Built environment metadata collection

Methods, sensors, and the Hospital Microbiome Project

3rd Sloan Conference on the Microbiology of the Built Environment
June 2014

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Hospital Microbiome

Oct 2012 – Jan 2014

2

OPEN SOURCE BUILDING SCIENCE SENSORS

Nov 2013 – present

3

Building science to advance research in the microbiology of the built environment (MoBE)

Supported by the Alfred P. Sloan Foundation

May 22-23, 2014 | Illinois Institute of Technology | Chicago, IL

May 2014

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Hospital Microbiome

The Hospital Microbiome Project (HMP)

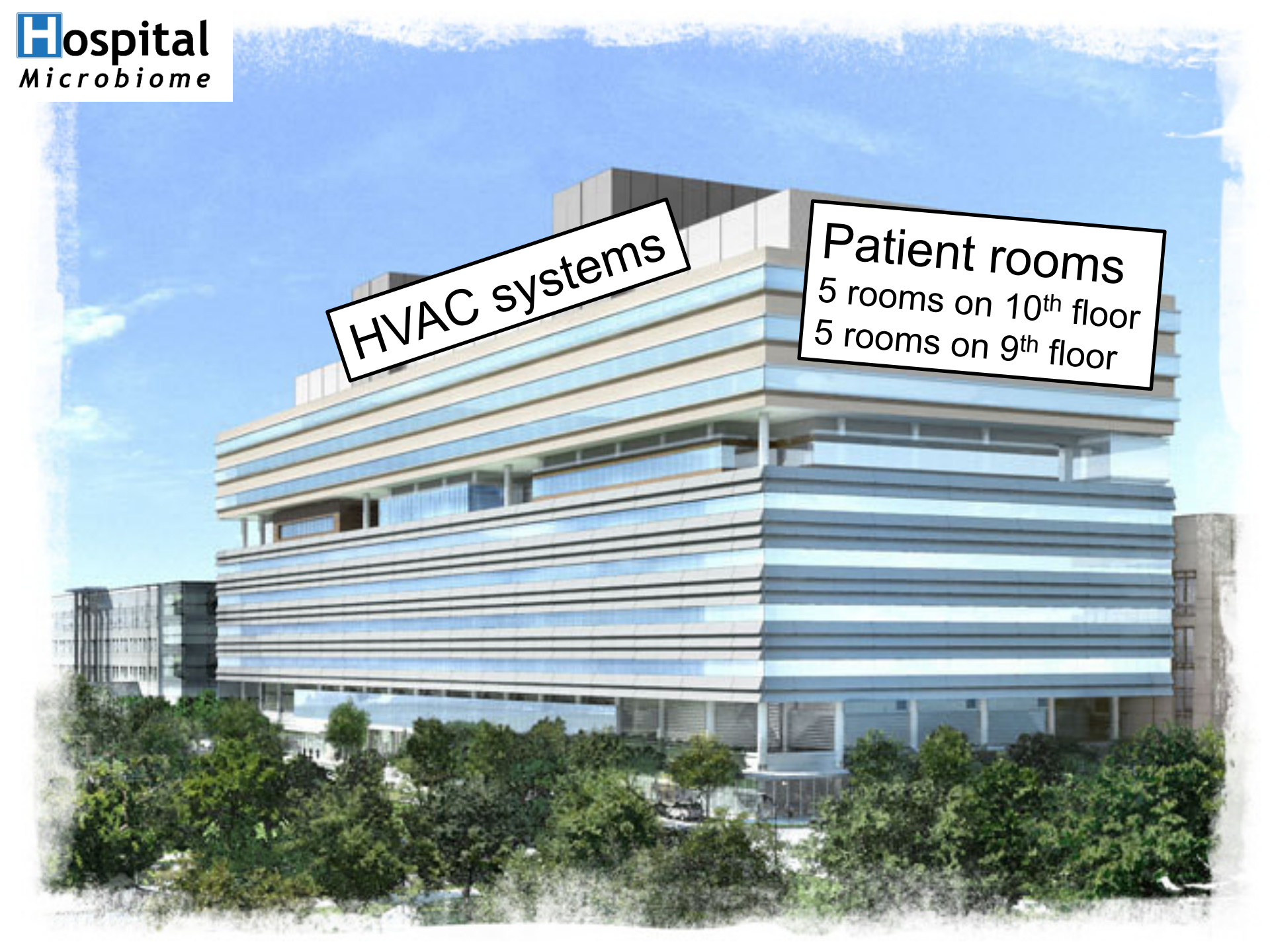
PI: Jack Gilbert
Co-PI: Jeff Siegel

The Hospital Microbiome Project (HMP) collected microbial samples from surfaces, air, staff, and patients from the University of Chicago's new hospital pavilion in order to better understand the factors that influence bacterial population development in healthcare environments

The HMP provided a unique opportunity to sample in a newly constructed hospital environment …

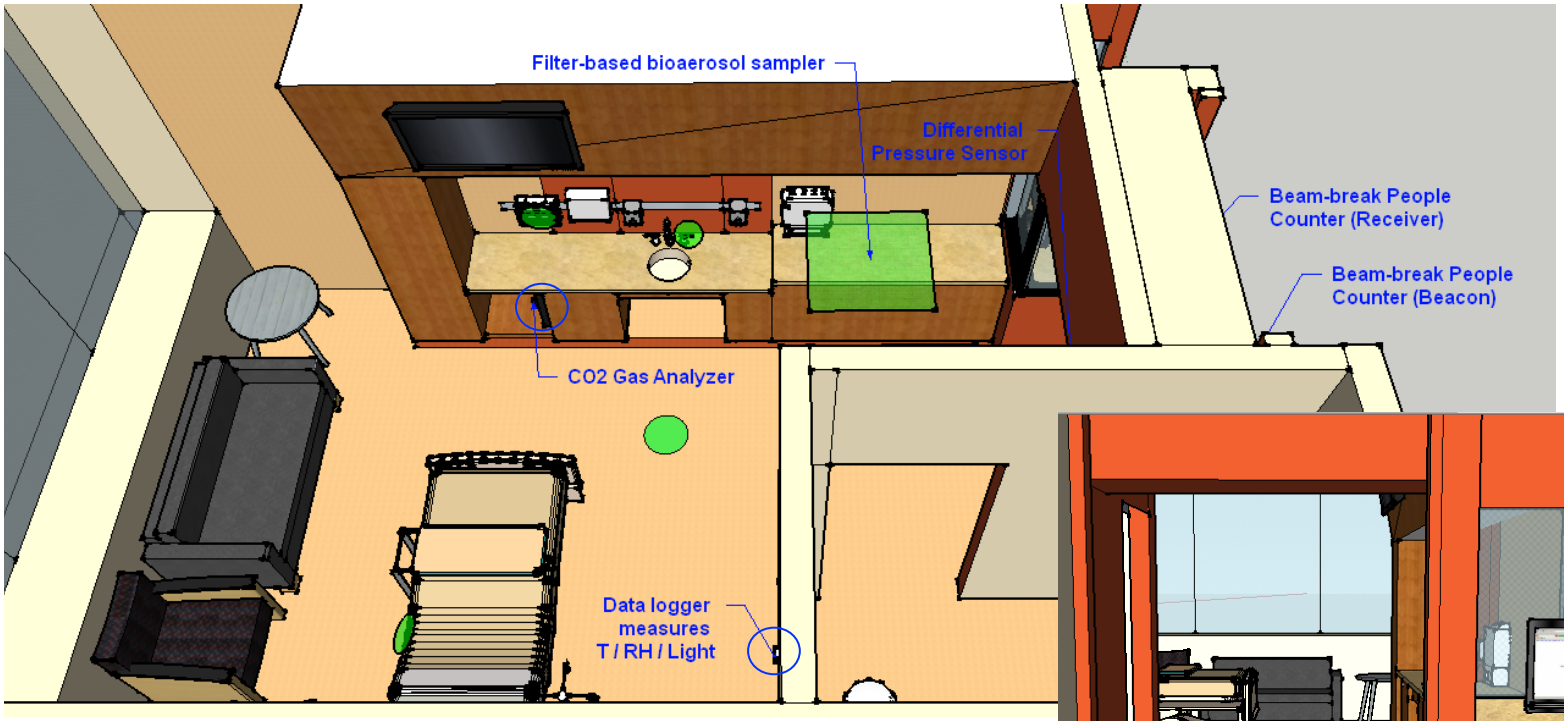
… immediately prior to occupation and for nearly one year afterward

