Acoustic Environment Technical Brief

***Green Guide for Health Care™* Environmental Quality Credit 9**

Overview

Managing health care facilities' acoustic environments by lowering noise levels and introducing appropriate levels of background sound to mask intruding noise can improve health care delivery. In addition, reducing noise-related stress may improve patient outcomes and staff performance and reduce health care costs.

Hospital noise has been extensively discussed in the popular press and medical literature. According to Ulrich et al., a review of over 130 research articles investigating noise in hospital settings found that patients, research subjects, and clinical staff identify noise as a major stressor.[1] These studies found that in hospitals with reduced noise levels, patients' satisfaction with caregiving increased, their sleep improved, and their blood pressure lowered; similarly, staff in low-noise environments were more positive about their jobs and indicated improved sleep.

The *Green Guide* has introduced a two-point credit (GGHC v2.2 Environmental Quality Credit 9) addressing the acoustic environment in health care facilities. The credit references the 2006 AIA/AHA Draft Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities (AIA/AHA Guidelines) and follows their organizational structure. The approach to acoustical design advocated by both the *Green Guide* and the AIA/AHA Guidelines favors acoustical control both at the source and in areas impacted by unwanted noise. The resulting design should, at a minimum, comprehensively address the following categories: (1) Exterior Noise, (2) Acoustical Finishes, (3) Room Noise Levels, (4) Sound Isolation, (5) Paging & Call Systems, (6) Building Vibration.

The Challenges

Health care facilities face many non-acoustical requirements that supersede attention to noise control and often prohibit or restrict acoustical solutions used in other building types. Busch-Vishniac et al. cited the following challenges to reducing noise levels in hospitals:

- use of overhead paging
- proliferation of clinical alarms
- lack of sound absorptive materials in typical health care environments due to infection control concerns.[2]

In many cases, health care facilities' traditional solutions to infection control concerns work against creating a healthy acoustic environment. For example, surfaces are often covered with hard materials designed for easy cleaning and disinfection, though they generally reflect vs. absorb sound. In contrast, in commercial office buildings where infection control is not a concern, porous finishes are often introduced to improve sound absorption in the space. Even if proper consideration has been given to acoustic design in patient rooms, the benefits can be lost when patient room doors are left ajar to allow easy observation from the nurse's station. High efficiency filtration is often required for air handling systems, adding to fan horsepower and increasing noise output. Compounding this problem, in many

[1] R. Ulrich et al., "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity," 2004, Center for Health Design.
[2] Busch-Vishniac et al. "Noise levels in Johns Hopkins Hospital," Journal of the Acoustical Society of America, 2005, 118(6), 3629-3645.

areas of the facility, acoustical duct linings designed to muffle mechanical noises are prohibited between final filters and air terminal devices.[3]

Best Practices

Definitions

- Sound absorption is quantified by the sound absorption coefficient. This is the fraction of sound energy not reflected from a surface and varies from 0.00 for a totally reflective surface to 1.00 for a totally absorptive surface[4]. The sound absorption of most materials varies with frequency and is often reported in octave-band sound absorption coefficients. The common single-number description of sound absorption performance is the Noise Reduction Coefficient (NRC), which is the average of the sound absorption coefficients in the 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz octave bands.
- The Ceiling Attenuation Class (CAC) is a measure of the sound transmission loss properties of acoustical ceiling tiles. Lower CAC values indicate lesser blocking of sound while higher CAC values indicate greater blocking of sound. A Potential Technology & Strategy of Environmental Quality Credit 9.1 is to "specify and install ceiling tiles with Ceiling Attenuation Class (CAC) ratings of 35 or greater for spaces with noisy plenum equipment or for walls that stop short of the deck."
- Definitions are listed in the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities.

1. Exterior Noise Levels

Exterior Mechanical System Noise, especially from heat rejection equipment, may be radiated to the surrounding environment, where it can affect the neighboring community.[5]

Table 1.4-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities lists maximum allowable levels of noise generated by health care facilities.

