

Academy of Architecture for Health On-line Professional Development

Understanding Noise in Healthcare Environments Masters Studio Series

Tuesday, April 10, 2018

2:00 pm – 3:00 pm ET

1:00 pm – 2:00 pm CT

12:00 am – 1:00 pm MT

11:00 am – 12:00 pm PT

Presenters

Erica E. Ryherd, Ph.D., LEED AP

University of Nebraska – Lincoln
Durham School of Architectural Engineering
& Construction

Ilene Busch-Vishniac, Ph.D.

President, BeoGrin Consulting

Moderator

Kelly A. Miller, AIA, NCARB

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Masters Studio Series

The Academy's multi-channel on-line approach provides emerging professionals, journeymen, and master professionals with convenient and economical opportunities to develop their chosen area of interest.

Masters Studio Series sessions are tailored to provide healthcare design professionals with sufficient exposure to jump-start interest in wanting to learn more.

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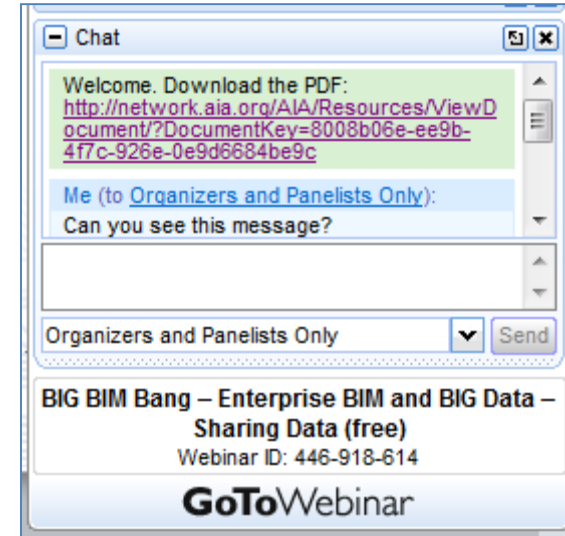
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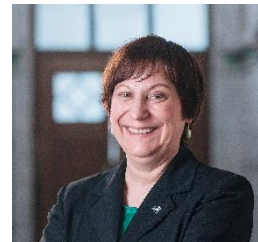


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Understanding Noise in Healthcare Environments

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Outline



- Why do we *care* about hospital acoustics?
- How do we *characterize* hospital noise?
- What are the impacts of noise in hospitals on *patients and staff*?
- What are some *interventions* to improve the hospital soundscape?
- What are the implications for *architectural designs*?



Why Do We Care About
Hospital Acoustics?



**"in the world nothing can be said to be certain except
death and taxes"**

...and spending time in a hospital at some point in your life!

--Ben Franklin, reinterpreted

**On any day, 1 out of every 600-700 people
in the US is a patient in the hospital!**

**Noise is among the top complaints of
hospital patients, visitors and staff.**

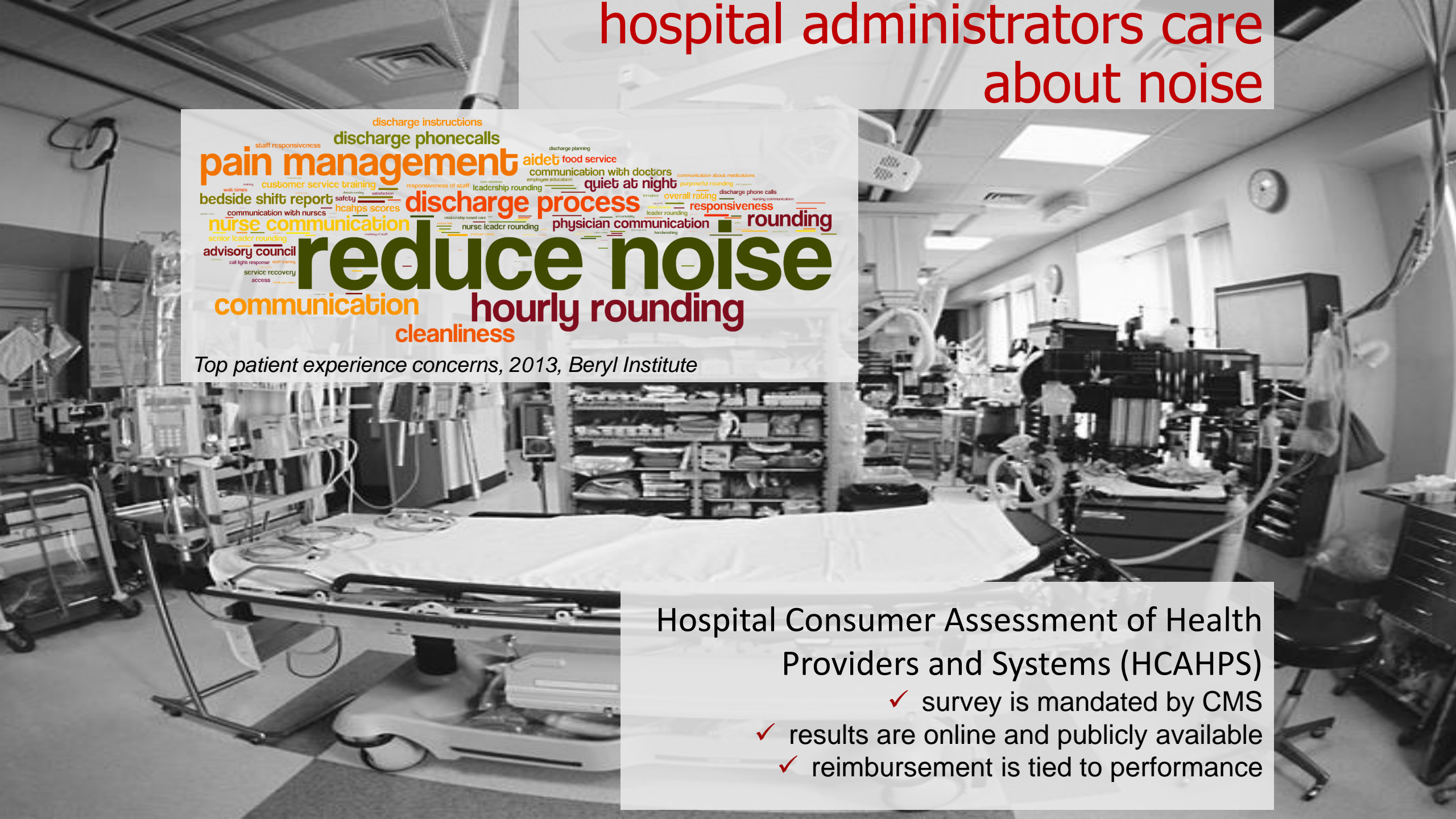
healthcare is a huge industry

- ✓ 19 million healthcare & social assistance industry employees
 - ✓ 5 million working specifically in hospitals
- ✓ Projected as fastest growing industry sector through 2024

U.S. DOL 2016

- ✓ Costs per capita per year for healthcare now exceed \$10,000
 - ✓ Healthcare facility construction comes to \$20B/yr

U. S. Bureau of the Census, 2017

[illegible]A grayscale photograph of a hospital room. In the foreground, there's a patient bed with white linens. To the left, various medical monitors and equipment are visible. In the background, there are shelves stocked with supplies and more medical equipment. The room appears busy and clinical.