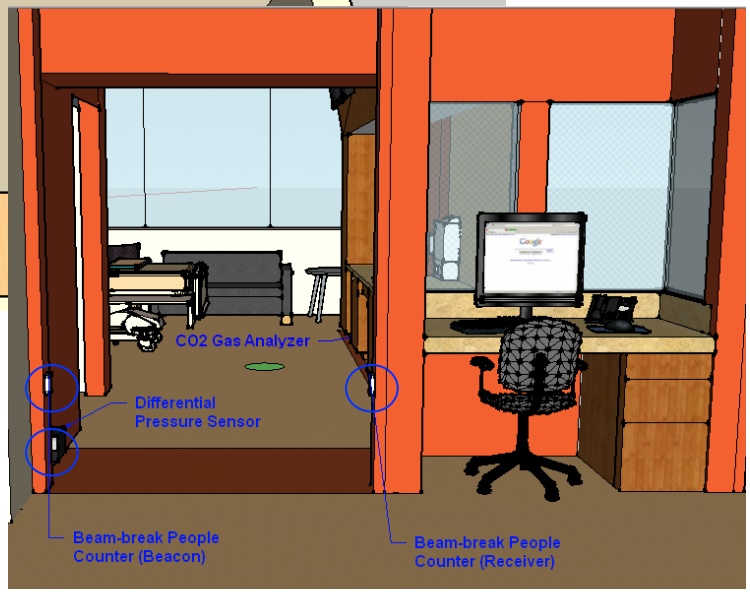
http://hospitalmicrobiome.com/


Hospital
Microbiome
HVAC systems
Patient rooms
5 rooms on 10th floor
5 rooms on 9th floor

Hospital Microbiome

Bio sampling + building science measurements





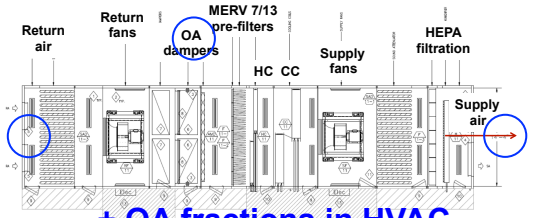
Biological sampling sites **Building science equipment sites**

Bio sampling summary

- ~13,000 swabs in rooms, nurse stations, and on staff
- 16S/18S/ITS (ongoing)

Building science data summary

- 80+ variables measured continuously every 5 minutes
- 100,000+ data points per variable → 8 million+ data points
- over 8500+ hours of active data collection per variable

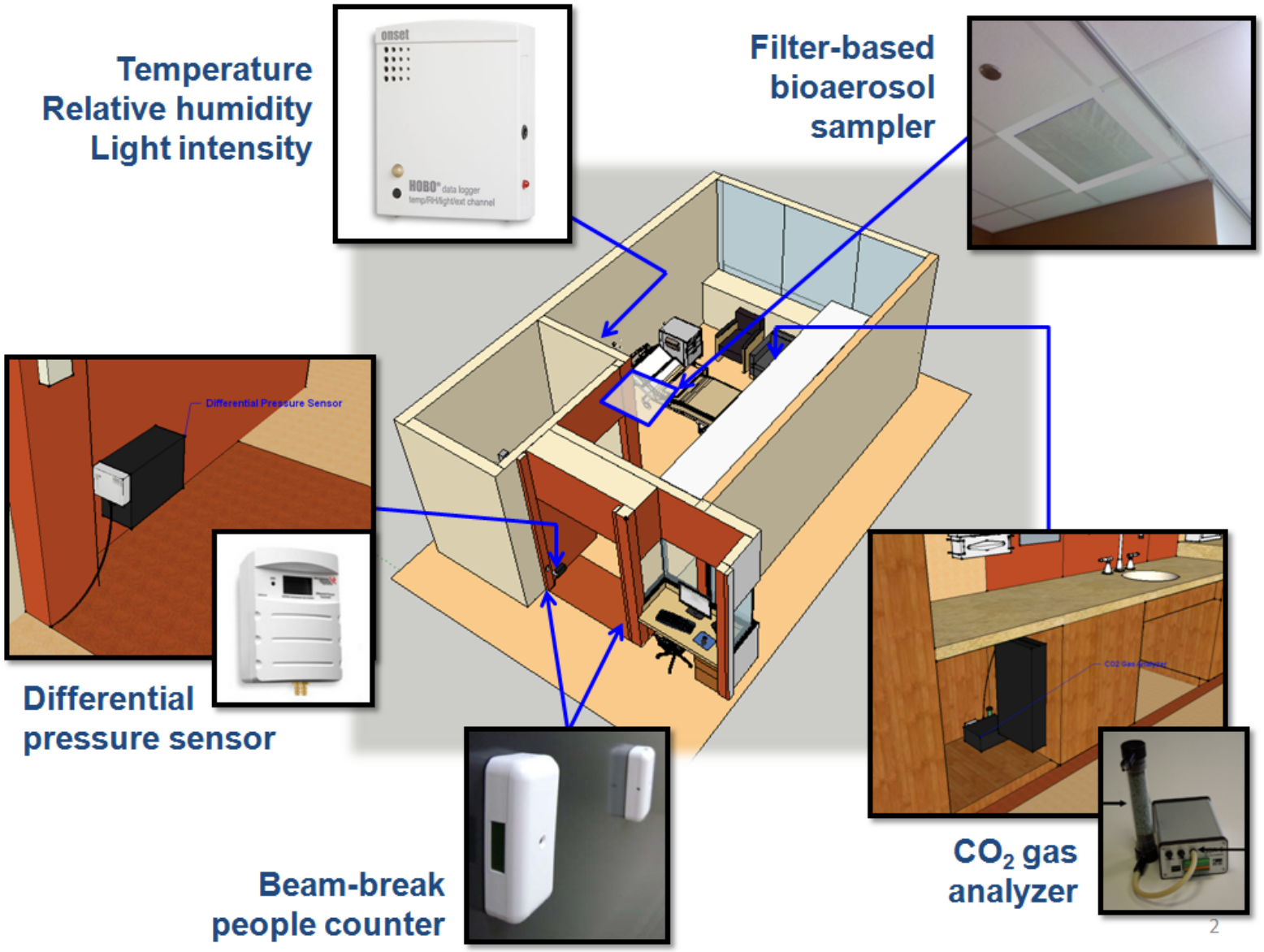


+ OA fractions in HVAC

Images courtesy of Tiffanie Ramos

Hospital Microbiome

Building science sensors in HMP



Images courtesy of Tiffanie Ramos

Hospital Microbiome

Building science data summary

How do _____ vary _____ ?

