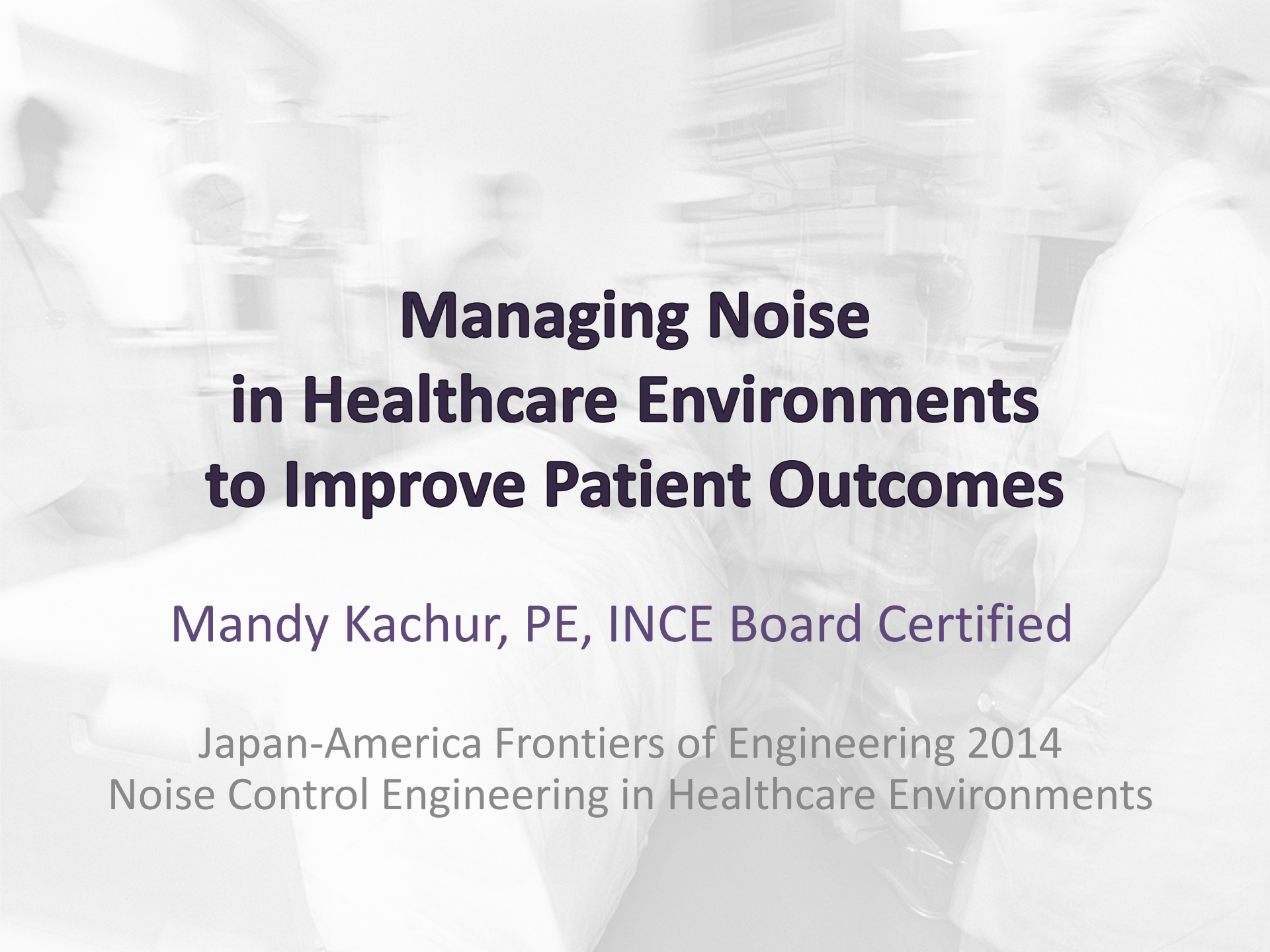




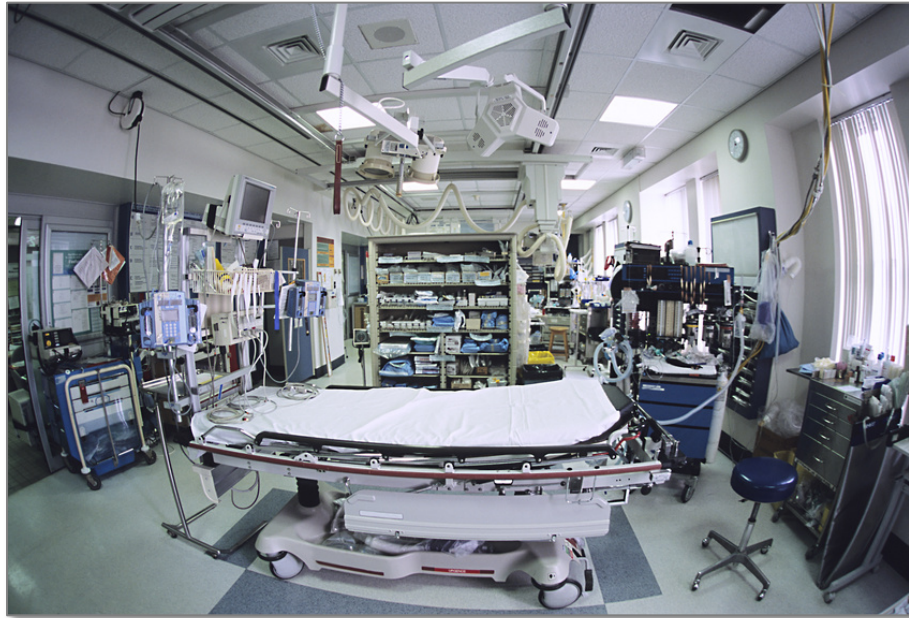
Managing Noise in Healthcare Environments to Improve Patient Outcomes

Mandy Kachur, PE, INCE Board Certified

Japan-America Frontiers of Engineering 2014
Noise Control Engineering in Healthcare Environments

Noisy Hospitals

Noise is
Unwanted
Sound



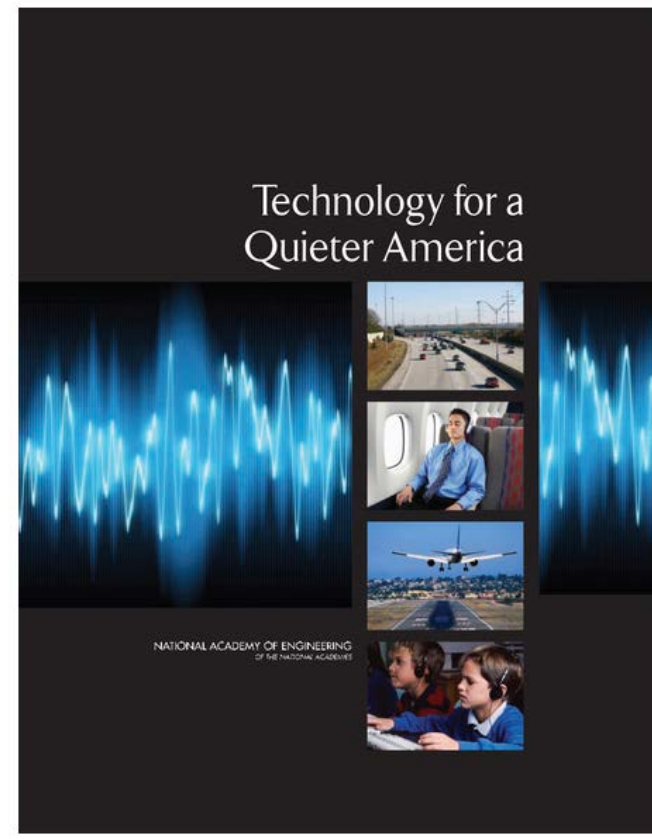
- Noise negatively affects clinical outcomes
 - Increased stress responses and physiological arousal
 - Sleep disruption
 - Increased pain
 - Medical errors, including harm and death

National Academy of Engineering - Technology for a Quieter America

“Almost every aspect of hospital design is in dire need of noise control.” -2010

Reinforced by World Health Organization (Berglund, et al, 1999)

- WHO hospital noise level guidelines are exceeded on a regular basis



What is being done about noise?



