiling panels to act as a positive distraction from the sterile environment into which patients are entering.

Printed acoustical ceiling panels that offer custom design flexibility are also available.

WAITING ROOMS. Waiting areas play an important role in healthcare settings because they can either accentuate or alleviate the stress and anxiety known to accompany a visit to the hospital. A comfortably designed environment can at least partially mitigate the stress and anxiety of a hospital visit or stay.

Research validates this hypothesis. In one study, for example, researchers conducted a comparative analysis of waiting rooms, and found patients indicated their perceived quality of care would be greater in waiting rooms that were nicely furnished, well-lighted, contained artwork, and were warm in appearance compared to those that had outdated furnishings, were dark, contained no artwork, and were cold in appearance.

CEILING CHOICES. The addition of wood ceilings can help impart a warm ambiance to a space. Wood ceilings are available in a variety of sizes and finishes ranging from maple and cherry to beech and bamboo. In addition, the panels can be perforated to provide acoustical control. Perforations vary in size depending on the aesthetic appeal. When backed with an acoustical liner, the NRC of perforated panels ranges from 0.40 to 0.75.

In addition to wood ceilings, other acoustical ceiling design opportunities for public spaces include metal ceilings and “free floating” clouds and canopies. Metal ceilings can impart a very high tech or sophisticated look to a space and can also be perforated for acoustical performance. Acoustical clouds and canopies offer an aesthetically pleasing visual while helping to reduce reverberation time in the space below them.

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