① Air temperature
② Relative humidity
③ Absolute humidity
④ Illumination levels
⑤ Human occupancy
⑥ Pressurization
⑦ Ventilation rates (OA fractions)

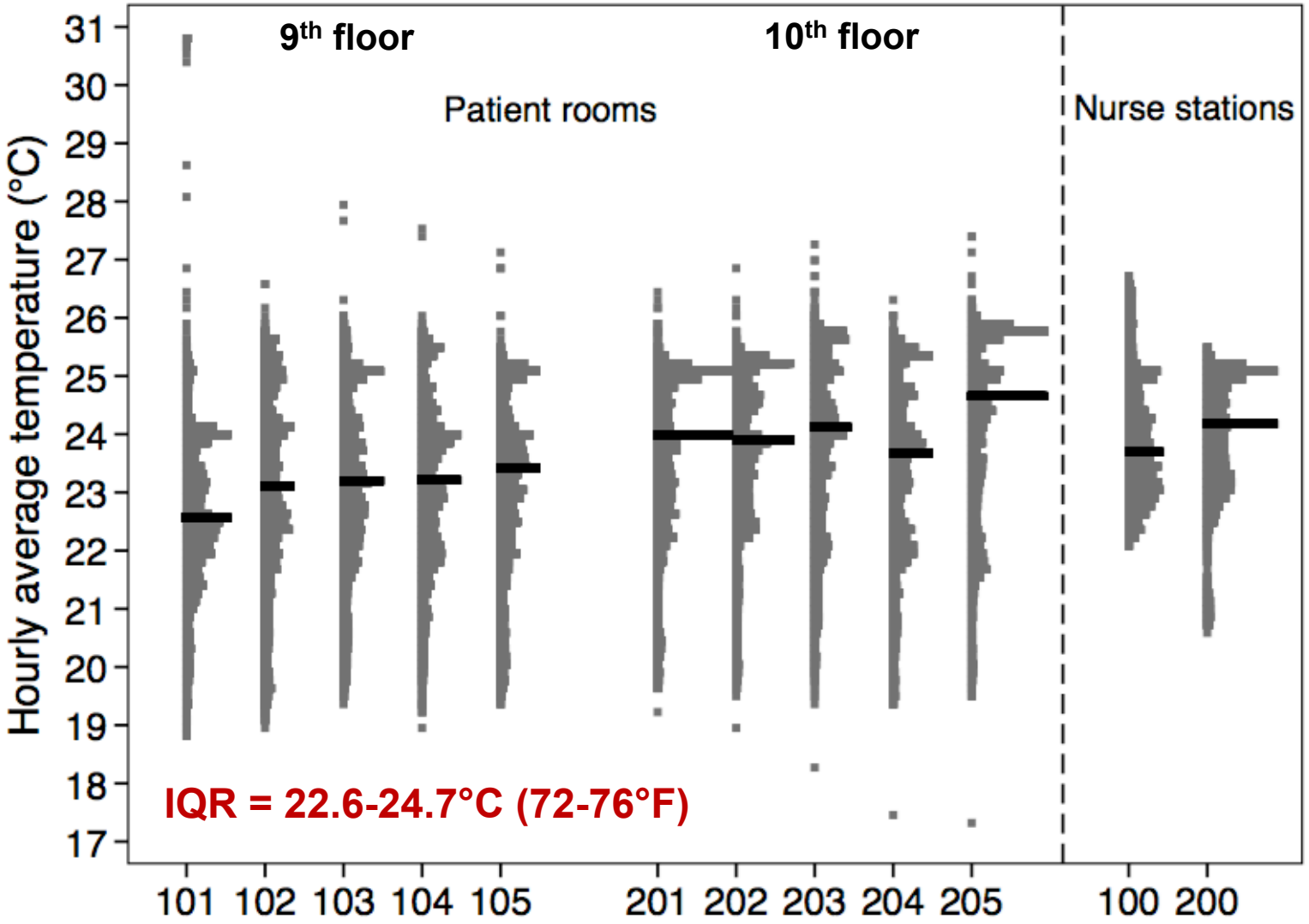
① Within rooms
② Between rooms
③ Between floors
④ Between night and day

And what are the potential implications for microbiology?

Hospital Microbiome

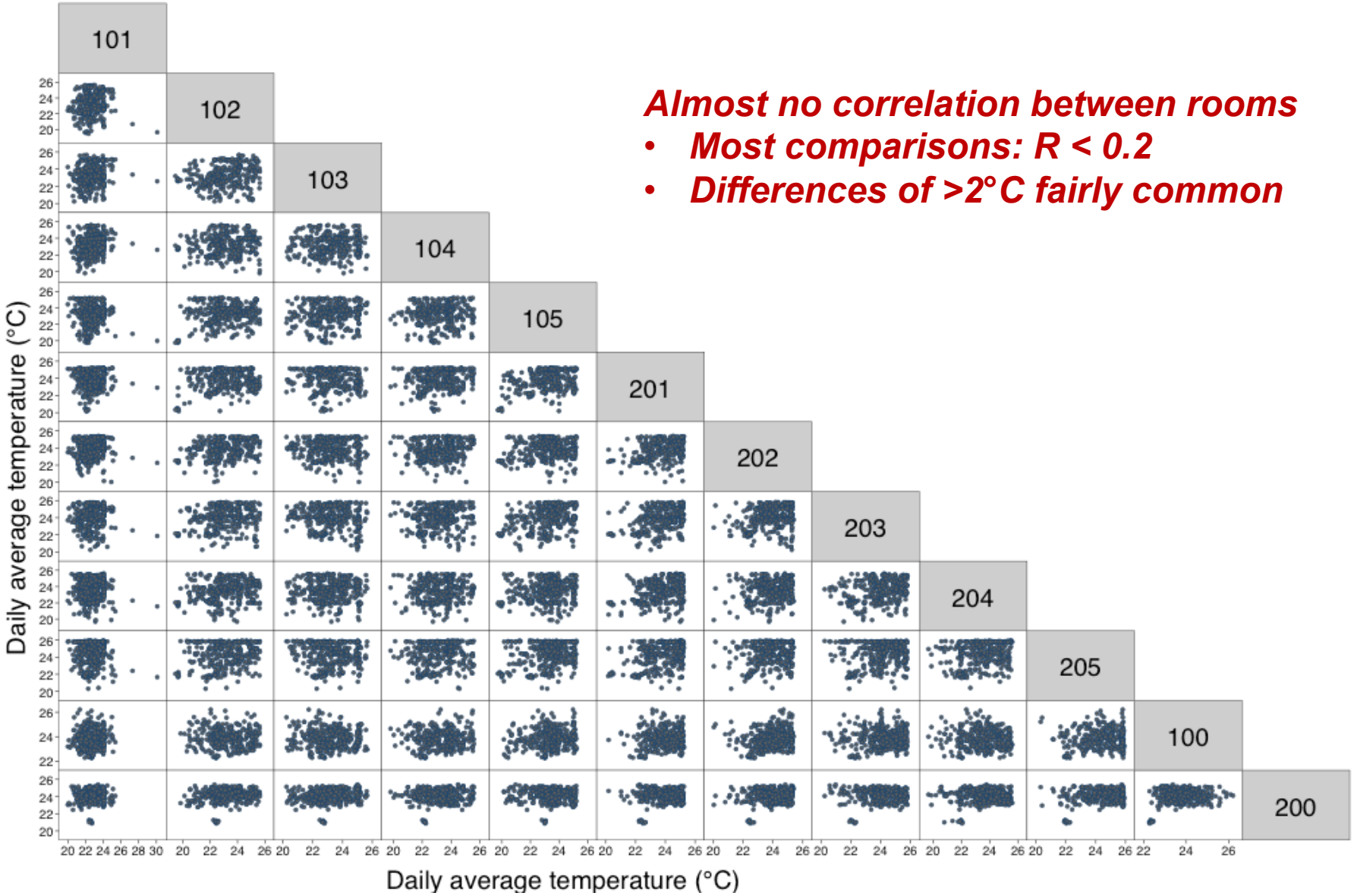
Hourly mean air temperatures

Similar distributions across patient rooms and nurse stations | Range 19-27°C 66-80°F