Noise Control Initiatives

- Patient centered
- Staff centered
- Medical evidence-based research for codes and regulations
- New frontiers
- Interspersed case studies

Acoustics in Action

Old Problem: Lack of Communication

Acoustics Engineers

not initiating studies
in medical field

$$L_p = 10 \log (p/p_{\text{ref}})$$



Medical Personnel

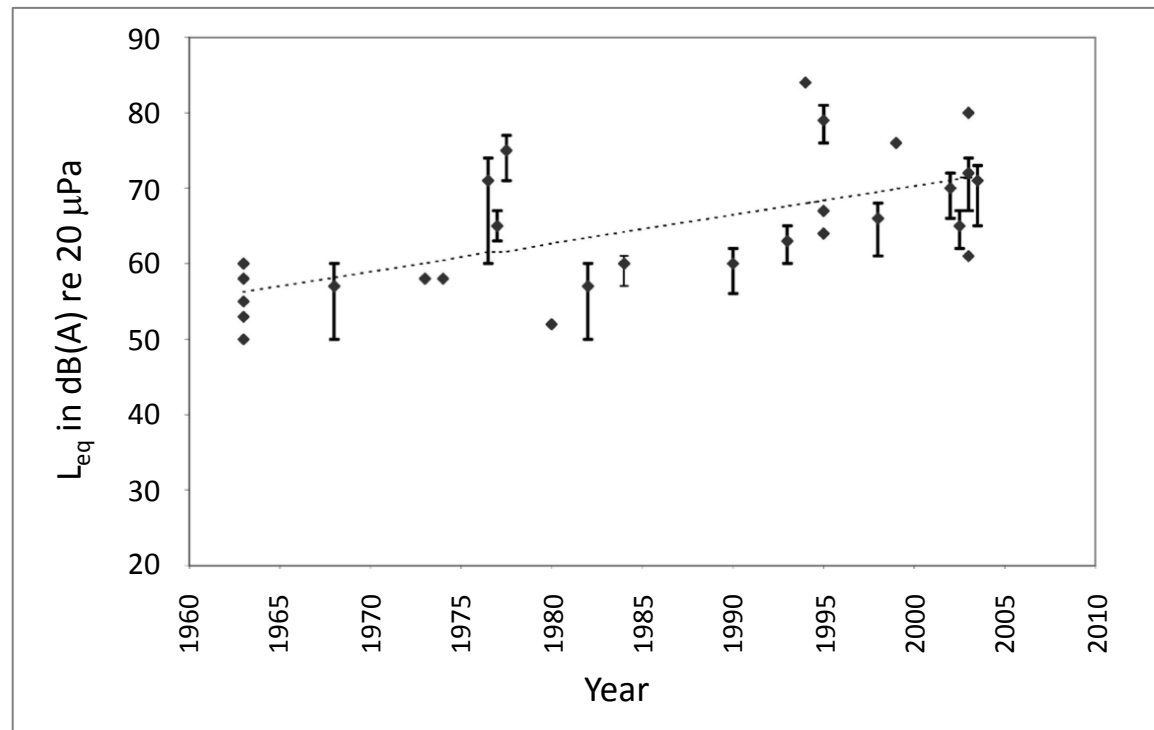
doing sound studies but little
to no acoustics knowledge



2005: Identification of Coordination Problem

Worldwide survey of healthcare noise studies by Johns Hopkins Univ.

- Not many studies by acoustics engineers
- Many studies by medical professionals could not be included because they were not done properly

