# Noise Monitoring: A Strategy for Better Patient Care in Hospitals

by Chris Roberts and Estelle Schweizer


## Executive summary

Noise levels in hospitals have increased tenfold in the past five years and are continuing to escalate. Hospital workers and patients are being overwhelmed by the constant noise of alarms, paging systems, and medical equipment. All this noise leads to sensory overload, alarm fatigue, and negative impacts on patient recovery. This white paper reviews the causes and effects of hospital noise on patients, staff, and the organization as a whole. Recommended best practices for noise monitoring and reduction are provided, along with guidance on what to look for in a noise-monitoring solution.


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# Introduction

Patients are typically admitted to a hospital because they have an illness or injury, or are giving birth. In any of these cases, it is paramount that the hospital protects the health and mental well-being of the patient by providing a safe and healing environment.

Hospitals are littered with QUIET PLEASE signs, yet the hospital "quiet zone" unfortunately has become an oxymoron. Noise is an emerging threat to patient safety and comfort. Measured levels of hospital noise in patient rooms, operating theaters, and other patient environments has escalated above 50 decibels (dB), a level that has been shown to delay recovery and rehabilitation times for patients, as well as bring about added stress and job dissatisfaction for clinical staff (**Figure 1**).


**Figure 1**
*Hospital noise has increased steadily since the 1960s.*

Despite these findings and the healthcare industry's attempts to correct the noise situation, hospital noise levels have almost doubled over the past six decades— fueled by a cacophony of beeping patient monitoring alarms, gurneys rolling through the hallways, televisions in patient rooms, visitors talking loudly on cell phones, and hallway chatter between nurses and other clinical staff, just to name a few of the common sources of high-decibel sounds.

Research confirms the far-reaching effects of this "culture of noise" on patient safety and clinician productivity and makes a strong case for adopting noise monitoring solutions in today's hospitals:

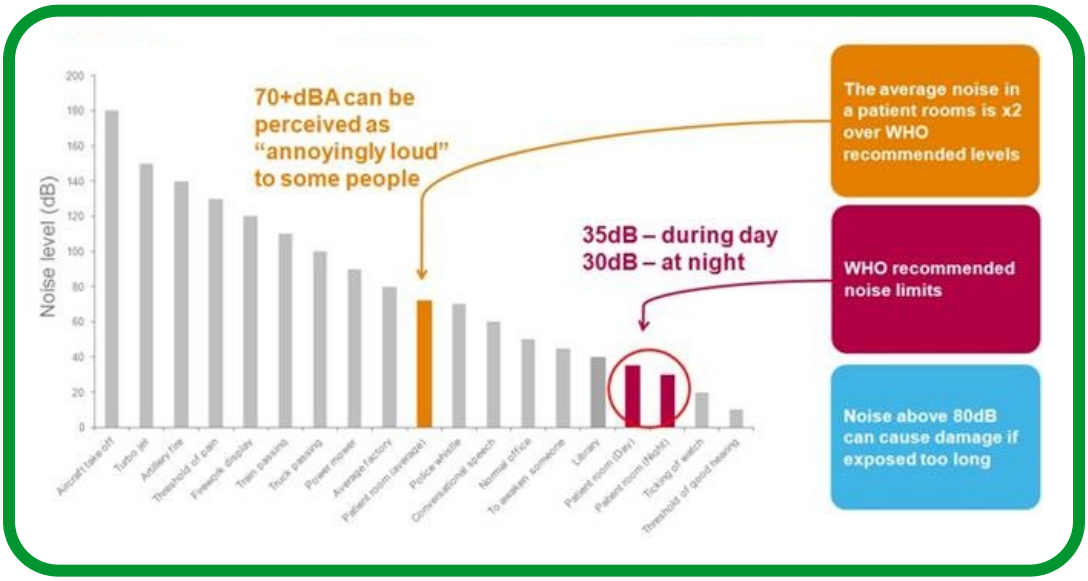
- A 2012 study published in the *Annals of Internal Medicine* analyzed how noise affected patients' sleep and heart rate. After three nights of sleeping in a typical noisy hospital environment, the healthy volunteers who participated experienced an increased heart rate whether they woke up or not.[1]
- The World Health Organization (WHO) recommends that hospital room noise levels not exceed 30dB, but University of Chicago researchers have reported that the average hospital noise level actually fluctuates between 50dB to 80dB — nearly as loud as a chain saw.[2]

[1] "Sleep Disruption due to Hospital Noises: A Prospective Evaluation," *Ann Intern Med.* 2012;157(3):170-179.