Hospital Microbiome

Daily mean air temperatures



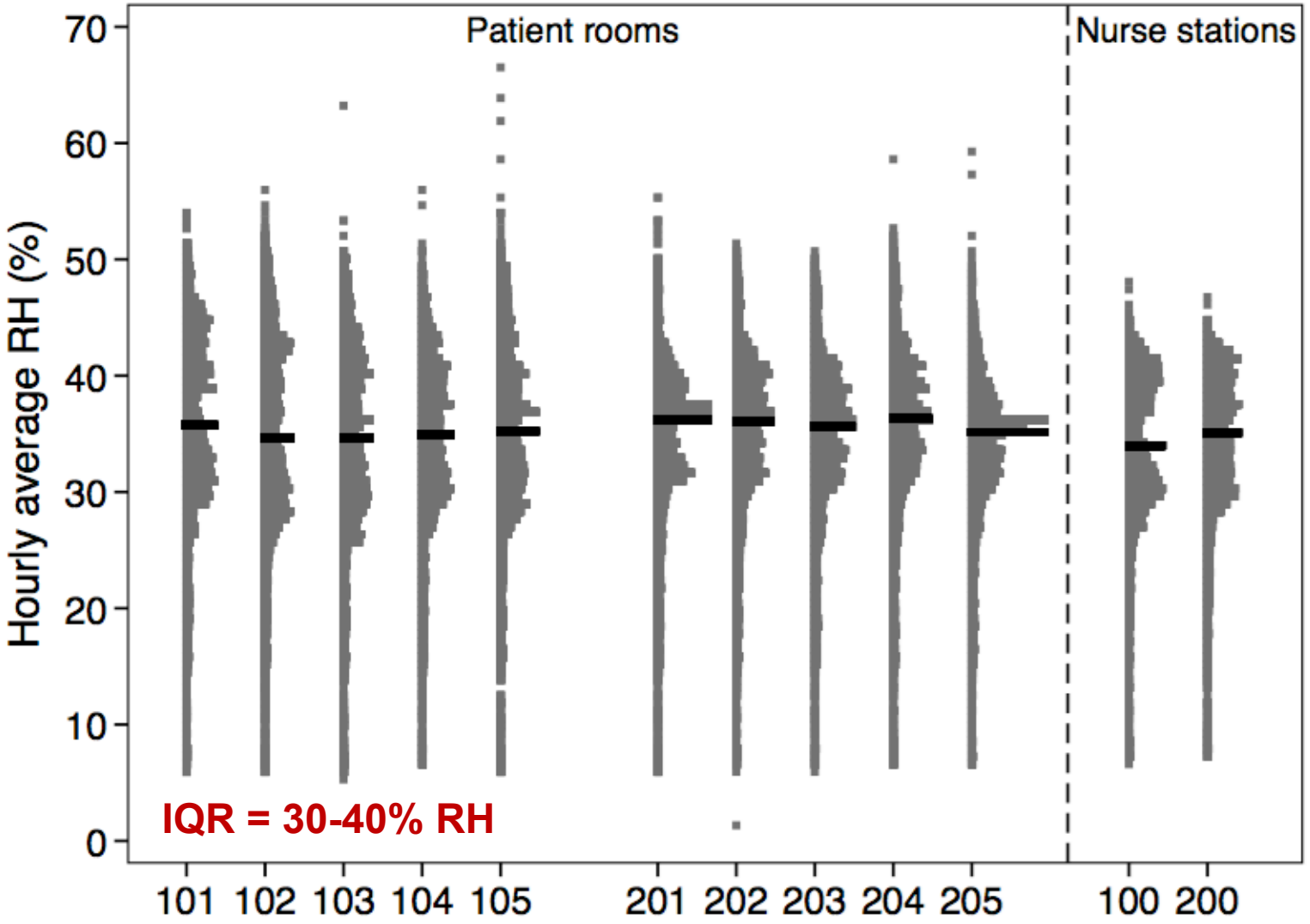
Almost no correlation between rooms

- ***Most comparisons: R < 0.2***
- ***Differences of >2°C fairly common***

Hospital Microbiome

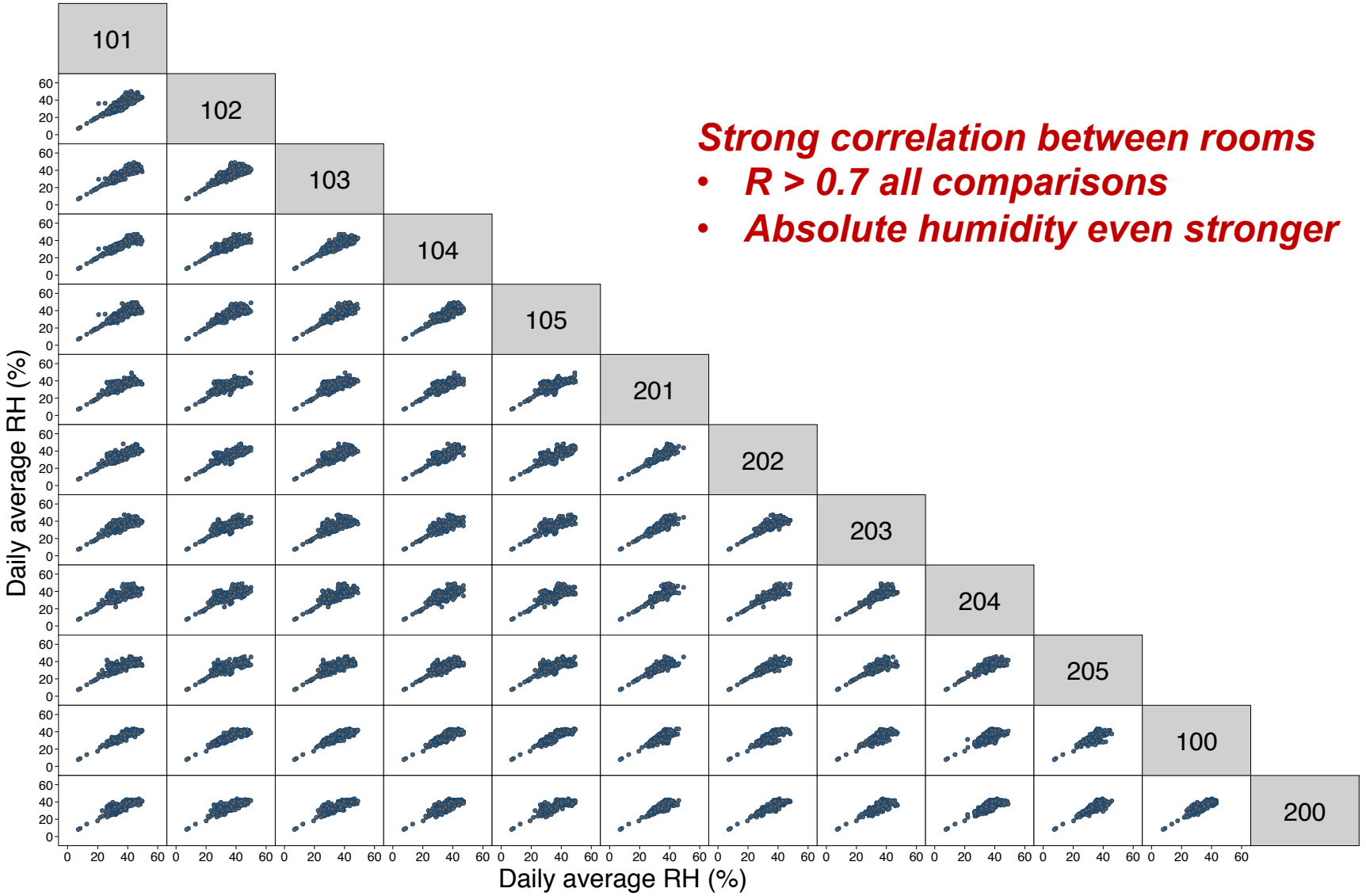
Hourly mean RH