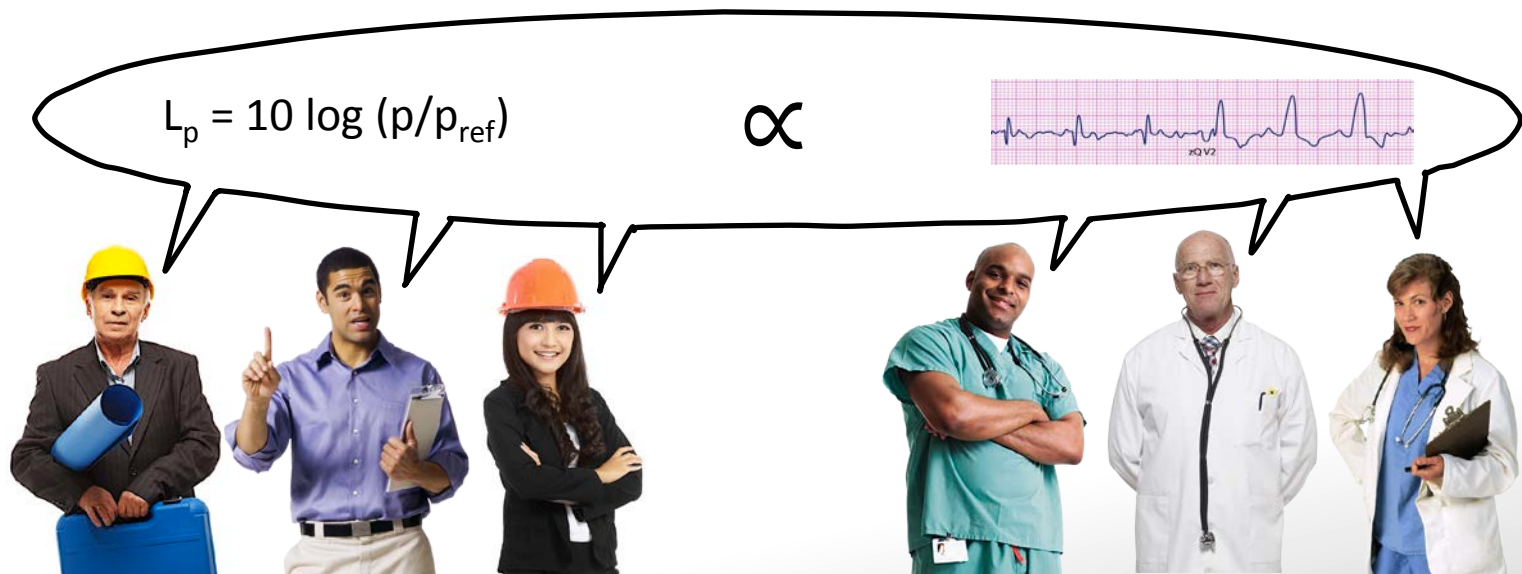


Busch-Vishniac,
et al., J. Acoustical
Society of
America, 2005

New Communication and Partnership

Acoustics engineers and medical personnel
now partner to solve problems

- Interdisciplinary teams *key* for progress and impact
- Measurable and documented results of health indicators
- Body of research emerging from top research universities & institutions



Patient and Staff Centered Initiatives



Patient & Staff Centered Initiatives

New emphasis on **patient centered care** and providing a **healing environment**



- For many years, efficiency and financial viability were the main motivators for administrative decisions
- Several organizations that promote healing philosophy provided evidence of better patient outcomes
 - Reduction in burden of disease and shorten healing time
- Patient evaluations of their hospital stay (HCAHPS)
 - Noise is the lowest scoring category
- U.S. government financial reimbursement now based, in part, on these evaluations

Patient & Staff Centered Initiatives

- Healthcare Acoustics Research Team (2005)
 - **Multidisciplinary:** Architecture, Engineering, Medicine
 - **International:** U.S. & Sweden
 - Research is focused on how architecture and acoustics influence patient and staff well-being
 - Patient: physiological arousals (heart rate, blood pressure, etc.), sleep disturbance, anxiety, satisfaction
 - Staff: communication, medical errors, job strain and health
 - Visitors: comfort, satisfaction
- Harvard Sleep Study (2008)
 - **Interdisciplinary project team:** Behavioral medicine, Neuroscience, Neurology, Statistics, Acoustics
 - Focused on sources of sleep disturbance
- Many hospitals, acoustics consulting firms and universities working to increase patient satisfaction (HCAHPS)
 - Building design and identifying operational procedures