[2] Cited in AARP, "Do Noisy Hospital Rooms Affect Your Recovery?"

- In 2011, alarm fatigue (failing to respond to monitor alarms in a timely manner as healthcare workers "tune out" the constant noise of beeping machines) was cited as the possible cause of death of a patient at UMass Memorial Medical Center. The hospital was cited for numerous violations by the Massachusetts Department of Public Health.[3]

**Figure 2**
*Hospital decibel levels compared with other environments*




This white paper explores solutions for integrating next-generation noise-monitoring technology with the hospital's building management system so that clinical personnel and facility managers alike can more efficiently monitor and control noise levels throughout the healthcare facility. The paper also offers best-practice recommendations to architects and other key stakeholders involved in the planning, design, and construction of hospitals and other healthcare facilities.

## Why hospital noise is so prevalent

Anyone walking down the hallway of a patient-room corridor will hear the steady beeps or pulsing alarms of the medical equipment that monitor patients' vital signs, provide painkilling intravenous drugs, and keep patients breathing and alive when they cannot do so on their own. Interspersed among the beeps and chimes, television programs provide an endless stream of dialog and music, while patients, visitors, and staff converse or talk on the phone both inside and outside patient rooms. Adding to the cacophony of hospital noise is the clatter and rumble of patient gurneys and medication and food service carts as they roll down the hallways. And the noise continues steadily all hours of the day and night as new patients are admitted and clinical staff respond to patient emergencies.

*"Noise levels above 50dB can lead to hypertension, depression, and myocardial infarction."*

However, hospital noise is more than just annoying. It can actually provoke physical changes in the patients and staff who are immersed in a constantly noisy environment. Noise levels above 50dB can lead to hypertension, depression, and myocardial infarction.[4] In turn, patients have less tolerance for pain and they experience overall unease amidst the constant noise. Sleep disturbance and delayed healing can also contribute to lower patient satisfaction scores, which are tied to insurance reimbursement in the United States. Delayed healing can also lead to longer length of stay for patients, which increases the chance that they will acquire healthcare-associated infections (HAIs) — non-reimbursable events that can cost hospitals billions.[5]

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[3] "Shhhh: UH project tamps down hospital noise, raises patients' satisfaction," *Cleveland Plain Dealer,* Aug. 6, 2012.

[4] World Health Organization, "Night Noise Guidelines for Europe" (2009).

[5] "New Report Estimates Societal Cost of HAIs at a High of Nearly $150 Billion Annually," *Infection Control Today*, Oct. 3, 2013.

**Table 1**
*Hospital noise has a negative impact on patients, staff, and the healthcare organization as a whole.*

| Impact of hospital noise | |
|---|---|
| Patients | • Annoyance<br>• Sleep disruption and awakening<br>• Decreased oxygen saturation, elevated blood pressure, increased heart and respiration rate among neonatal intensive care patients<br>• Delayed recovery |
| Staff | • Increased perceived work pressure, stress, and annoyance<br>• Increased fatigue<br>• Emotional exhaustion and burnout<br>• Difficulty in communication possibly leading to errors |
| Healthcare organization | • Lower patient satisfaction and safety scores<br>• Patient attrition<br>• Longer length of stay for patients, which could increase the chances for HAIs<br>• Higher incidence of re-hospitalization |

Noise can also impact hospital staff negatively. For example, a 2012 study by researchers at the University of Illinois at Chicago found that a noisy hospital environment caused clinicians to make numerous medication-dispensing errors simply because they misheard the name of the drug.[6] The increased stress caused by noise can also cause nursing staff to ignore noises, leading to a phenomenon called "medical alarm fatigue." A study by Stanford University, presented by researchers at the AMMI Medical Device Alarm Summit in October 2011, found that only 3.6 percent of cardiac alarms were triggered by critical patient events[7]. Alarm fatigue may cause staff to tune out the alarms and not respond as quickly, and patients suffer agitation and sleep deprivation when awakened multiple times by non-critical alarms. The result is a potentially dangerous situation in which patient safety is at risk and staff performance drops — as does the hospital's satisfaction rating and reputation. Moreover, hospital staff who work in a noisy environment day after day report more instances of job burnout, depression, irritability, and exhaustion[8] — all factors leading to high staff turnover rates, low staff productivity, and barriers to finding and retaining top-level clinical staff. Most serious, however, is the potential of making medical errors when trying to communicate and manage several patients at once in a distracting, noisy workplace.