hospital administrators care about noise

A word cloud graphic overlaid on the hospital room image. The words are arranged in a roughly rectangular shape, with varying font sizes and colors (primarily green, orange, and red). The most prominent words include "reduce noise", "communication", "hourly rounding", "discharge process", "nurse communication", "physician communication", "rounding", "quiet at night", "pain management", "discharge instructions", "discharge phonecalls", "aide food service", "communication with doctors", "overall rating", "responsiveness", "cleanliness", "advisory council", "senior leader rounding", "relationship based care", "nurse leader rounding", "leader rounding", "bandwidth", "service recovery", "access", "call light response", "wait planning", "hcahps scores", "safety", "shift report", "bedside", "wait times", "customer service training", "staff responsiveness", "leadership rounding", "employee education", "purposeful rounding", "communication about medications", "discharge phone calls", "nursing communication", "handwashing", "environmental cleaning", "noise levels", "patient education", "family involvement", "care coordination", "medication reconciliation", "infection control", "falls prevention", "pressure ulcer prevention", "pain assessment", "vital signs monitoring", "documentation", "time management", "resource utilization", "cost containment", "quality improvement", "patient safety", "risk management", "legal compliance", "accreditation requirements", "regulatory standards", "industry best practices", "innovative solutions", "technology integration", "interdisciplinary collaboration", "shared decision making", "patient-centered care", "evidence-based practice", "continuous learning", "professional development", "teamwork", "communication skills", "cultural competence", "health equity", "social determinants of health", "population science", "public health", "global health", "translational research", "implementation science", "systems thinking", "complexity theory", "resilience engineering", "antifragility", "adaptive leadership", "servant leadership", "distributed leadership", "networked organization", "flat hierarchy", "agile methodology", "lean principles", "six sigma", "total quality management", "balanced scorecard", "key performance indicators", "benchmarking", "best practices", "lessons learned", "root cause analysis", "failure mode and effects analysis", "fishbone diagram", "5 whys", "PDCA cycle", "PDSA cycle", "plan-do-check-act", "plan-do-study-act", "kaizen", "muda", "muri", "mura", "waste reduction", "value stream mapping", "just in time inventory", "single minute exchange of die", "concurrent engineering", "cross-functional teams", "matrix organization", "project management", "scrum", "kanban", "waterfall model", "V-model", "UML", "RUP", "ITIL", "COBIT", "ISO 9001", "ISO 14001", "ISO 27001", "HIPAA", "HITECH Act", "EMR/EHR implementation", "cloud computing", "big data analytics", "artificial intelligence", "machine learning", "robotics", "nanotechnology", "biotechnology", "genomics", "precision medicine", "personalized medicine", "predictive medicine", "preventive medicine", "curative medicine", "rehabilitative medicine", "palliative care", "end-of-life care", "organ donation", "stem cell transplantation", "gene therapy", "cellular therapy", "immunotherapy", "targeted therapy", "precision oncology", "cancer research", "rare diseases research", "neuroscience research", "psychiatry research", "behavioral science research", "sociology research", "anthropology research", "history research", "philosophy research", "ethics research", "law research", "politics research", "economics research", "business research", "education research", "healthcare research", "life sciences research", "physical sciences research", "earth and space sciences research", "social sciences research", "humanities research", "interdisciplinary research", "transdisciplinary research", "multidisciplinary research", "collaborative research", "open science", "citizen science", "crowdsourcing", "peer review", "academic publishing", "knowledge sharing", "open access", "digital scholarship", "informatics research", "computer science research", "engineering research", "materials science research", "chemical engineering research", "biomedical engineering research", "mechatronics research", "electrical engineering research", "mechanical engineering research", "civil engineering research", "environmental engineering research", "industrial engineering research", "agricultural engineering research", "food engineering research", "textile engineering research", "paper engineering research", "plastic engineering research", "metals engineering research", "ceramics engineering research", "composites engineering research", "polymer engineering research", "rubber engineering research", "glass engineering research", "carbon engineering research", "silicon engineering research", "semiconductor engineering research", "microelectronics engineering research", "nanoelectronics engineering research", "photonics engineering research", "optoelectronics engineering research", "quantum engineering research", "space 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"insolvency research", "debt restructuring research", "asset protection research", "estate planning research", "tax optimization research", "financial planning research", "retirement planning research", "wealth management research", "private banking research", "trust services research", "fiduciary services research", "asset management research", "portfolio management research", "equity research", "fixed income research", "derivatives research", "structured products research", "alternative investments research", "real estate investment research", "hedge funds research", "private equity research", "venture private equity research", "buyouts research", "leveraged buyouts research", "initial public offerings research", "secondary offerings research", "redemptions research", "spinoffs research", "divestitures research", "restructuring research", "turnarounds research", "liquidations research", "bankruptcies research", "reorganizations research", "voluntary restructurings research", 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Hospital Consumer Assessment of Health Providers and Systems (HCAHPS)

- ✓ survey is mandated by CMS
- ✓ results are online and publicly available
- ✓ reimbursement is tied to performance

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noise is a top patient complaint

“patients complain about noise two times more often than anything else... including the food”

Fick and Vance 2012

Low score historically on HCAHPS is #9:
During this hospital stay, how often was the area around your room quiet at night?

Jha et al 2008

Preceded now only by “Care Transition” rating

and noise is getting worse

Locke and Pope 2017



and new hospitals are not better than old

Madaras 2017

occupants have a special
sensitivity to the environment
patients, staff, visitors