Exterior Site Noise Exposure Category	**A**	**B**	**C**	**D**
General description	Minimal	Moderate	Significant	Extreme
Exterior envelope composite STC rating	≥ 35	≥ 40	≥ 45	≥ 50
Exterior patient sitting areas	Some shielding of principal noise sources may be required	Requires shielding of principal noise sources	Generally not acceptable without special acoustical consideration	Generally not acceptable
Design goal for hospital nighttime exterior equipment sound[1] (dBa)	45	50	55	60

Notes
1 Transmitted to adjacent residential receptors, in the absence of a local code. For equipment operating during daytime only, levels may be increased by 5 dBA. These values differ form sound levels in Table 1.3-1 of the AIA/AHA Guidelines which are used in the evaluation of required building envelope sound isolation.

[3] AIA Guidelines for Design and Construction of Hospital and Health Care Facilities (AIA 2006).
[4] M. D. Egan, Architectural Acoustics, McGraw-Hill, New York, 1988, page 42.
[5] ASHRAE, HVAC Design Manual for Hospitals and Clinics, 2003, pages 62-63.

To reduce noise radiation:

- Install quiet mechanical equipment
- Install duct silencers
- Locate equipment in partial or full enclosures or behind sound barrier screens

2. Acoustical Properties of Interior Finish Materials

Sound absorptive finishes on room surfaces in health care spaces can reduce the buildup of noise associated with speech, clinical alarms, medical devices, and other sound sources.

Table 2.3-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities lists recommended room acoustical performance..

Space	$\overline{\alpha}_{design}$	Subjective description
Private patient room	0.15	"Average" room
Multi-bed patient	0.15	"Average" room
Corridor	0.15	"Average" room
Waiting area	0.25	"Medium-dry" room
Atrium	0.10	"Medium live" room
Physician's office	0.15	"Average" room
Treatment room	0.15	"Average" room
Additional spaces to be added based on program for particular healthcare facility involved.		

Ceiling - Acoustical ceiling tiles

- *Glass fiber acoustical ceiling tiles* can provide effective sound absorption, often achieving NRC ratings of 0.90 or greater. These tiles can be encapsulated in a thin antimicrobial film for clean room applications while retaining most of their sound absorptive properties. The high sound absorption properties of glass fiber tiles are well suited to open spaces such as corridors and open plan offices because they can reduce the sound propagated through these spaces. While glass fiber tiles are acoustically transparent, ceiling plenum noise and speech from adjacent spaces are less of a concern in open spaces where background sound levels are usually high enough to mask these disturbances.
- *Mineral fiber acoustical ceiling tiles* are less absorptive than glass fiber, but have greater sound transmission loss properties, usually falling in the CAC 30-39 category. The upper-limit NRC absorption value for mineral fiber is around 0.70. These ceiling tiles are recommended where both absorption and transmission loss are necessary.
- *Perlite-based ceiling tiles* also exhibit strong sound transmission properties (roughly a 37 CAC rating). Because perlite ceiling tiles do not contain organic material, they do not support the growth of mold or microbial material. In addition, no coatings, paint, or added chemicals are used with these products, ensuring that they do not off-gas volatile organic compounds (VOCs) during their lifetime or in the event of a fire. [6]

Walls - Acoustical wall panels

Adding sound absorptive finishes to more than one room surface, such as both wall panels and ceiling tiles in corridors, can reduce sound levels propagated in that space.[7]

- Glass or cotton fiber wall panels can be encapsulated in a thin impervious film to enhance cleanability.

[6] http://www.chicagometallic.com/productpdf/EuroStone-pg-0605.pdf
[7] H.G. Davies, "Noise propagation in corridors", Journal of the Acoustical Society of America, 1973, 53(5), 1253-1263.

- One-inch wall panels with NRC values of 0.70 or greater for surface mounting will provide effective sound absorption for speech and most health care-related activity noise.

Flooring

The floor finish and the sub-floor structure in health care facilities can mitigate noise levels transmitted by an impact in an adjacent space, such as footfall or cart rolling.

- Of smooth, cleanable flooring surfaces in hospitals, rubber produces the least impact noise and VCT and terrazzo produce the most impact noise.
- Carpet is a mediocre finish to absorb airborne sound. The NRC performance for most carpeting used in health care spaces falls in the range from 0.20 to 0.30. As a result, carpet should not be relied upon as a primary source for airborne sound absorption. The acoustical benefit of carpeting is reducing *impact* vs. *airborne* noise, with carpet providing the highest level of impact noise reduction of all flooring types in the health care setting.