[6] "Shhhh: UH project tamps down hospital noise, raises patients' satisfaction," *Cleveland Plain Dealer,* Aug. 6, 2012.

[7] Barbara J. Drew, PhD, RN, FAAN, FAHA, "Cardiac Monitoring Devices Clinical Alarm Fatigue," May 12, 2011.

[8] Connor, Alison, and Elizabeth Ortiz. "Staff Solutions for Noise Reduction in the Workplace." *The Permanente Journal* 13.4 (2009): 23–27.

## Not all hospital noise is created equal

Acceptable noise level thresholds vary by hospital department. What may be unacceptable hospital noise in a neonatal intensive care unit (NICU) may be more than tolerable in the emergency room. These variations make it challenging to easily evaluate and choose a noise-monitoring solution. Therefore, it is important to first understand where noise is occurring and determine different noise-reduction strategies for each area. The following examples indicate that a noise-monitoring solution must be flexible enough to accommodate a wide range of sound levels:[9]

- **Patient rooms** The WHO recommends that background sound levels should not exceed 30 dBA during the day and 30 dBA at night, with transient sounds not to exceed than 40 dBA at night.
- **NICU** To promote infants' sleep and healing, transient noise in the NICU should not exceed 65 dBA, and operational sounds should not exceed 45 dBA.
- **Clinical staff areas** Typical workflows can generate noise in excess of 90 dB, which can filter down from nurses' stations and hallways to patient rooms and disturb patients' sleep.

As shown in the pie chart below (**Figure 3**), hospital noise is a common complaint and comes from many sources: paging systems, medical equipment alarms, moving bedrails, telephones, entertainment systems, staff members, visitors and other patients, ice machines and disposal bins, pneumatic tubes, trolleys, and many more.[10] Environmental surfaces can also contribute to noise. Floors, walls, and ceilings are usually hard and reflect sound instead of absorbing it, creating poor acoustic conditions. Sound-reflecting surfaces cause noise to travel down corridors and into patient rooms, adversely affecting patients and staff over larger areas.

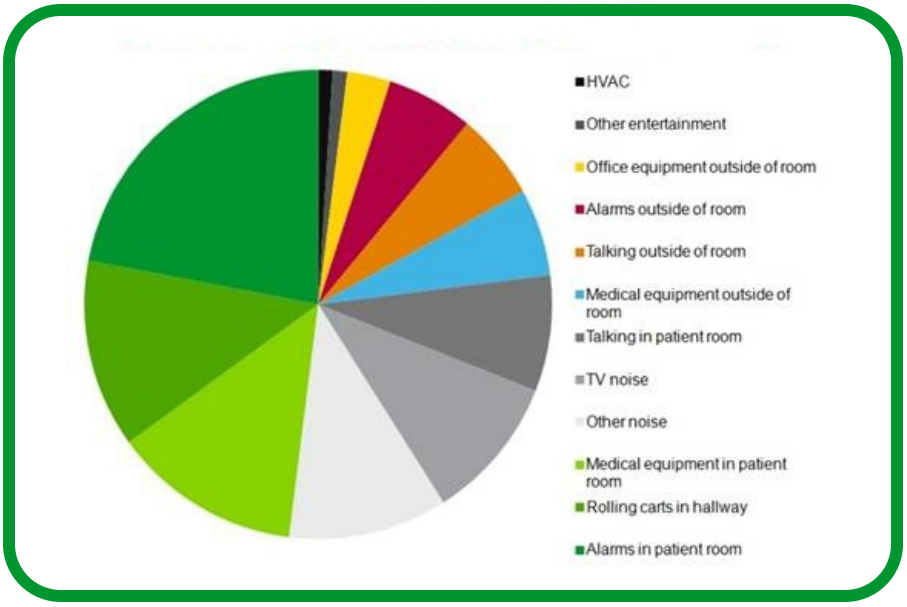


**Figure 3**
*Hospital noise comes from a wide variety of sources.*

[9] "Noise Pollution in Intensive Care Units and Emergency Wards," *Iran J Otorhinolaryngol*. 2011 Autumn; 23(65): 141–148, at National Center for Biotechnology Information.