unique building requirements

safety, hygiene, portability, aesthetics,
high density of equipment & occupants



**How Do We Characterize
Hospital Noise?**

Decibels

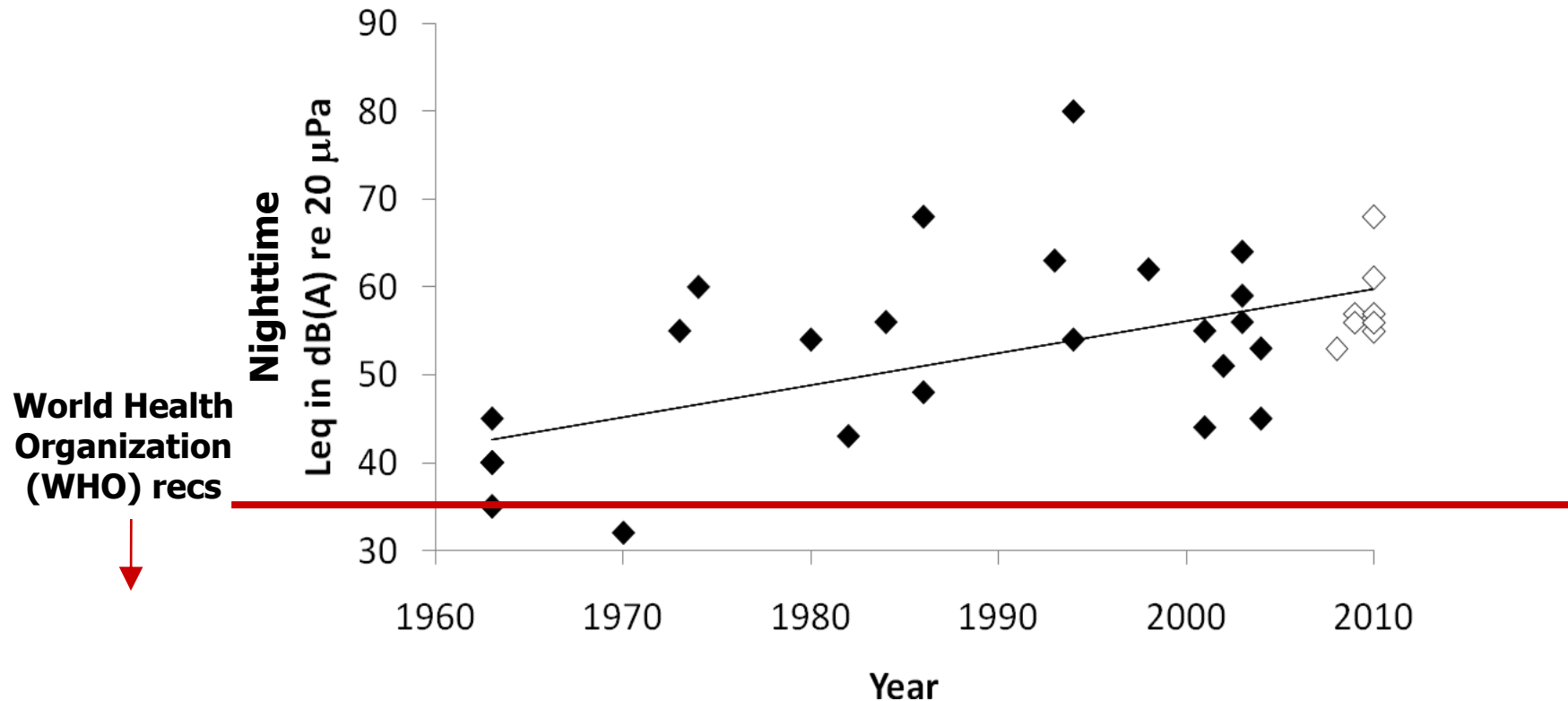


- We measure sound intensity using a logarithmic measure because our hearing is logarithmic.
+3 dB = doubling of energy, +10 dB = 10 times the energy
- Leq, equivalent sound level, is the level for the sound energy average over a stated time
- A-weighting matches our hearing so it is better at predicting perceptions
We hear best in the speech pitch range

Levels historically



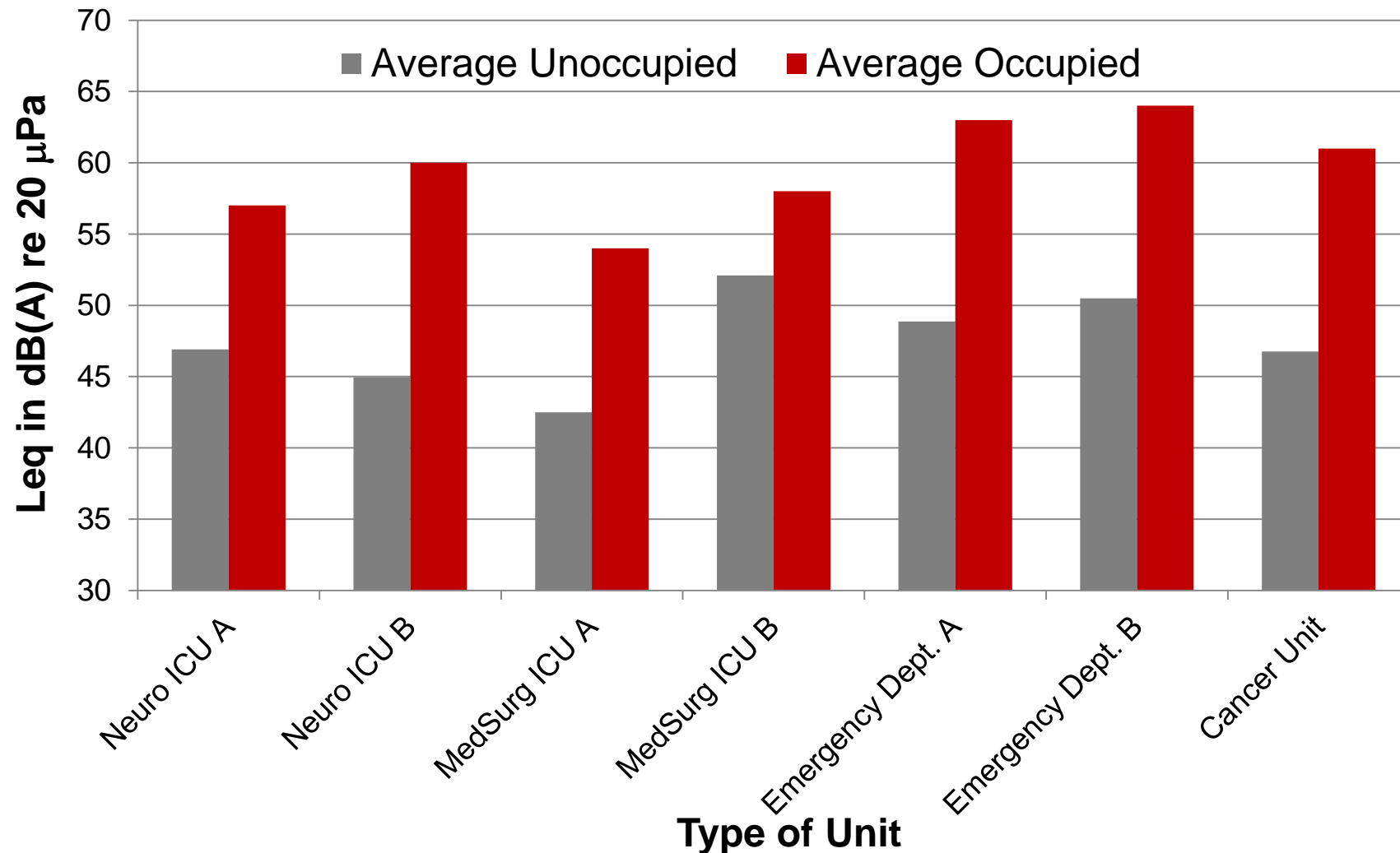
- Overall noise levels in hospitals are:
 - Higher than recommended by guiding agencies
 - Steadily rising over time