3. Room Noise Levels

Patient Rooms

The World Health Organization (WHO) recommends a limit of 40 dBA (comparable to a residential area at night) for maximum nighttime noise levels in hospitals and 30 dBA in patient rooms.[8] Patient room doors are often kept open to allow supervision, providing an easy conduit for noise transmission. Many noises generated in the corridor outside an open patient room door are transmitted to the patient location at levels in excess of the WHO limit.

The following strategies reconcile the need for visual access while providing acoustical control:

- *Glass doors* – Glass doors can provide a degree of acoustical privacy for patient rooms while allowing visual supervision.
- *Television headphones* – Pillow speakers or headphones located within easy reach of the patient can reduce the level of television audio noise in the inpatient unit.
- *Background sound in patient rooms* – If patient room doors located off active corridors must be left open at night, sound masking systems may be used to elevate the continuous room background sound above those recommended in Table 3.3-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities listed below. Personal bedside systems could provide acceptable low levels of background sound in each patient room while reducing the amount of sound added to the rest of the patient care environment. The appropriate level and type of background sound to be used at the patient bed requires further research, but the appropriate level probably lies between 40 and 60 dBA. Appropriate background sound could include a steady sound masking spectrum, nature sounds, or music.[9]

  An exception to the beneficial effects of elevated background sound are patients at risk for hearing damage due to ototoxic medications, which leaves their hearing vulnerable to any sound of moderate to high level. These patients should be placed in rooms with gasketed, heavy doors; reduced mechanical noise; and, minimal noise interference from clinical alarms, pumps, etc.

Mechanical systems

Mechanical systems generate noise, transmitted via direct airborne radiation through structure-borne paths and duct paths to various hospital spaces. Cooling towers and chillers are sources of both radiated and structure-borne noise. Air handling units and other fans in the mechanical system are sources of radiated, structure-borne, and duct-borne noise. Low frequency noise, which constitutes a

[8] World Health Organization, Guidelines for Community Noise, 1999. www.who.int
[9] G. Hempton, personal communication, 2005.

significant component of mechanical system noise, can produce annoyance, elevated blood pressure, and sleep disturbance.[10]

When designing mechanical systems, ensure that mechanical background sound levels do not exceed the recommended design criteria for room noise levels listed in Table 3.3-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities.

Room Type	NC/RC(N)/RNC[3]	dBA
Patient rooms	30-40	35-45
Multiple occupant patient care areas	35-45	40-50
NICU[1]	25-35	30-40
Operating rooms[2]	35-45	40-50
Corridors and public spaces	35-45	40-50
Testing/research lab, minimal speech[2]	45-55	50-60
Research lab, extensive speech[2]	40-50	45-55
Group teaching lab	35-45	40-50
Doctor's offices, exam rooms	30-40	35-45
Conference rooms	25-35	30-40
Teleconferencing rooms	25 (max)	30 (max)
Auditoria, large lecture rooms	25-30	30-35

Notes
1 NICU building mechanical noise levels were set for compliance with AIA requirements when added to NICU activity noise.
2 Noise levels on upper end of range due to practical airflow requirements.
3 Please see Appendix A3.4.3 in the AIA/AHA Guidelines for a discussion of different Room Noise Rating Criteria.

NC = Noise Criteria
RC(N) = Room Criteria, Neutral Spectrum
RNC = Room Noise Criterion
dBA = A-weighted Sound Pressure Level

Mechanical noise can be controlled using several techniques:

- *Fan selection* – Centrifugal airfoil fans and plenum fans can be quieter than other fan types.[11] HVAC engineers should determine appropriate sound power levels for fans given available technology and should specify maximum allowable sound power levels in design documents.[12]
- *Filter performance* – High-efficiency filters required for health care air handling units increase the fan's static pressure load as they get dirty, increasing the required fan speed and overall operational costs.[13] ASHRAE recommends planning for dirty filter pressure drops that are 2 to 4 times the initial clean filter loss.[14] Increased fan speed generally produces higher noise levels. The increased waste stream generated by frequent filter replacement should be weighed against the increased energy cost and noise levels produced by dirty filters.
- *Terminal boxes* - Variable air volume (VAV) terminal boxes contain dampers that control the amount of air supplied to spaces.[15] Discharge noise levels produced by VAV boxes should be addressed in design.[16] Most sound attenuators provided by terminal box manufacturers are simply short sections of lined duct. When these attenuators are specified for health care projects,

[10] B. Berglund et al., "Sources and effects of low-frequency noise", Journal of the Acoustical Society of America, 1996, 99(5), 2985-3002.
[11] ASHRAE, HVAC Design Manual for Hospitals and Clinics, 2003, page 91.
[12] Ibid., page 102.
[13] Ibid., Page 159.
[14] ASHRAE, HVAC Simplified, page 129.
[15] ASHRAE, HVAC Design Manual for Hospitals and Clinics, 2003, page 99.
[16] Ibid., Page 102.

the sound absorptive lining is covered with film or a foil lining that drastically reduces the attenuator's effectiveness. Such attenuators, however, can be helpful in increasing the distance between the VAV box damper and the downstream coil, reducing flow noise generation at the coil. Using parallel-baffle duct silencers with a film lining can reduce discharge noise from VAV terminal boxes.

- *Vibration isolators* – Conventional vibration isolation mounts, such as springs and rubber pads for isolating mechanical equipment, are in use in many different building types and need no specific alteration for health care facilities. The performance requirements for vibration isolators are usually stated in terms of isolator efficiency or minimum static deflection. Review the current edition of the ASHRAE Applications Handbook for suggested minimum isolator static deflection requirements for a variety of mechanical equipment. Avoid chlorinated rubber pads such as neoprene in accordance with GGHC v2.2 Materials & Resources Credit 4.1: PBT Elimination: Dioxin. For more information about PBT avoidance, see the *Green Guide for Health Care* PBT Elimination Technical Brief.
- *Duct attenuation* – Standard duct noise attenuation strategies, such as glass fiber duct lining and glass fiber filled parallel-baffle duct silencers, are often prohibited in hospital duct systems for hygiene and indoor air quality reasons. Antimicrobial-treated recycled cotton duct lining is available as an alternative to glass fiber duct lining and glass fiber duct silencer fill. Where any exposed fibrous material in the duct airstream is prohibited, install duct silencers with a film lining that separates the airstream and the fibrous fill while minimally affecting the acoustic performance.[17] 100% metal no-fill silencers are also available; however, these silencers have diminished acoustic performance relative to conventional silencers.[18] No-fill silencers can generate significant levels of high frequency noise when air passes through them and should be used cautiously. HVAC designers should take into account inlet and outlet conditions at silencers, since these conditions affect the effective static pressure drop of the silencers and in turn the operation of the system.[19] Fabric-covered wire-helix flexible ducts allow sound to "leak" out of the duct into the ceiling plenum, where it can be blocked from occupied spaces with high Ceiling Attenuation Class (CAC) tile. See the "Acoustical Properties of Interior Finish Materials" section on page 3 for more information on acoustical ceiling tile.
- *Airflow velocities* – Airflow velocities affect background noise levels through the generation of turbulence noise.[20] The ASHRAE Applications Handbook includes recommendations for maximum velocity limits in ducts and at air devices. Manual balancing dampers should be remotely located from diffusers and registers to reduce the level of damper noise transmitted to these air terminal devices.[21] Diffusers and registers usually have NC ratings that are based on ideal flow conditions measured in a laboratory. The effective noise levels of these air devices may increase with unfavorable flow conditions.[22] Airflow velocities at diffusers and registers should be kept below 400 feet per minute (fpm) if low noise levels are desired.[23]
- *Cross-talk* – Ductborne cross-talk is the transmission of sound from one occupied room to another via connecting ductwork, and should be considered in the design of duct systems.[24] Duct attenuation measures, discussed above, can be used to reduce cross-talk.