Similar distributions across patient rooms and nurse stations | Range 5-60%



Hospital Microbiome

Daily mean RH



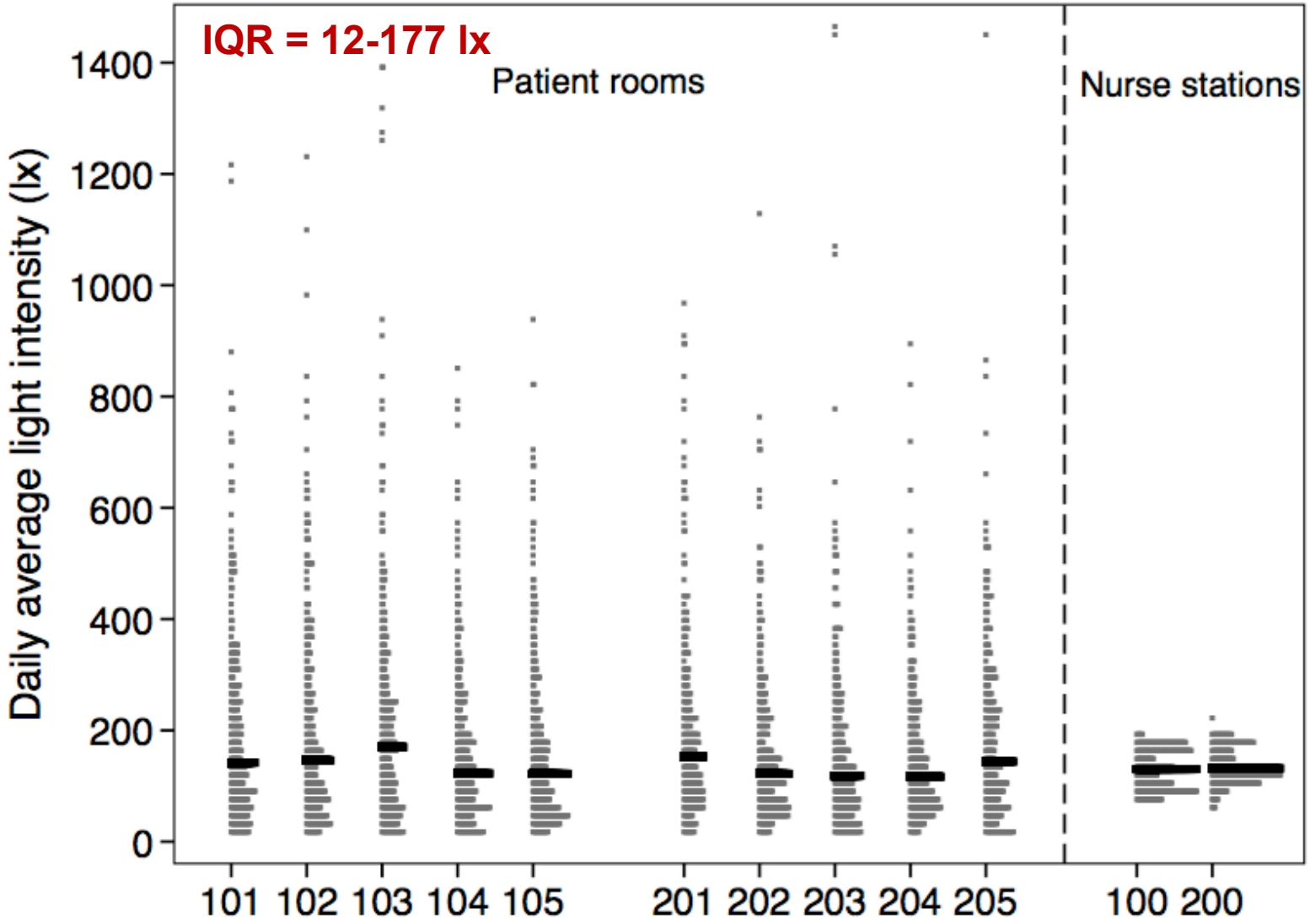
Strong correlation between rooms

- ***R > 0.7 all comparisons***
- ***Absolute humidity even stronger***

Hospital Microbiome

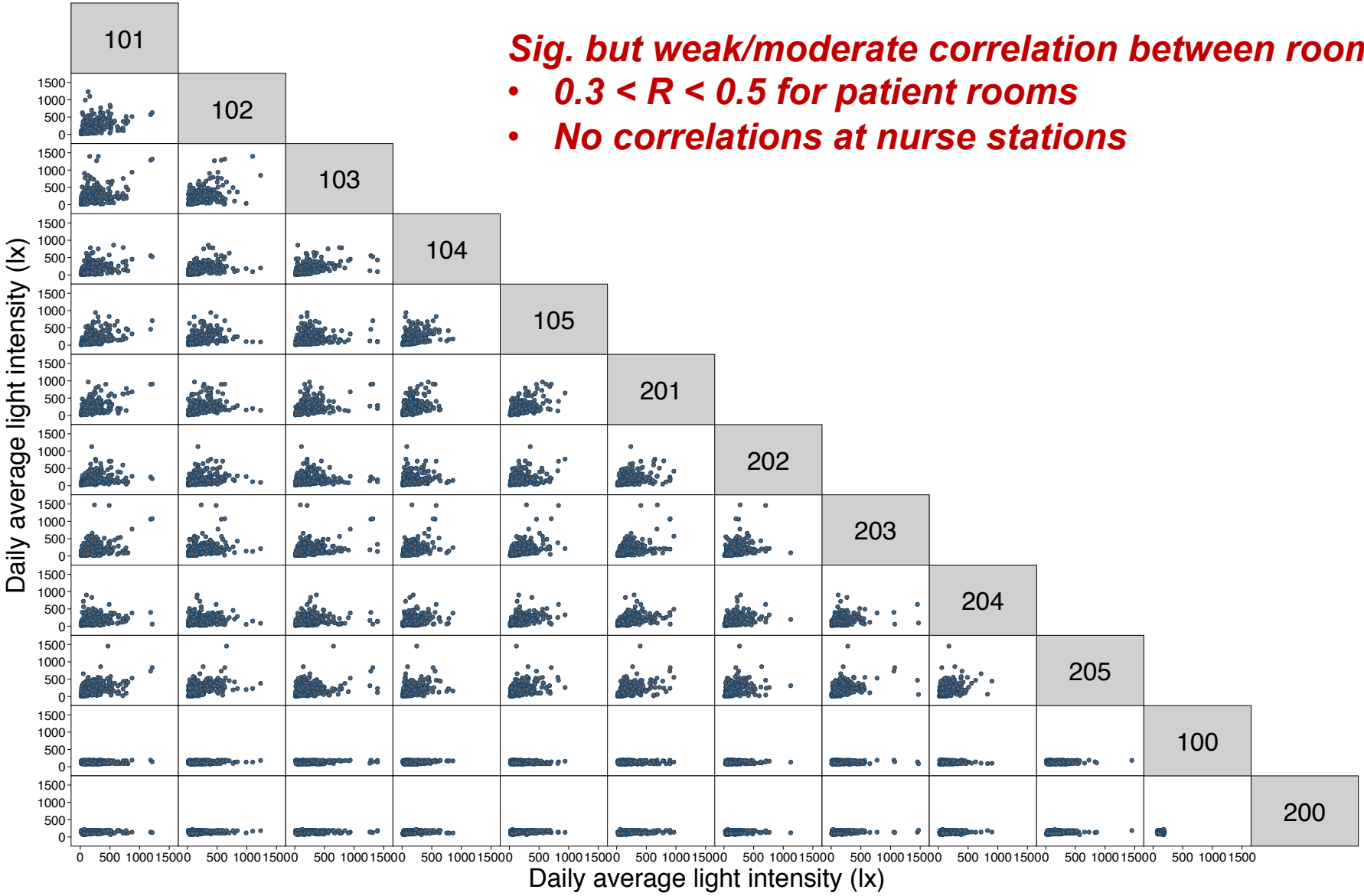