Occupied vs. Unoccupied



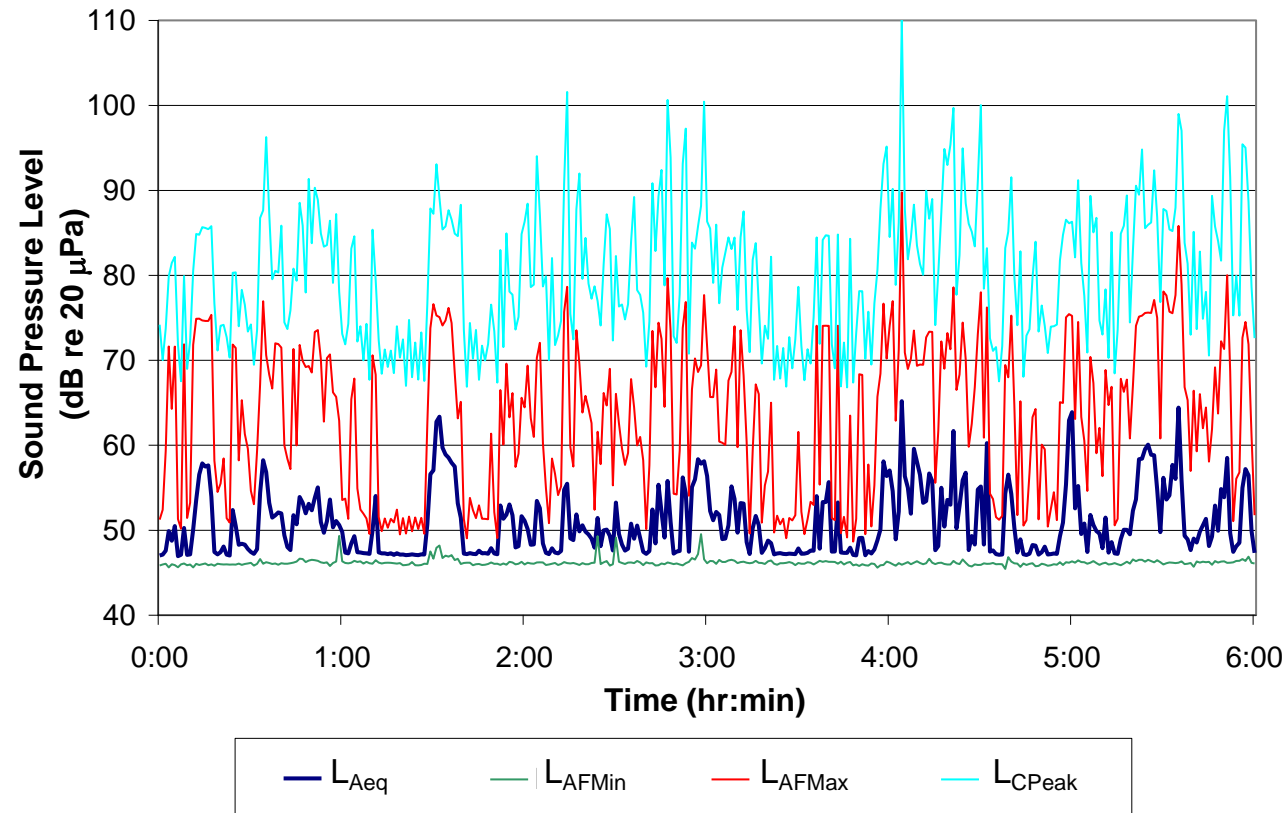
- Large differences b/w occupied & unoccupied noise levels



Level vs. Time



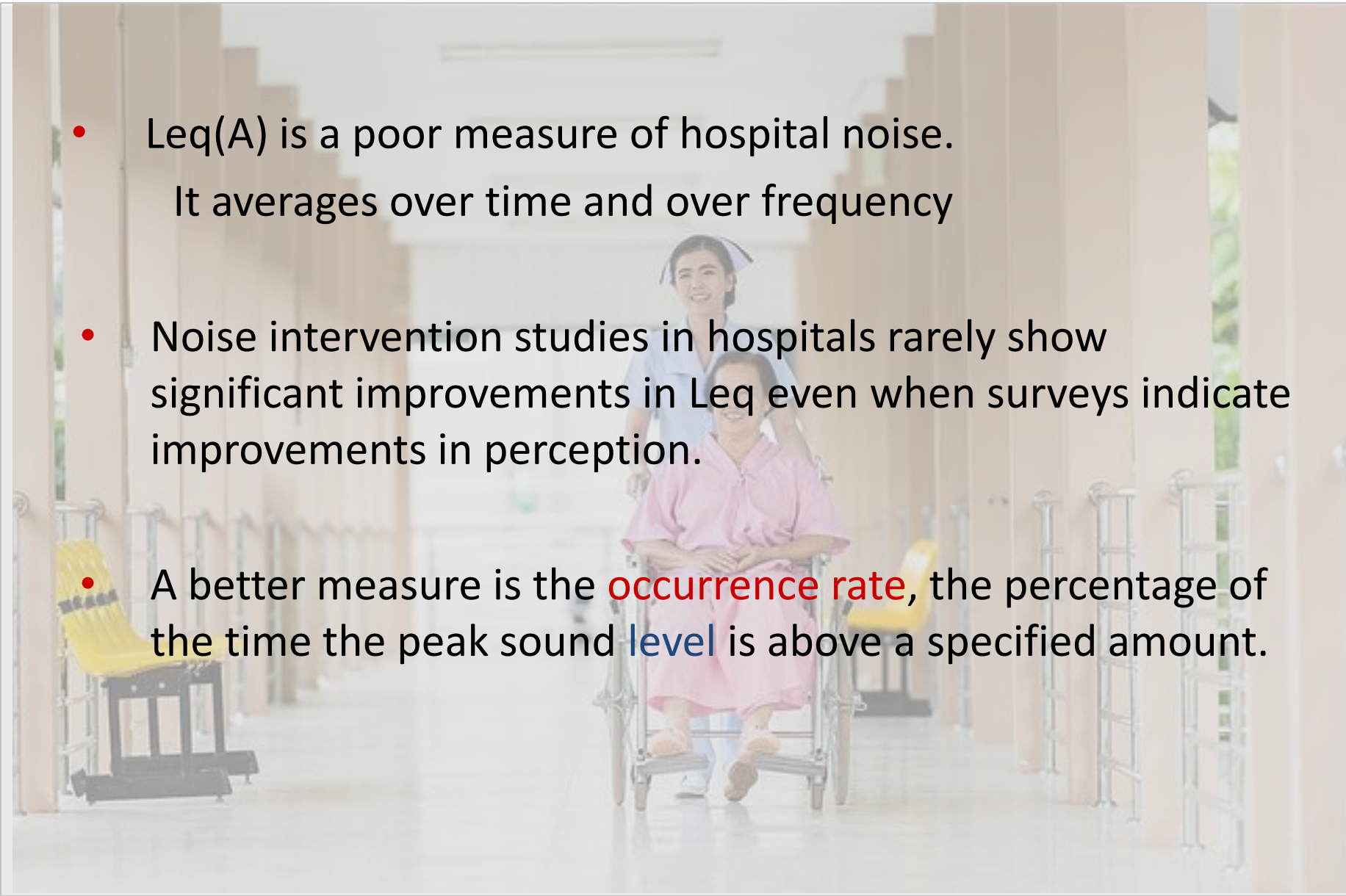
- Small differences between time of day or work shift & day of the week
 - Overall values not changing substantially over large periods of time
 - Short-term fluctuations are problematic



Better Measures



- $Leq(A)$ is a poor measure of hospital noise. It averages over time and over frequency
- Noise intervention studies in hospitals rarely show significant improvements in Leq even when surveys indicate improvements in perception.
- A better measure is the **occurrence rate**, the percentage of the time the peak sound **level** is above a specified amount.