[17] Ibid., page 93.
[18] Ibid., page 93.
[19] Ibid., pages 93-94.
[20] Ibid., pages 96-97, pages 101-102.
[21] Ibid., pages 102, 157.
[22] ASHRAE, HVAC Design Manual for Hospitals and Clinics, 2003, page 102.
[23] Ibid., page 102.
[24] Ibid., page 102.

4. Sound Isolation

Speech Privacy

Speech privacy concerns have taken on increased importance with Health Insurance Portability and Acountability Act (HIPPA) regulations, enacted in 1996. According to conventional wisdom, full walls are required between talkers and listeners to achieve speech privacy. However, full height walls can affect construction cost, design flexibility, and material use. In addition, research has shown that the level of speech privacy between talker and listener is determined by an equal consideration of background sound and noise reduction from barriers and finishes[25].

Speech privacy can be objectively measured using the Articulation Index (AI) and Privacy Index (PI)[26]:

- *AI* varies from 0 (absolute privacy) to 1.0 (perfect intelligibility, no privacy).
- *PI* is a related rating system and the inverse of *AI*, with 100% meaning absolute privacy and 0% meaning no privacy. The general groups of privacy rankings are listed in the following table.
- Normal privacy = "concentrated effort is required to understand intruding speech"[27]
- Confidential privacy = "speech cannot be understood"[28]

Table 4-3 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities recommends speech privacy goals for enclosed rooms.

Speech Privacy Goal	AI	PI	STI	SII
Normal	≤0.15	≥85%	≤0.19	≤0.20
Confidential	≤0.05	≥95%	≤0.12	≤0.10
Secure	Special consideration required.			

To improve speech privacy, it is necessary to either improve the noise reduction or increase the background sound level.

- *Noise reduction* – Noise reduction can be improved by adding barriers to block sound and/or by reducing reflections from room surfaces by adding sound absorptive finishes.
- *Background sound* – Electronic background sound systems can provide uniform, controlled sound levels throughout an area. Distributed ceiling-based systems can achieve speech privacy over open areas such as waiting rooms. See the "Room Nose Level" section on page 4 for more information.

Sound Isolation Between Enclosed Rooms

Table 4.3-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities recommends composite STC ratings for constructions between enclosed rooms.

Adjacency combination		STC_c
Patient Room	Patient Room (horizontal)	45[1]
Patient Room	Patient Room (vertical)	50
Patient Room	Corridor (with entrance)	35[2]
Patient Room	Public Space	50
Patient Room	Service Area	60[3]
Exam Room	Corridor (with entrance)	35[2]

[25] W. Cavanaugh et al., "Speech privacy in buildings", Journal of the Acoustical Society of America, 1962, 34(4), 475-492.
[26] ASTM, E1130-02 Standard test method for objective measurement of speech privacy in open offices using articulation index, 2002.
[27] Ibid.
[28] Ibid.

Adjacency combination		STC_c
Exam Room	Public Space	50
Toilet Room	Public Space	45
Consultation Room	Public Space	50
Consultation Room	Patient Rooms	50
Consultation Room	Corridor (with entrance)	35[2]
Patient Room	MRI Room	60[3]
Exam Room	MRI Room	60[3]
Exam Room	Exam Room (no electronic masking)	50
Exam Room	Exam Room (with electronic masking)	40
Public Space	MRI Room	50

5. Paging & Call Systems

Clinical alarms and audible paging are used by the hospital staff for various alerts, but are often sources of disruptive noise to patients. Reducing the sound levels provided by these systems makes the hospital environment quieter for patients and staff but may have negative consequences for patient safety and staff communication. Addressing needs for staff notification and patient comfort can be met with the following strategies and technologies:

- Nurse call and patient telemetry systems reduce the need to broadcast pages and alarms throughout patient care areas.
- Clinical alarm noise should be directed away from patients as much as possible. "Alarm management" and "alarm integration" are concepts currently discussed in the clinical engineering community to address clinical alarms. The American College of Clinical Engineering's Health Care Technology Foundation has launched a clinical alarm initiative, with the goal of improving clinical alarm management.[29]
- Wireless communication devices for staff and future "smart" algorithms for patient-specific alarm thresholds can help reduce the number of alarms and alarm noise level.[30]
- Remotely locate alarms at nurse stations.
- Use variable sound volume to adjust loudness to the urgency of the alarm.