[10] , Cassandra H Wiese and Lily M. Wang, PhD, PE, "Measured Levels of Hospital Noise Before, During, and After Renovation of a Hospital Wing, and a Survey of Resulting Patient Perception," 2011 ASHRAE Winter Conference, Las Vegas, NV.

# Turning down the noise: best practices and solutions

Current best practices for noise reduction and noise monitoring in hospitals include a wide gamut of manual and behavioral solutions, such as lowering the volume of alarms on patient monitoring devices, enforcing quiet times, reducing conversation, providing patients with sleep aids such as earplugs and eye masks, or even trying to mask the noise with white noise machines.

A more effective approach integrates noise-monitoring solutions into the facility's building management system (BMS) — either at the design stage of new facilities or as a retrofit into an existing BMS. Hospitals of the future are embracing the following noise-monitoring and management best practices.

## Evaluate acoustic design

Architects and engineering teams can design or retrofit hospitals using a combination of sound-dampening surfaces that meet hospital standards for sterility and washability, as well as improved noise attenuation in ventilation systems. This design approach also provides practical usage guidelines, such as giving patients personal headsets for in-room televisions, which can result in a significant noise reduction.

## Integrate noise-monitoring solutions within BMS infrastructure

*"Noise-monitoring technology can be easily integrated into an 'intelligent healthcare facilities infrastructure' to drive staff and patient comfort."*

The hospital of the future is coming of age now with integrated healthcare infrastructure solutions that combine building management and security into a single, intuitive system. The progressive development of information communication technology (ICT) and other emerging wireless and mobile communications protocols has resulted in a new design solution termed an "intelligent healthcare facilities infrastructure." This design solution integrates a number of previously separate systems into a single intelligent infrastructure, enabling a facility and its staff to function more effectively and efficiently to improve patient outcomes and to reduce the cost of providing care. These unified services are designed to provide an optimal healing environment for patients through the provision of heating, ventilation, lighting, air conditioning, and at-bed services — all of which are geared toward a patient-centric networked model of care and have been proven to improve recovery rates. Noise-monitoring technology can be easily integrated into this intelligent infrastructure solution to drive staff and patient comfort.

## Centralize monitoring systems

Noise reduction in patient rooms is a key step toward improving patient safety and patient satisfaction. Some hospitals accomplish this by centralizing nurse call systems outside of the patient room where staff can easily view and quickly respond to system alerts without disturbing the patient unless necessary. See the Schneider Electric white paper "Effect of Intelligent Technology Infrastructure on Hospital Operating Costs and Patient Care." In addition, hospital staff productivity increases because they have a noise-monitoring solution at their fingertips in a centralized, user-friendly dashboard that provides the right information at the right time in a completely integrated BMS infrastructure.

## Sound map the hospital

An integrated control panel can help hospitals manage noise more efficiently by measuring the zone noise and identifying locations where volume exceeds recommended levels. By providing specialized noise-monitoring devices in patient rooms and corridors, the noise level can be monitored to provide sound mapping of the hospital. Graphical images can be created to show the noise "hot spots" and the average levels throughout the day and night. Armed with this insight, targeted noise-reduction strategies can be developed and implemented.

### Change staff workflow

Corridors used by nursing staff during shift changes can be noisy, and changing staff routes to reduce noise may be necessary. An LED display can also be used to illustrate rising noise levels and provide a subtle warning.

## What to look for in a hospital noise monitoring solution

First and foremost, noise-monitoring solutions should not add more noise with distracting alarms. Nor should it require extensive training or a long learning curve for clinical teams who are already overworked and managing multiple systems. Furthermore, the technology supporting the noise-monitoring solution must be designed specifically for the hospital environment and adhere to compliance regulations.

The following checklist provides key factors to consider when researching noise-monitoring solutions:

- **Technology requirements** The solution should be able to analyze noise patterns by monitoring both A-weighted and C-weighted noise levels. A (dBA) is the most commonly used weighting scale, as it also predicts quite accurately the risk of damage to the ear. Sound level meters set to the A-weighting scale will filter out much of the low-frequency noise they measure, similar to the response of the human ear. However, the addition of C-weighted (dBC) noise monitoring follows the frequency sensitivity of the human ear at very high noise levels. The C-weighting scale is quite flat, and therefore includes much more of the low-frequency range of sounds than the A scales. Many key documents on hearing conversation rely on dBC in determining noise exposures.
- **Easy integration** The most effective noise-monitoring technology should integrate easily with automated BMS solutions and not require extensive infrastructure build-out if the system is being added to an existing BMS.
- **Simplicity and silence** In-room sound-monitoring devices should be easily wall mountable, invisible to the patient, and display the noise level in an intuitive, easily understood LED graphical interface. A silent warning, such as a flashing red light, on devices in the hallways should alert hospital personnel when the noise level exceeds the acceptable limit. For example, a green light could indicate acceptable noise levels, an amber light could alert that noise is approaching the predetermined threshold, and a red light could alert staff that noise has surpassed the threshold.
- **Flexibility** The solution should be able to be used in all sensitive hospital areas where patients and visitors are exposed to environmental noise, including patient rooms with several beds, operating rooms, recovery rooms, neonatal units, intensive care units, and waiting rooms.
- **Compliance** Choose a noise monitoring solution that has been specifically developed for use in hospitals and is compliant with the IEC 60601-1 Part 1 and Part 2 regulations covering general requirements for basic safety and performance of medical electrical equipment.
- **Noise level reporting** Reports should allow the hospital to analyze where the noise issues are occurring, including room comparisons and departmental reports. Historical data should be accessible so that future analysis can correlate the noise levels with patient recovery rates and satisfaction surveys results.
- **Graphical interface** Choose a system that displays noise data in way that enables users to react quickly. Use of graphical images can be created to show noise “hot spots”, so that nurses can quickly react if necessary adjustments or “quiet please” requests are needed.

## Improved patient outcomes and satisfaction

Patients, staff, and hospital management all benefit from reducing and controlling noise levels in the hospital environment. For example, a study at the University Hospital in Hannover, Germany, found that patients experience fewer complications and a better clinical outcome when hospitals reduce noise levels.[11] The study, published in the university's *Annals of Surgery,* cited data on the effect of noise reduction in the hospital's pediatric operation ward. Noise levels were recorded before and after deploying SoundEar® electronic noise meters that provide a visual warning that a pre-set noise limit has been exceeded. With the new noise-monitoring solution in place, the hospital significantly lowered the median noise levels in the operating theater from 63dB to 59dB. As a result, doctors and nurses reported feeling less stressed during the surgeries. Most telling was that the hospital reduced instances of patient postoperative complications by 50% — only 10 out of 56 patients reported complications after the noise-monitoring system was deployed, as opposed to 20 out of 58 before the noise-reduction program.

The benefits to patients and hospital staff extend to the hospital organization as well through improved patient outcomes, higher patient satisfaction scores, shorter lengths of stay, lower re-admission rates, and improved staff retention rates. As such, hospitals can improve their competitive advantage and reputation as the preferred healthcare provider in their city or region, as well as become a more attractive place for clinicians to work.

## Conclusion

Today's hospitals should be an oasis of quiet for those who seek medical care and for the professionals who provide it. The excessive hospital noise created by people and technology is contributing to poor patient outcomes, stressed and ambivalent employees, and unnecessary strain on hospital budgets and reputation. Although the "culture of noise" continues to be an ongoing challenge, noise-monitoring solutions are providing successful solutions today, even as they evolve to meet the changing needs of the hospital IT infrastructure and compliance regulations. The caveat, however, is to choose a noise-monitoring solution that is specifically designed for compliance within the hospital environment and can be easily integrated with a BMS for the most efficient, compliant, and cost-effective operation.

Moreover, the question is not *if,* but *when,* organizations must address the problem of hospital noise and its effect on patients and clinical staff. The world's population age 60 and above will double by 2050, and with it the demand for healthcare services. The potential for hospitals to become even noisier in the future as its patient population increases is a clear motivator for hospitals to adopt a strategic approach to noise reduction now, not later. Those "hospitals of the future" that do so will be well prepared to attract and keep the lion's share of the burgeoning market for healthcare services.

[11] "A noise-reduction program in a pediatric operation theatre is associated with surgeon's benefits and a reduced rate of complications: a prospective controlled clinical trial," *Ann Surg* 2014 May;259(5):1025-33.

## About the authors

**Chris Roberts** is the Global Solution Architect for Healthcare Solutions at Schneider Electric and is responsible for the strategic design, development, and support of intelligent healthcare infrastructure solutions that improve the environment of care and the bottom line. He speaks regularly at healthcare conferences around the world on best practices for creating customer-driven, intelligent healthcare solution design and implementation.

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