Hourly mean light intensity

Similar distributions across patient rooms but not nurse stations



Hospital Microbiome

Daily mean light intensity



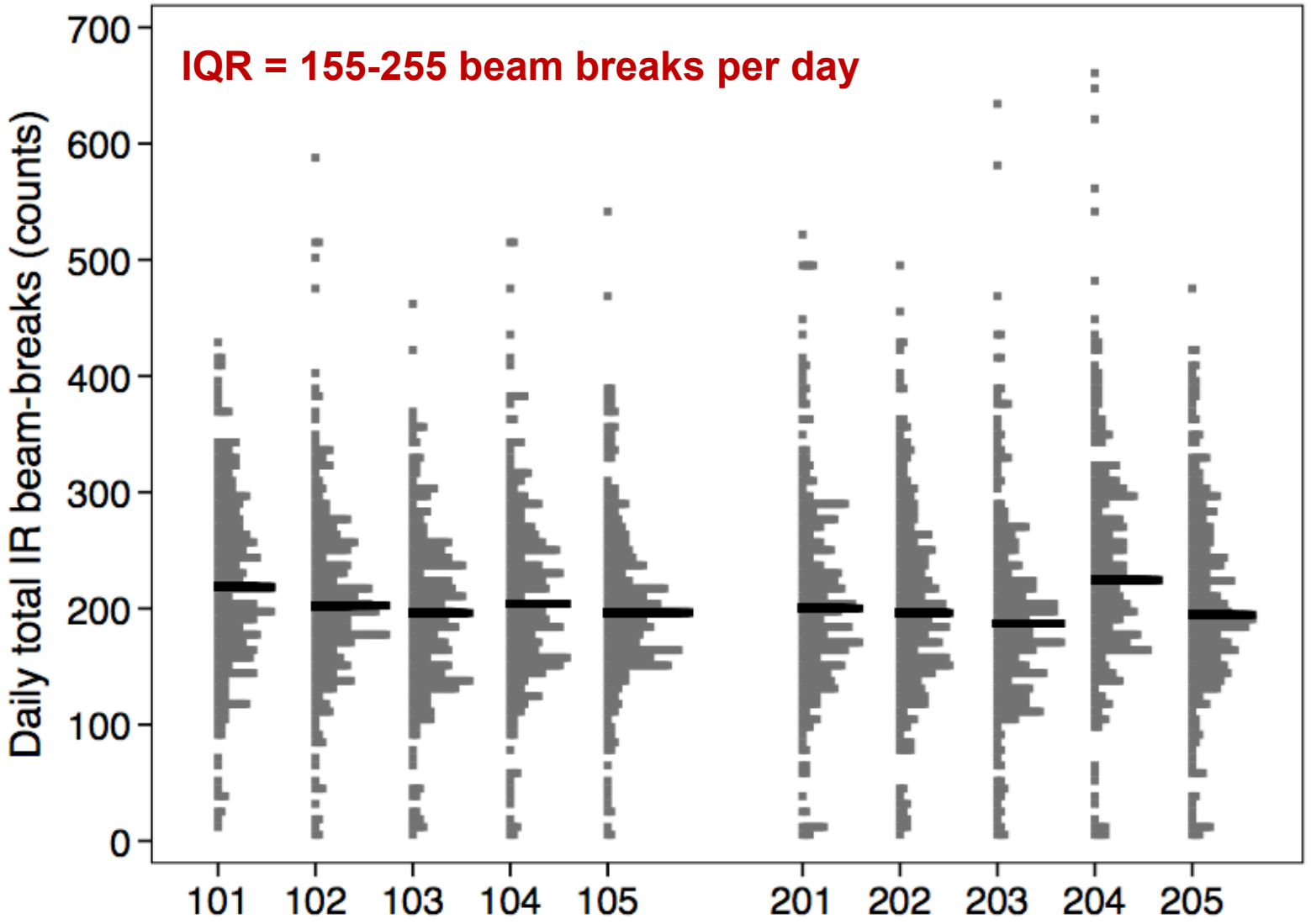
Sig. but weak/moderate correlation between rooms

- ***0.3 < R < 0.5 for patient rooms***
- ***No correlations at nurse stations***