6. Building Vibration

Building vibration is typically caused by footfall impact noise and mechanical equipment vibration.

Table 6.3.2-1 of the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities recommends limits on footfall vibration in hospitals.

Space Type	Footfall Vibration Peak Velocity (μin/s)
Patient Rooms and other Patient Areas	4000
Operating and other Treatment Rooms	4000
Administrative Areas	8000
Public Circulation	8000

See the "Acoustical Properties for Interior Finishes" section on page 3 for additional guidance on reducing footfall impact noise.

See the "Room Noise Levels" section on page 4 for guidance on reducing mechanical system vibration noise.

[29] American College of Clinical Engineering, Health care Technology Foundation, www.acce-htf.org
[30] T. Gee, "Trends in point-of-care alarm notification", Patient Safety & Quality Healthcare, 2007, 4(1), 30-33.

Benefits

Health

Reduction in sleep awakenings and sleep onset latency are major health benefits of proper management of the acoustical environment in health care facilities. Nighttime noise disturbances in hospitals have been found to contribute to disruption of sleep patterns.[31,32,33] Sleep deprivation has been shown to diminish immune system performance,[34] while regular deep slow-wave sleep appears to aid in its performance.[35] Stanchina et al. have found that the reduction in signal-to-noise ratios of intruding sound to background sound can improve sleep patterns.[36] Further research on the links between the acoustical environment, inpatient sleep patterns, and patient outcomes will enrich the understanding of the benefits of hospital noise control.

Ecologic

Noise has been shown to adversely affect humans and wildlife.[37,38] Noise pollution can impair animals' sense of direction, eating patterns and mating rituals. Reducing noise levels generated by health care can reduce the adverse effects of facility noise on the surrounding environment. Some state and local noise regulations provide a benchmark for exterior noise emission control. Visit the websites for the Acoustic Ecology Institute and the World Forum for Acoustic Ecology for more information on the health and environmental impact of noise pollution.[39,40]

Economic

Length of stay is an important economic metric for health care.[41,42] A study by Fife and Rappaport shows that reduced exterior construction noise correlates with shorter hospital stays.[43] Medication costs also have been linked to noise in hospitals. Studies such as Minkley et. al. found that patients requested increased pain medication during periods of elevated noise in a recovery room.[44] Patient and staff satisfaction can be influenced by the acoustic environment, and can affect a hospital's economic performance, Cmiel et. al. have reported favorable patient comments in response to a concerted noise control effort.[45] Topf and Dillon linked noise-induced occupational stress with "burnout" for critical care nurses, implying that lower occupational noise levels would reduce nurse turnover.[46]

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[31] J. Aaron et al., "Environmental noise as a cause of sleep disruption in an intermediate respiratory care unit", Sleep, 1996, 19(9), 707-710.
[32] N. Friedman et al., "Abnormal sleep/wake cycles and the effect of environmental noise on sleep disruption in the Intensive Care Unit, American Journal of Respiriratory and Critical Care Medicine, 2001, 163, 451-457.
[33] J.Y. Gabor et al., "Contribution of the intensive care unit environment to sleep disruption in mechanically ventilated patients and healthy subjects", American Journal of Respiriratory and Critical Care Medicine, 2003, 167, 708-715.
[34] J. H. Daruna, Introduction to Psychoneuroimmunology, Elsevier Academic Press, Boston, 2004, Page 124.
[35] Ibid., Pages 214-215.
[36] M. Stanchina et al., "The influence of white noise on sleep in subjects exposed to ICU noise", Sleep Medicine, 2005, 6, 423-428.
[37] Noise Effects Handbook, U.S. E.P.A., 1981, available at http://www.nonoise.org/library/handbook/handbook.htm
[38] http://www.nonoise.org/library/fctsheet/wildlife.htm
[39] http://www.acousticecology.org
[40] http://interact.uoregon.edu/MediaLit/WFAE/home/index.html
[41] D. Scalise, "What insurers know about your hospital, and how they are using it", Hospitals & Health Networks, 2004;78: 34-38, 2.
[42] F.D. Baldwin, "Where Medicare goes…the rest of the system may well follow CMS' pay-for-performance example", Healthcare Informatics, 2004;21:24-26.
[43] D. Fife and E. Rappaport, "Noise and hospital stay", American Journal of Public Health, 1976, 66, 680-681.
[44] B. Mincley, "A study of noise and its relationship to patient discomfort in the recovery room", 1968, 17, 247-250.
[45] C. Cmiel et al., "Noise control: a nursing team's approach to sleep promotion", American Journal of Nursing, 2004, 104(2), 40-48.
[46] M. Topf and E. Dillon, "Noise-induced stress as a predictor of burnout in critical care nurses", Heart and Lung, September 1988, 17(5), 567-574.