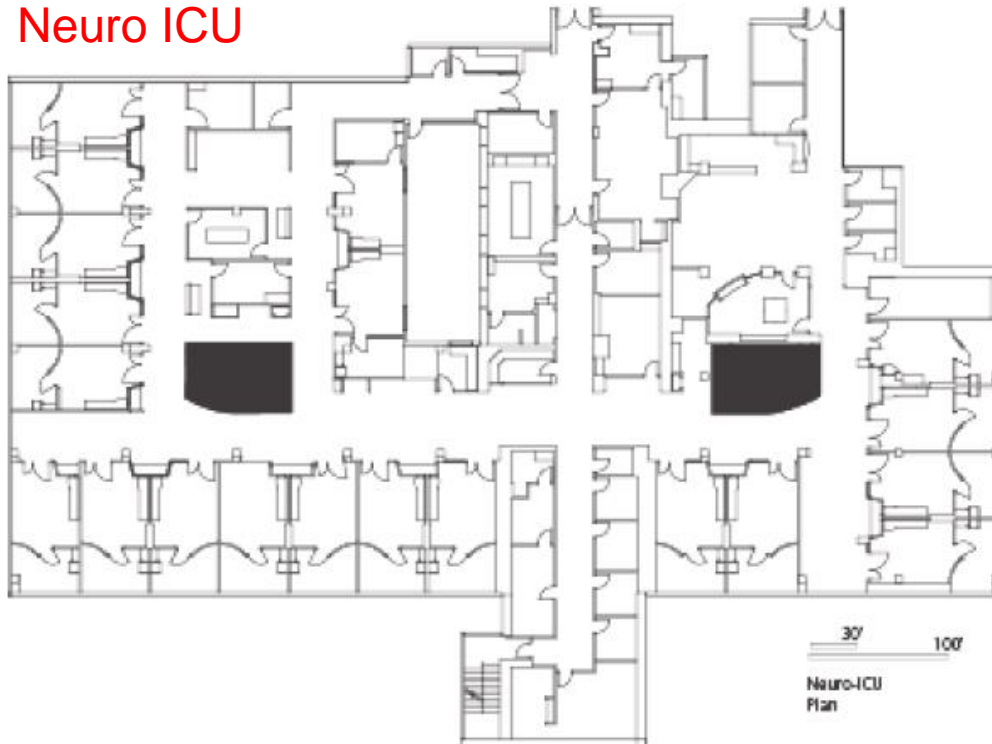


Example Two ICUs

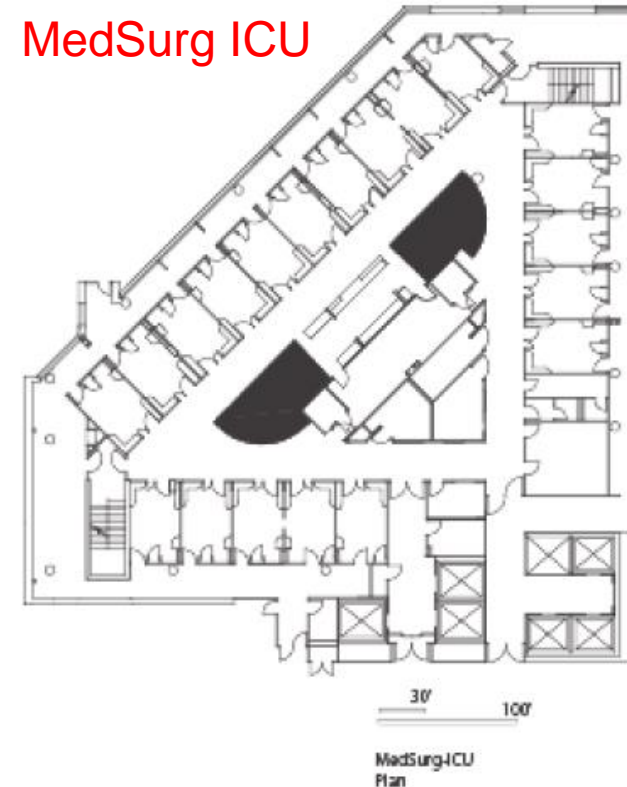


- Similar patient acuity & staff activities, but different architectural layouts & MedSurg perceived as “worse” unit