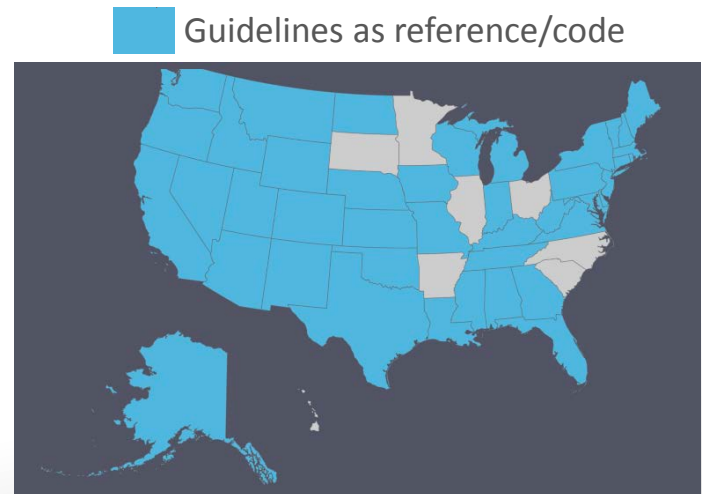
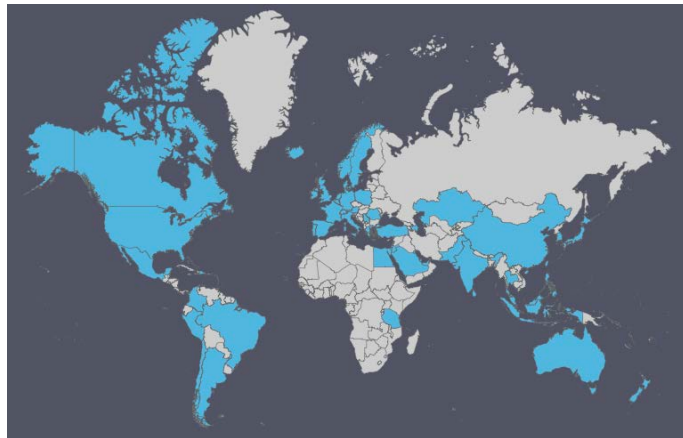
Medical Evidence-Based Guidelines, Code & Regulation



Guidelines, Code & Regulation

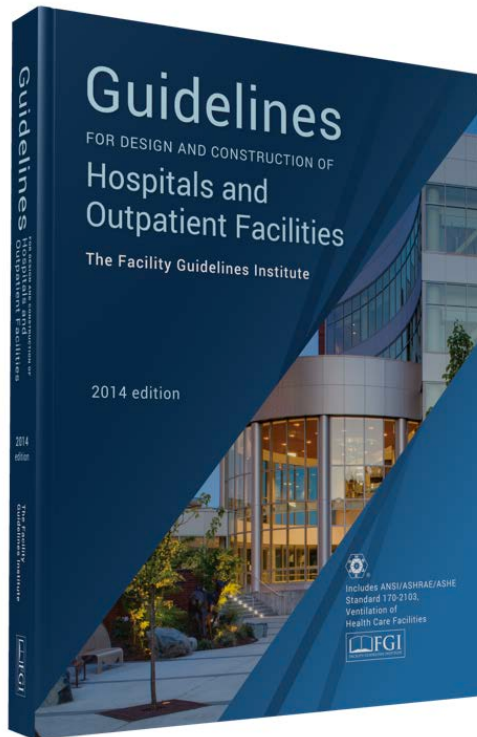
2010: FGI Building Guidelines

- Facilities Guidelines Institute (FGI) *Guidelines for Design and Construction of Hospitals and Outpatient Facilities* (in use since 1947) is the primary reference to design hospitals and health care facilities.
 - Code or referenced in 42 U.S. states and over 60 countries
 - 2010: Greatly expanded acoustics section incorporating recent research
- **Interdisciplinary authors and users:** Architects, Building Engineers, Acoustical Engineers, Medical personnel, Hospital administrators



Guidelines, Code & Regulation

2010: FGI Building Guidelines



- Site exterior noise
 - Block sound through façade
- Acoustical finishes
 - Sound absorbing surfaces to control reverberation
- Ventilation and building systems
 - Equipment selection and system design to control background sound level
- Speech privacy
 - Sound isolating construction and careful control of background sound levels
- Building vibration
 - Isolation and structural design