Case Study

Cmiel et al. created a sleep promotion team on the surgical thoracic intermediate care nursing unit at St. Mary's Hospital, a Mayo Clinic affiliated hospital in Rochester, MN[47]. They measured sound levels during night shifts and found average levels of 45 dBA in empty patient rooms and 53 dBA in an occupied semi-private room. They also measured peak levels as high as 113 dBA. The sleep promotion team implemented several interventions:

- Conducting shift reports in closed report rooms during shift change.
- Closing patient room doors.
- Muffling beep sounds of IV pumps while making programming changes.
- Anticipating IV infusion completions and making changes before pump alarm sounds.
- Eliminating overhead paging between 9 am and 7 PM.
- Using computerized personnel tracking and location system to locate staff.
- Moving supply stocking time from 3-4 am to 9-11 PM.
- Avoiding housekeeping staff shortcuts through patient unit.
- Using nursing station phones instead of hallway phones.
- Reducing the number of routine nighttime chest X-rays with portable X-ray machines.
- Using variable volume control on bedside cardiac monitors.
- Adding foam padding to pneumatic tube canister receptacles to reduce noise of arriving canisters.
- Padding the bottoms of patient chart holders outside patient rooms.
- Changing paper towel dispensers from rolled type to folded type.

The post-intervention average sound level was 42 dBA during the night shift and the greatest peak level during shift change was 86 dBA, lower than the pre-intervention peak level. Cmiel et al. reported that a majority of the patient comments received about noise and sleep after the intervention was positive. This study also resulted in an increased awareness of noise levels among the unit staff.

Resources

In addition to the resources noted in the Green Guide for Health Care, the following may offer additional assistance:

2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities, November 1, 2006, http://www.healthcareacoustics.org

2006 AIA Guidelines for Design and Construction of Health Care Facilities, http://www.aia.org.

Acoustical Society of America, "Are Our Hospitals Too Noisy?," http://www.acoustics.org/press/137th/medeiros-e.html

Busch-Vishniac, I. J., J. West, M. MacLeod, and J. Dunn, "Quieting Weinberg 5C: A Case Study in Hospital Noise Control," Journal of the Acoustical Society of America, 2006, http://asa.aip.org/jasa.html

European Heart Journal, "Noise Burden and the Risk of Myocardial Infarction," http://eurheartj.oxfordjournals.org/cgi/content/abstract/ehi658v1

Johns Hopkins, "An Rx for Noisy Hospitals," http://www.jhu.edu/~gazette/2005/28nov05/28noisy.html

[47] Cmiel et al., "Noise control: a nursing team's approach to sleep promotion", American Journal of Nursing, 2004, 104(2), 40-49.

Joseph, Anjali and Roger Ulrich, "Issue Paper #4: Sound Control for Improved Outcomes in Healthcare Settings," Center for Health Design, January 31, 2007, http://www.healthdesign.org

Mazer, Susan E., "Patient Safety & Quality Healthcare," http://www.psqh.com/marapr05/noise.html

Montefiore Medical Center's Silent Hospitals Help Healing, http://www.montefiore.org/whoweare/stories/shhh

Tech brief authored by Benjamin Davenny, Acentech Incorporated and member of the Acoustical Working Group that authored the 2006 AIA/AHA Draft Interim Sound and Vibration Guidelines for Hospital and Healthcare Facilities. Reviewed by William J. Cavanaugh and David Sykes.

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