Neuro ICU



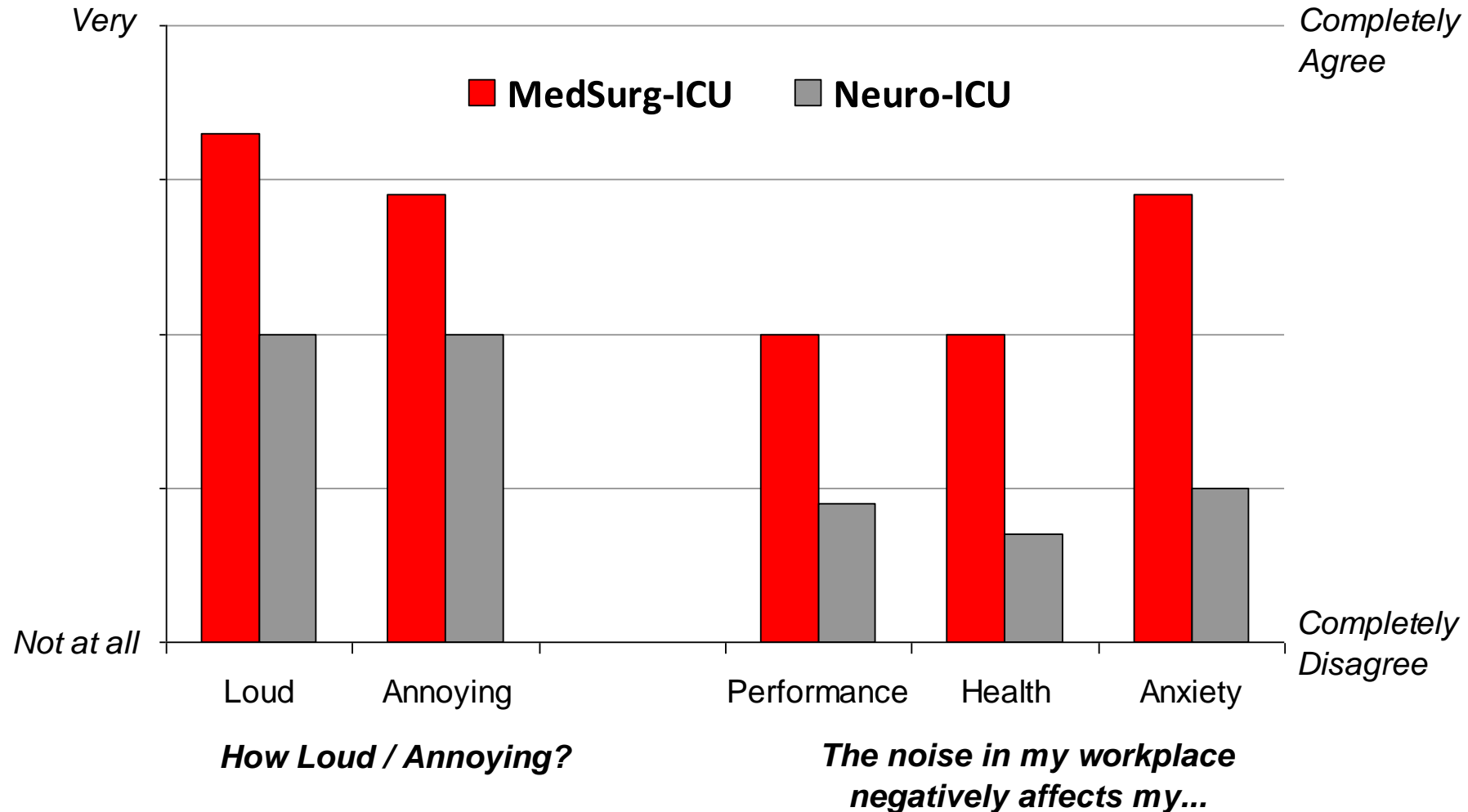
MedSurg ICU



Nurse Perception in Two Units



- Does nurse perception differ in the two units? **Yes!**

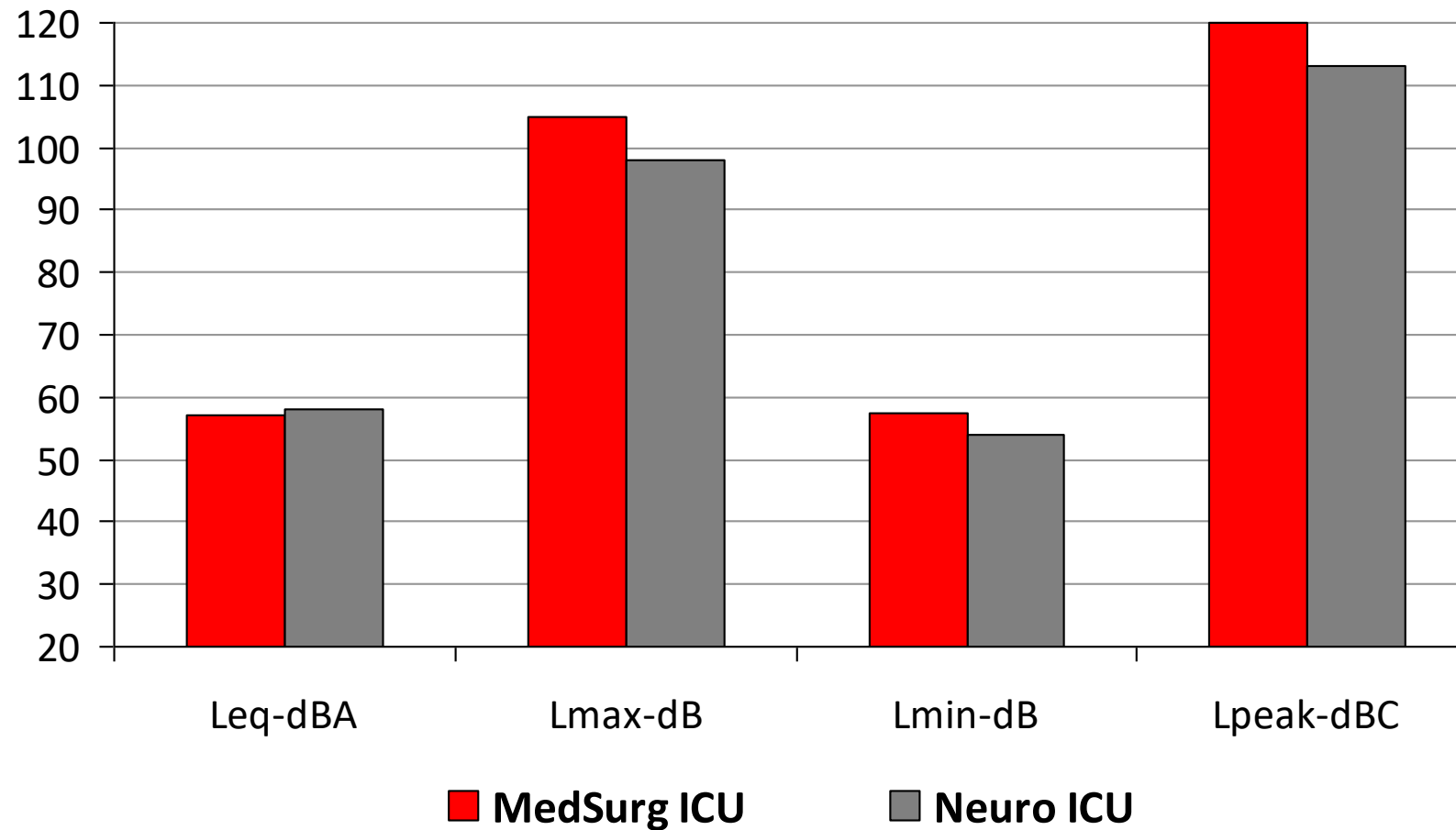


Noise Levels in the Units



- Do *overall* noise levels differ in the two units?

NOT really!