Hospital Microbiome

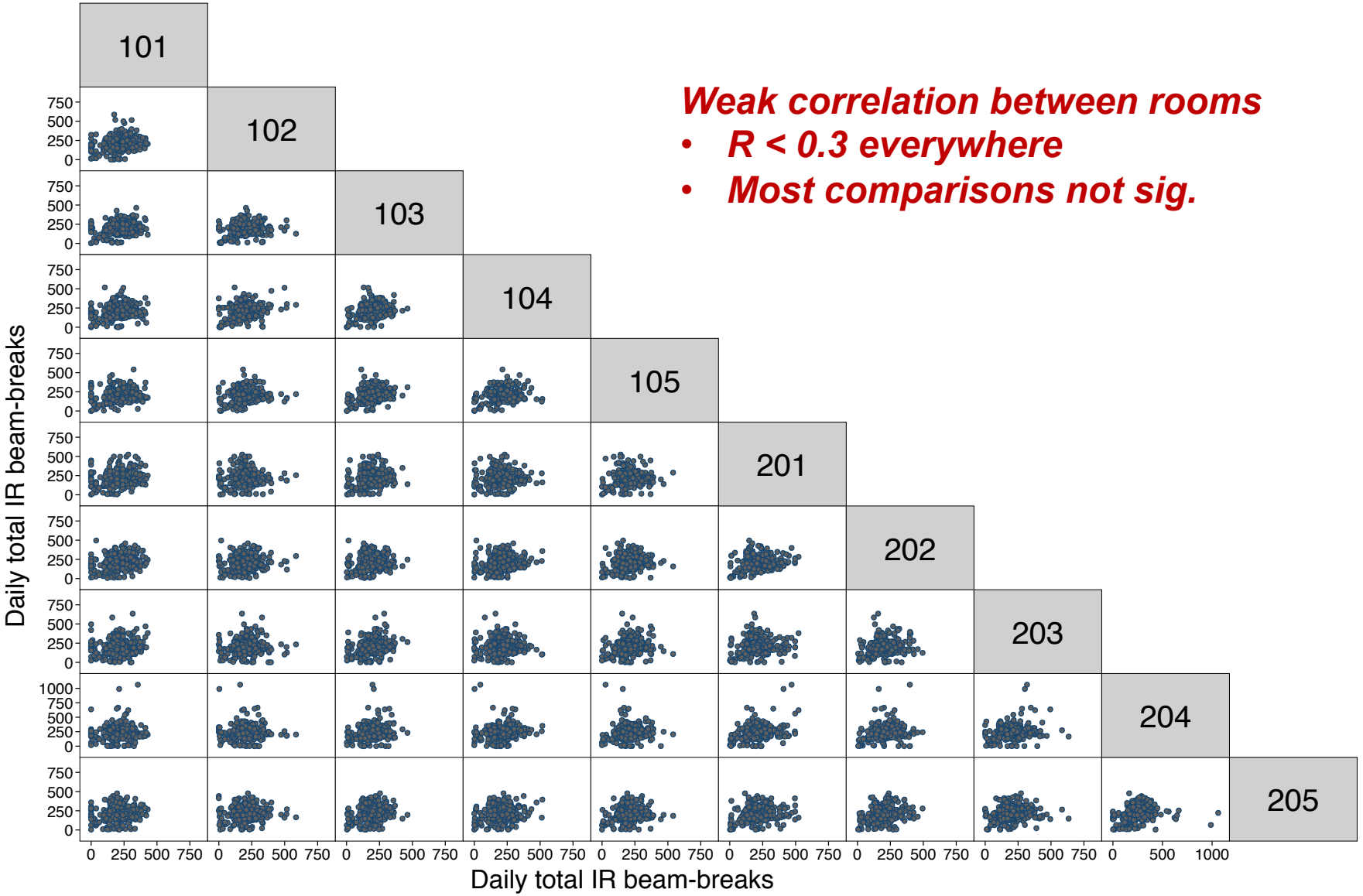
Daily doorway IR beam breaks

Similar distributions across patient rooms | Range 0 to 400



Hospital Microbiome

Daily doorway IR beam breaks



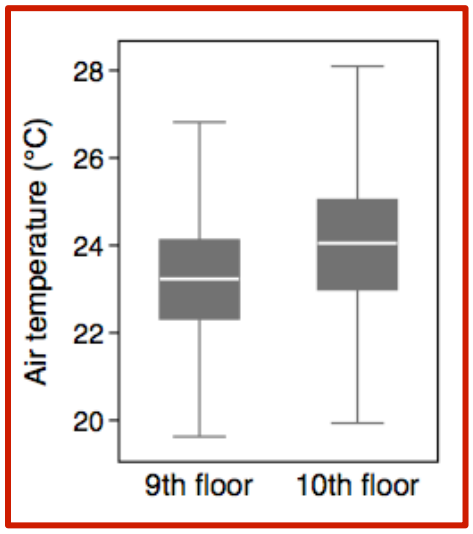
Weak correlation between rooms

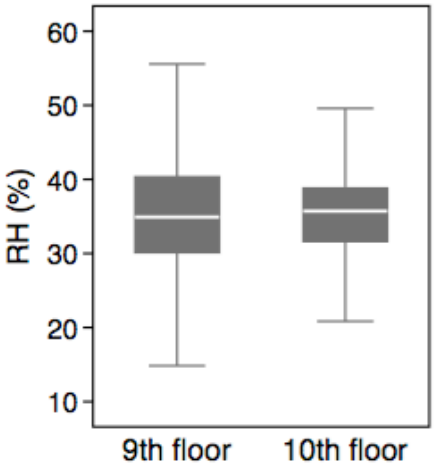
- ***R < 0.3 everywhere***
- ***Most comparisons not sig.***

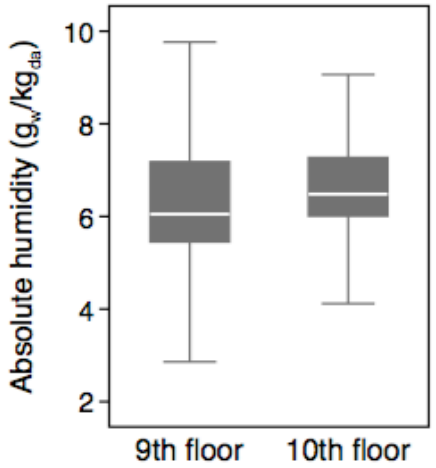
Hospital Microbiome

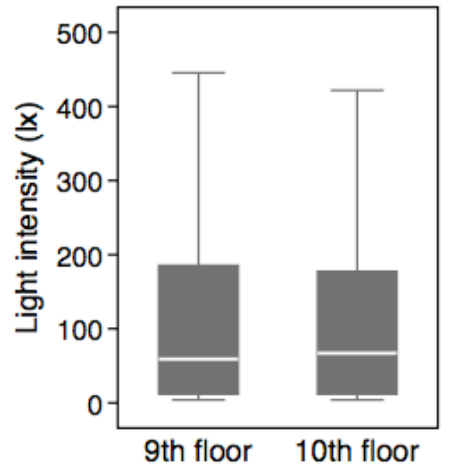
Variations between floors

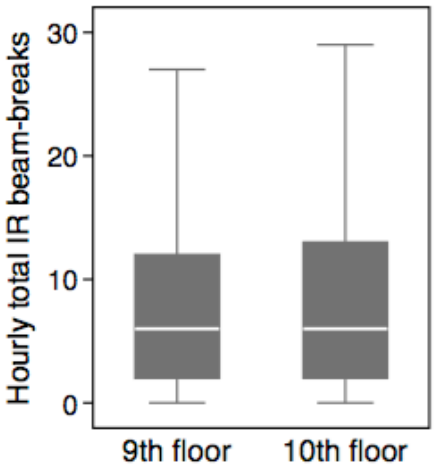
Air temperatures ~1°C higher on 10th floor

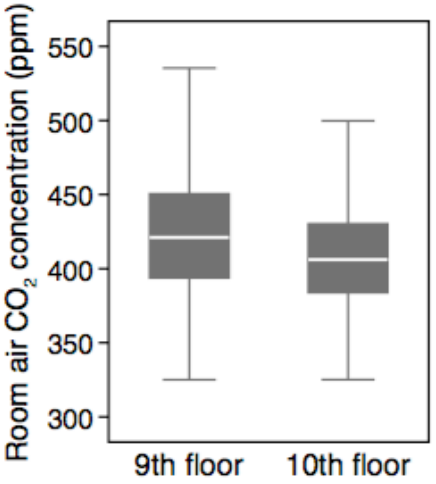




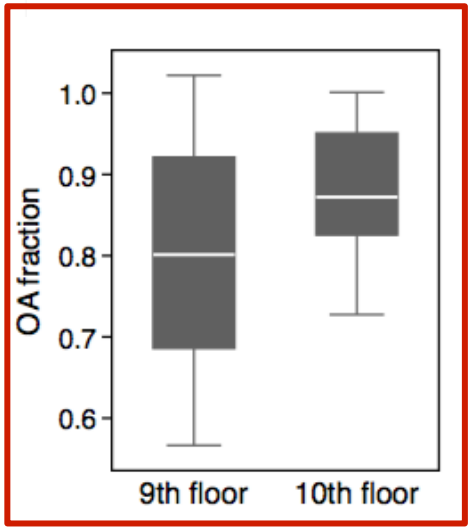








OA fractions lower on 9th floor



Potential implications for microbiology

- Differences in human occupancy patterns are likely the largest influence
- Environmental conditions have also been shown to influence both surface-bound and airborne microbes in varying ways
  - Varying suppression responses Tang **2009** *J R Soc Interface*
- Temperature affects survival of MRSA, hepatitis A, others
  - Across wider ranges than differences between locations herein

    Noyce et al **2006** *J Hosp Infect*; Mbithi et al **1991** *Appl Environ Microbiol*
- RH and AH influence evaporation rates, deposition rates, and viability of both bacteria and viruses

  Baughman, Arens **1996** *ASHRAE Trans*; Jawad et al **1996** *J Clin Microbiol*; McEldowney, Fletcher **1988** *Lett Appl Microbiol* ; Coughenour et al **2011** *Microb Drug Resist*
- Light (particularly sunlight) also potentially important (or not)

  Hobday, Dancer **2013** *J Hosp Infect*
- OA fractions unlikely to influence
- Room pressurization was neutral

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OPEN SOURCE BUILDING SCIENCE SENSORS

*The **Open Source Building Science Sensors (OSBSS)** project is designing and demonstrating how to build inexpensive building environmental and operational sensors for long-term studies of the indoor environment using open source hardware and software*

T/RH

Surface T

Eq. RH (a_w)