Guidelines, Code & Regulation

2012-15: FGI Safety Risk Assessment

- Questionnaire to help building project team reduce risk for:
 - Falls (noise causing poor sleep)
 - Medication errors (noise and distraction)
 - Behavioral health (noise reduction)
 - Hospital acquired infections
 - Security
 - Patient handling
- Interdisciplinary development team:
Doctors, Nurses, Human factors,
Ergonomics, Architects, Engineers,
Facility owners & managers, Security,
Government & NGO, Research personnel

Risk Assessment

☐	<i>Severe</i>
☐	<i>High</i>
☒	<i>Significant</i>
☐	<i>Moderate</i>
☐	<i>Low</i>
☐	<i>Very Low</i>



Guidelines, Code & Regulation

Speech Privacy and Intelligibility



- In U.S. healthcare, confidentiality required by law since 1995
- Patients without privacy less likely to divulge accurate health information
 - Patient in Emergency Room neglected to tell doctor important personal information because she knew the patient on other side of curtain*

* Planetree Focus Group patient statement

Acoustics in Action

Noise Control

Lakeland Regional Medical
Center western Michigan, U.S.



quiet
ventilation
system

acoustically
absorptive
ceiling

sound
blocking
walls &
doors

staff data input and
supply storage
outside patient room
for less disturbance

glass doors block
sound while
allowing staff to
see patient



Henry Ford
Hospital
near Detroit,
Michigan, U.S.

only wall fixtures
used at night for
dim light

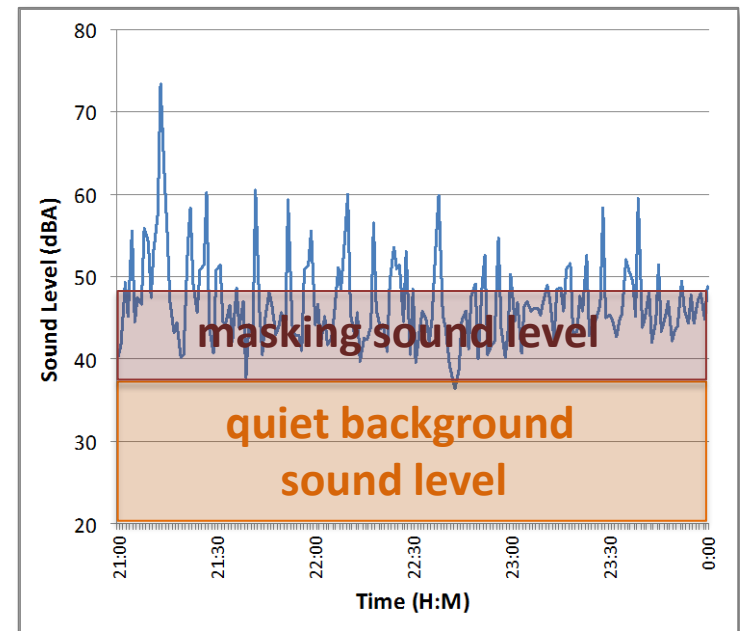
New Frontiers



New Frontiers

Sound Masking

- Sound masking, when background sound covers another sound, decreases the signal-to-noise ratio
 - Decreases disruption
 - Helps sleep
 - Aids concentration
- Medication safety
 - Errors can occur when staff is distracted while handling medications
 - Errors for medications that sound alike
 - 391 pairs on “Look Alike/Sound Alike List”
 - Cerebyx & CeleBREX
- Sound masking in healthcare facilities is gaining popularity in the U.S. but it is not used in European facilities



Acoustics in Action

Sound Masking

- St. Thomas Hospital, Tennessee, U.S.
 - After sound masking system installed, patient satisfaction noise scores **improved 33%**
 - Patient quotes*
 - “This is a quiet place.”
 - “It just kind of brings about some peace.”