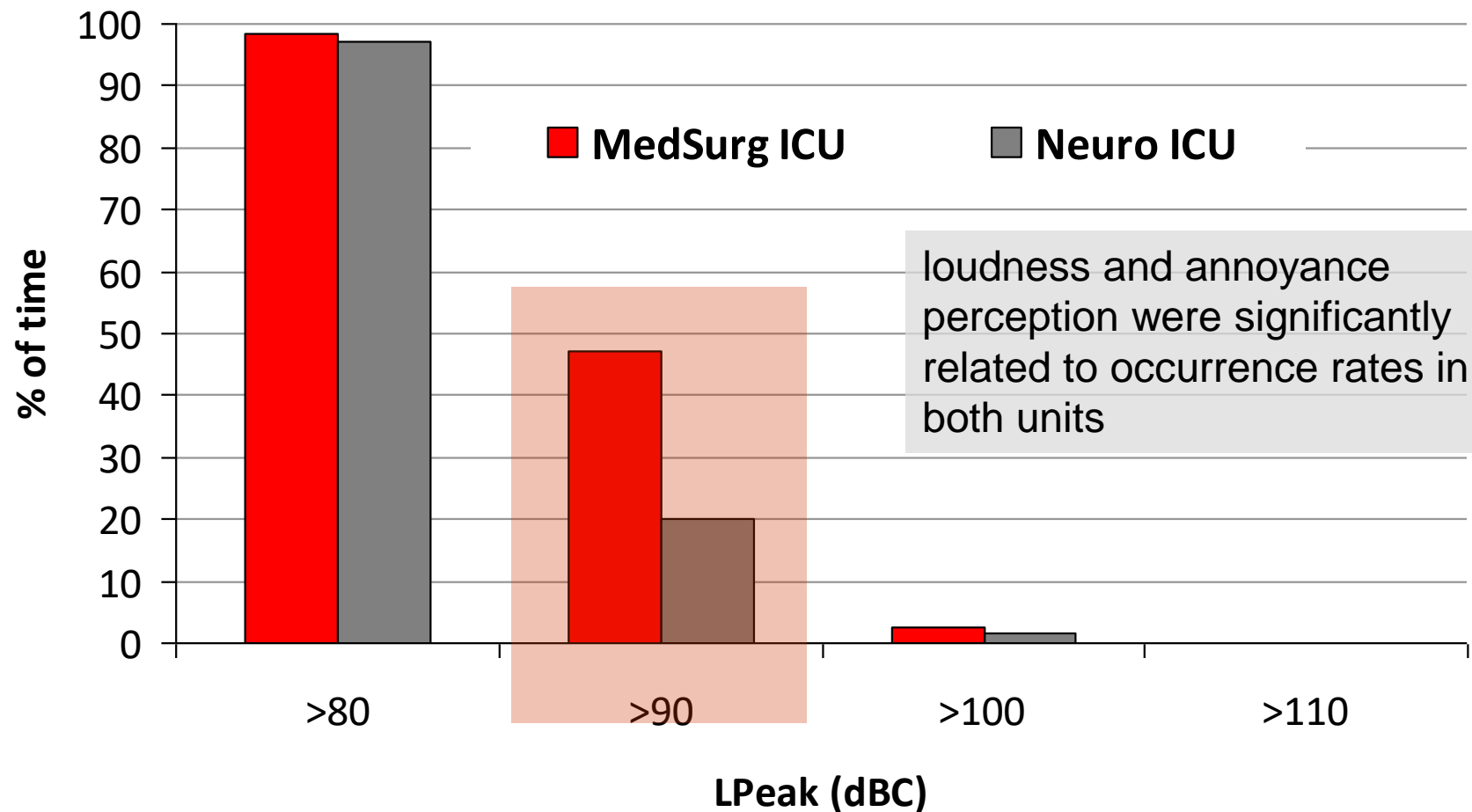


Occurrence Rate in Units



- Does the “Occurrence Rate” differ in the two units? **Yes!**

% of time peak levels are above certain levels



Speech Intelligibility Study



- Speech Intelligibility Index (SII)
measured in 5 hospitals & 20 units (*emergency, intensive care, inpatient, mother-baby, same-day-surgery, operating*)

Corridors	29%	65%	6%
Nurse Stations	47%	53%	
Patient Rooms	18%	65%	18%
	Poor (SII < 0.45)	Marginal (0.45 < SII < 0.75)	Good (SII > 0.75)

SII significantly related to staff perception of communication problems



Impacts of Noise on Staff and Patients

Staff Duties



Auditory monitoring is one of the key nursing functions for patient safety. Effective auditory monitoring is especially required in intensive & acute care units.

It requires the ability to:

- hear critical sounds
- interpret auditory cues
- respond and react to
 - *help calls*
 - *abnormal patient bodily sounds*
 - *safety threatening sounds*
 - *emergency and clinical alarms*



staff are impacted by noise

noise negatively affects me in my daily
working environment (91%)

Ryherd, Persson Waye, & Ljungkvist 2008

Noise affects my

- sleep (38%)
- concentration (43%)
- performance (43%)

Noise causes

- Irritation (66%)
- Fatigue (66%)
- Headaches (40%)

Staff Reaction to Noise



- Relationship between noise annoyance & health symptoms for ICU nurses
 - Symptoms reduced to 3 factors:
 - Factor 1: **Auditory Fatigue**
(sound sensitivity, sound tiredness, tinnitus)
 - Factor 2: **Mental Fatigue**
(tiredness, headaches, concentration difficulties, irritation)
 - Factor 3: **Tension**
(pain in the neck, stress, difficulty motivating myself)
- **Auditory Fatigue** was a highly significant explanatory factor for noise annoyance even after correcting for age, education, experience, and psycho-social factors incl. salary and leadership.

Patient Impacts



- Does acoustics really impact patients?

Yes!

- **Positive** sounds can create feelings of safety, security & familiarity
 - e.g., staff working quietly, music
- **Negative** sounds can create feelings of fear, helplessness, and anxiety
 - e.g., sick patients, medical equipment

Patient Physiologic Measures




- Risk of Physiological Arousals

If overall noise level (Leq) increases above 50 dBA...
risk of physiological response goes up:

Physiological Response	Increased Risk
Heart rate	22%
Respiratory rate	47%
Systolic Blood Pressure	63%
Diastolic Blood Pressure	44%

Example: Above 50 dBA, 22% increased risk that your heart rate will rise



neonates and noise

Use of earmuffs improves sleep, reduces the fluctuation of oxygen saturation, stabilizes behavior, and might facilitate weight gain.

Romeu et al. 2016, Abou Turk 2009

However, some concerns over impacts of ear muffs on skin integrity, posture, & head shape

Philbin, 2000



Patient Satisfaction



The Physical environment is significantly related to satisfaction.

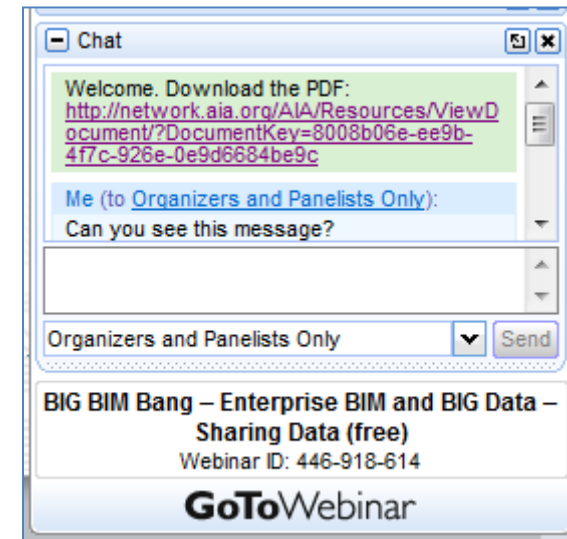
- A change in **spatial variables** can increase the odds of achieving top box **satisfaction scores** by 8 – 45%*
- **Noise** also plays a role
 - Perception of **noise** significantly related to **satisfaction**
HCAHPS found to correlate with**
 - Low frequency content (16 – 100 Hz)
 - “Quietest” sound levels (absolute Lmin)
 - Occurrence rate of peak levels
 - The variation of patient **noise** satisfaction by room can be partially explained by **spatial layout***

*MacAllister, Zimring, Ryherd & Hanna (2014)

**Bliefnick, Ryherd & Jackson (2017)

Upcoming Break for Questions and Comments

Submit a question to the moderator via the chat box.





Interventions

Potential Remedies



- Example **Administrative** measures
 - Maintenance and treatment schedules
 - Protocol (cell phones, etc.)
 - Education of staff & occupants
 - Implementation of Quiet Times
- Example **Engineering / Architecture** measures
 - Equipment/systems noise control
 - e.g., quieter heating & air-conditioning (HVAC) equipment
 - Architectural layout, form, materials, construction
 - e.g., decentralized nursing station
 - Acoustic treatments
 - e.g., sound absorbing walls & ceilings

What works?



- Kaur et al. (Noise and Health 2016) surveyed staff and patient families on a PICU regarding interventions that work:
 - Closing patient doors (93%)
 - Quiet times (82%)
 - lowering staff voices (88%)
 - decreasing number of alarms (80%)

Do Quiet Times Help



- Weber et al. (2017) surveyed nurses in NICUs on effectiveness of quiet times. Over 90% said they were useful to them, to their patients, and to the families of their patients.



- Adatia et al. (BMC Health Services Research 2014; 14: 604) showed that quiet times had a significant impact on new mothers.