Data logger

Diff. pressure

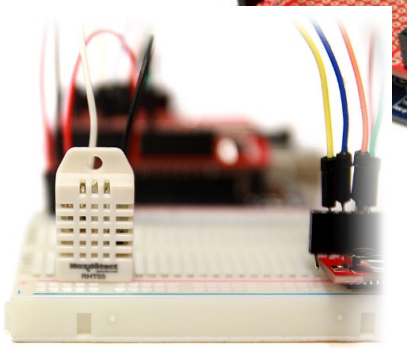
On/off

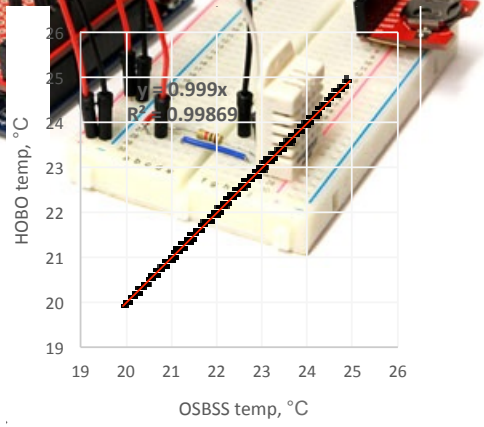
Proximity IR

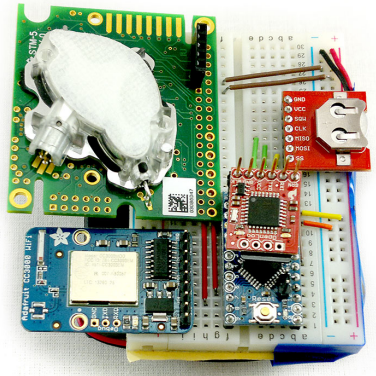
Dual IR beam break

CO_2

CO_2







http://www.osbss.com

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OPEN SOURCE BUILDING SCIENCE SENSORS

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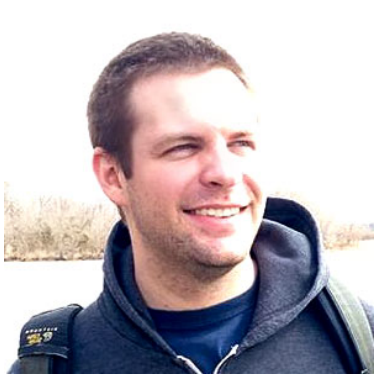
Akram Ali



Zack Zanzinger

Torkan Fazli

Deion Debose

“Bobo” Dong

OSBSS

“Tools to improve built environment data collection for indoor microbial ecology investigations” submitted

http://www.osbss.com

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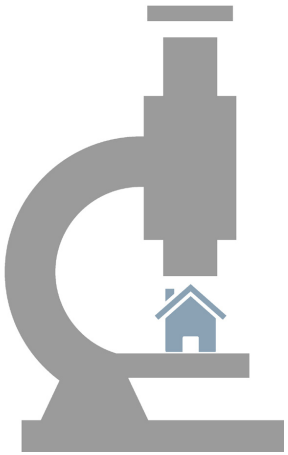

Building science to advance research in the microbiology of the built environment (MoBE)

Supported by the Alfred P. Sloan Foundation

May 22-23, 2014 | Illinois Institute of Technology | Chicago, IL

There remains a need to solicit input from expert building scientists and engineers on the overall effectiveness of previous MoBE studies, to identify existing gaps in these studies, and to inform a research agenda for future studies of the microbiology of the built environment that stems from deep knowledge of how buildings are constructed, operated, and occupied

http://built-envi.com/portfolio/mobe-building-science-workshop/

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Building science to advance research in the microbiology of the built environment (MoBE)

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Goals

- This workshop was designed to bring together a group of experts in building science and engineering (including those with expertise in *architectural engineering, environmental engineering, architecture, aerosol science, and environmental health*) with a smaller number of key microbiologists to ~~keep us honest~~ discuss existing gaps and future opportunities for research on the microbiology of the built environment (25 participants: ~75% non-microbiology)

- The primary goal of the workshop was to advance the MoBE program's research agenda and ultimately increase efficiency and impact among grantees

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Participants

	Name	Institution	Role
1	Jeffrey Siegel	University of Toronto	Building Science
2	Atila Novoselac	University of Texas at Austin	Building Science
3	Bill Fisk	LBNL	Building Science
4	Iain Walker	LBNL	Building Science
5	Brett Singer	LBNL	Building Science
6	Bill Rose	University of Illinois	Building Science
7	Paul Francisco	University of Illinois	Building Science
8	Michael Waring	Drexel University	Building Science
9	Shelly Miller	University of Colorado	Building Science
10	Hal Levin	Building Ecology	Architecture/Bldg Sci
11	Lew Harriman	Mason-Grant Consulting	Building Science
12	Ian Cull	Indoor Sciences	Building Science
13	Seema Bhangar	University of California, Berkeley	Env Eng/Env Health
14	Jack Gilbert	Argonne	Biology
15	Denina Hospodsky	Cornell	Biology/Env Eng
16	Kyle Bibby	University of Pittsburgh	Biology/Env Eng
17	Rachel Adams	University of California, Berkeley	Biology
18	Rachael Jones	University of Illinois at Chicago	Environmental Health
19	Ben Stark	Illinois Institute of Technology	Biology
20	Stephanie Kunkel	Illinois Institute of Technology	Biology
21	Brent Stephens	Illinois Institute of Technology	Building Science
22	Tiffanie Ramos	Illinois Institute of Technology	Env Eng/Bldg Sci
23	Edoarda Corradi	Illinois Institute of Technology	Architecture/Bldg Sci
24	Parham Azimi	Illinois Institute of Technology	Env Eng
25	Paula Osleiwski	Alfred P. Sloan Foundation	Program Director

http://built-envi.com/portfolio/mobe-building-science-workshop/

Building science to advance research in the microbiology of the built environment (MoBE)

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Research priorities / needs

Breakout group discussion summary

- Need to improve interpretation of microbiome data for health
  - Nonviable vs. viable. Dead vs. alive.
- Need to blend the two primary different goals of research
  - Understand microbial ecology
  - Application oriented: Inform policy, building design, health protection
- Need more hypothesis-driven research with identifiable application
- Need for small sample size intervention studies / controlled environment studies
  - Investigate fundamental processes (emission rates, survival)
  - Focus on transport mechanisms and dynamics
  - Explore impacts of built environment factors (ventilation…)
  - Possible to recreate standardized communities?

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Research priorities / needs

Breakout group discussion summary (cont.)

- Need to invest in development of better/easier/cheaper methods for microbial quantification
  - Abundance + relative abundance + diversity
- Need to host a cross-disciplinary *hands-on* workshop (methods swap)
  - Building science ←→ microbial ecology
- Need for methods standardization: *The Great Microbial Swab-off?*
- Consider human health consequences in research prioritization
  - Positive and negative
  - Immune system development
  - Inflammation
  - Infectious respiratory diseases, especially those with pandemic potential
- Need to make results more visible to practitioners

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Consensus

Research priorities / needs

Breakout group discussion summary (cont.)

- Need more complete assessment of built environment parameters to complement measurement of microbial communities
  - But metadata recommendations will vary among study types
- Need to piggy back on health studies (and other sources of funding)

"This type of multidisciplinary meeting very helpful for definition of priority directions"

Submit your integrated proposals NOW!

<olsiewski@sloan.org>

http://built-envi.com/portfolio/mobe-building-science-workshop/

Acknowledgments

- Jeffrey Siegel, University of Toronto (HMP)
- Jack Gilbert, University of Chicago and Argonne National Laboratory (HMP)
- Tiffanie Ramos, Parham Azimi, Laurit Dide, IIT (HMP)
- Akram Ali, Zack Zanzinger, Bobo Dong, Deion Debose, Torkan Fazli, IIT (OSBSS)
- Edoarda Corradi, Stephanie Kunkel, IIT (workshop)
- Funding from the Alfred P. Sloan Foundation

Questions/Comments

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web: www.built-envi.com

Built Environment Research @ IIT

Advancing energy, environmental, and sustainability research within the built environment

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