Images courtesy of Rockfon | Making Hospitals Quiet
Note: hospital shown is not St. Thomas

* Details, A Steelcase Company “Speech Privacy Case Study”

New Frontiers

2014: Alarm Fatigue

- “Alarm Fatigue” – desensitization to the many alarm sounds, resulting in ignoring the alarm or turning the alarm off
- Medical devices have alarms to signal problems *AND* signal that everything is fine
 - 150-400 alarms per critical care patient per day
 - 85% to 99% of alarms do not need any action
- The Joint Commission
 - 80 documented deaths in 3 year period
- U.S. Food & Drug Administration database
 - 2005 to 2008: 566 deaths reported from monitoring device alarms
 - Four months in 2010: 73 alarm related deaths



New Frontiers

2014: Alarm Fatigue

Examples from other industries

1997: Korean Air B747 crashed four miles short of the runway – cause: pilot error on approach in part due to control tower “intentional inhibition” of the “minimum safe altitude warning” alarm to reduce “nuisance” alarms **228 people dead, 26 injured**



2009: Washington DC subway crash, in part because dispatchers had been ignoring 9,000 alarms per week **9 people dead, 80 injured**

2010: Deepwater Horizon oil rig – emergency alarm intentionally disabled so workers would not be disturbed at night by nuisance alarms
11 people dead, 16 injured



New Frontiers

2014: Alarm Fatigue

Current initiatives

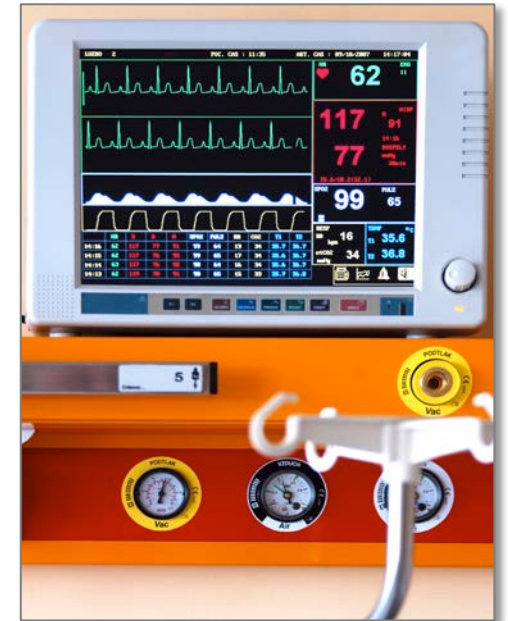
- The Joint Commission “National Patient Safety Goal”
- Research by top 5 medical universities, funded by U.S. National Institute of Health
- Systems integration
 - Aviation industry is excellent example
 - All cockpit alarms are integrated and prioritized for safety and reduction of pilot confusion and error
 - Medical alarm device software is proprietary and NOT open source software, thus hospitals cannot integrate alarm systems
 - Spring 2014: Medical device companies from Europe and North America agreed to start working together for better systems integration
- **Multidisciplinary team** currently writing a white paper to define “alarm fatigue” for code and legal purposes



Acoustics in Action

Alarm Fatigue

- Boston Medical Center
 - Adjusts alarm thresholds for each patient to reduce “false-positives”
 - Prioritizes crisis alarms – **89% reduction** in number and **12 dB reduction** in noise
 - 87,823 alarms per week reduced to 9,967 in cardiology unit
 - Staff rating of “acceptable” noise level before and after program: **approval increase from 0% to 64%**



Key Developments

Multidisciplinary research teams

(Doctors, Nurses, Engineers, Physical & Social research scientists)

Evaluating noise in real-world clinical settings

(Hospitals, Outpatient facilities, Nursing homes, etc.)

To provide **evidence** of healthcare outcomes

(blood pressure, sleep disturbance, harm, death, etc.)

To support design guidelines

(WHO, NAE, FGI and others)

For use by building designers

(Architects, Planners, Engineers, Healthcare Providers)

To build facilities for improved patient outcomes

Acoustically Optimized Facilities

- Reduce risk of patient harm and death
- Improve patient outcomes and experience
- Reduce medical errors
- Lower staff stress levels and absenteeism
- Increased speech privacy compliance
- Marketing advantage



Challenges and Ongoing Research

- Ongoing research to support that noise is detrimental to life and health, not just an annoyance
- Correlation of appropriate sound parameters to describe and predict outcomes
- Changing noisy behavior by staff and visitors
- Determining “good” sounds and incorporating them into healthcare facilities
 - Masking: Broadband, music or nature sounds
 - Comforting and familiar sounds
- One person’s “good” sound could be another person’s noise
 - How do we create pleasing soundscapes for all?

Thank you for your
kind attention

ご清聴ありがとうございました