Example 1 – Cancer Unit



- Can we improve the environment through added sound absorption? **Yes!**
- Remodel of 4 Cancer Units:
 - Absorption on walls + ceilings of corridors
 - Various iterations to optimize mounting, aesthetics



Results Achieved



Significant Results:

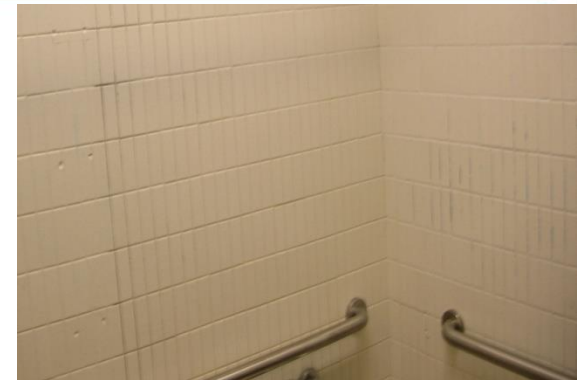
- Improvement in staff's perceived ability to concentrate, communicate with other staff, & have telephone conversations
- Less annoyance due to several sources
- Reduction in noise (LAeq) & reverberation time
- Improved speech intelligibility



Example 2 – Burn Unit



- Remodel of Burn Acute Care Unit
 - Focus: Debridement Facility
 - Acoustical Design by Howard Pelton
- Before Remodel:
 - All hard surfaces; institutional feeling
 - Privacy curtains b/w debridement stations
 - Isolation from rest of ward inadequate
- Main Interventions:
 - Sound lock corridors to debridement areas
 - Absorption on ceilings & walls
- Results:
 - L1 values for patient distress sounds in adjacencies:
 - Before = 88 dBA
 - After = 55-58 dBA





Implications 4
Architectural Design

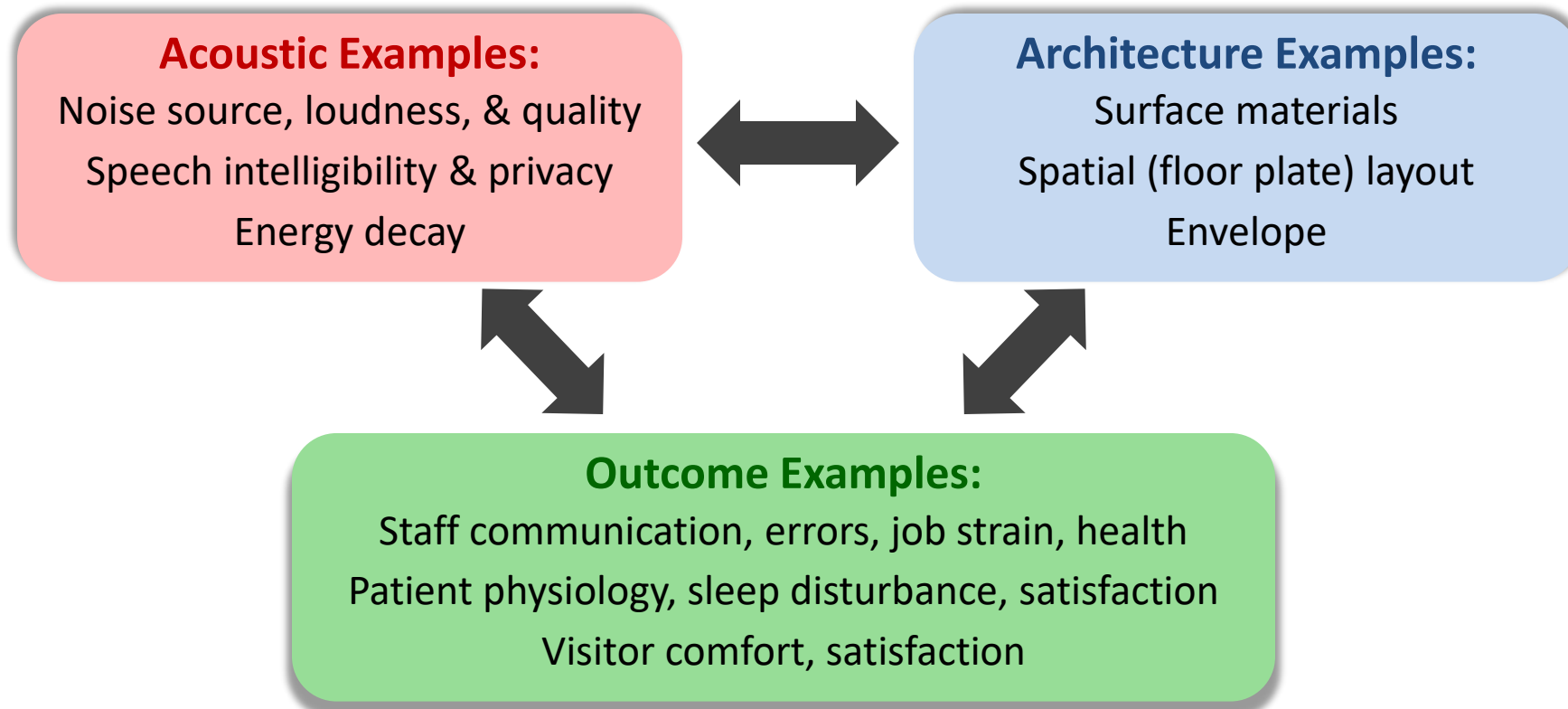
Ryherd Group Research



- Research in 2 countries, 24+ hospitals, 70+ units, 12+ types of units

Define relationships between:

acoustics, *architecture* & *occupant outcomes*



Architectural Layout and Noise



Can we “quantify” architectural layouts that are related to good acoustics?

**Architectural
Layout**

Acoustics

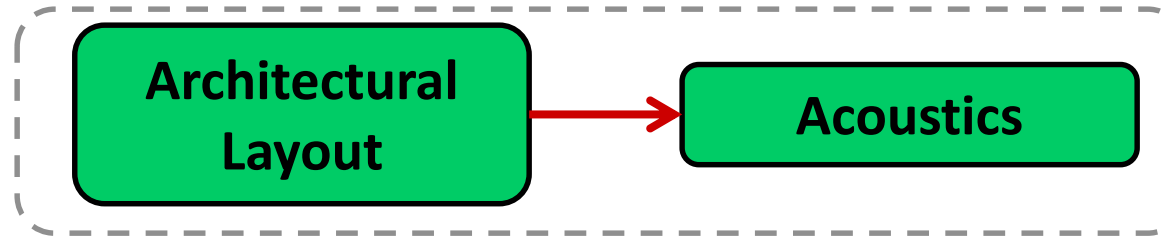
Floor-plate Design Metrics:

- Number of turns
- Number of branching corridors
- Branch distance
- Total corridor length
- Relative grid distance
- Visual fragmentation

Acoustic Metric:

Reverberation Time

Results



- **Results:**
 - Architectural Layout & RT significantly related
 - One unit change in the floor plate metrics associated with changes in RT of 0.01 – 0.57 seconds



Conclusions



- *Noise is a significant problem* in healthcare environments.
- We need to better document healthcare soundscapes using *metrics that relate to patient and staff reactions*.
- Noise has negative consequences for *staff and for patients*.
- Interventions exist to reduce impacts:
 - Administrative as in *Quiet Times*
 - Engineering as in *adding sound absorption*
- Acoustical environment is linked to *architectural designs*.

Time for Questions and Comments



Moderator
Kelly Miller
Francis Cauffman

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6/12	Case Study Series	Enhanced Integration - Changing and Improving Health Facilities Design
7/10	Case Study Series	UC Davis – Getting to Net Zero

*Dates and topics are subject to change

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