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Seminar 1

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## 40 is the new 20, balanced air-hydration for health!

### Updating Scientific Evidence about the Effects of Low Humidity on People

## Learning Objectives

- Understand the effects of humidity on health, comfort and IAQ
- Understand the relationship between low indoor relative humidity and increased healthcare-associated infections in the hospital setting
- Understand the human physiological reactions to low humidity
- Understand the effects of low humidity on human performance

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## Outline

- 1 Overlap between engineering and medicine
- 2 A new study to test the impact of the building on occupant health
- 3 Dry building syndrome
- 4 Conclusions and best practices

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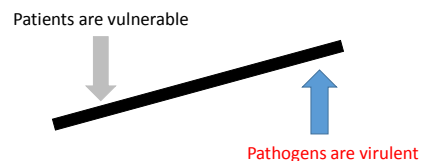
## Engineers and physicians have much in common

- Many years of school!!!
- Technical vocabulary that excludes outsiders
- Budgets control our jobs
- We both promote human health

*"ASHRAE is a global society **advancing human well-being** through sustainable technology for the built environment"*

## How does the building impact occupant health?

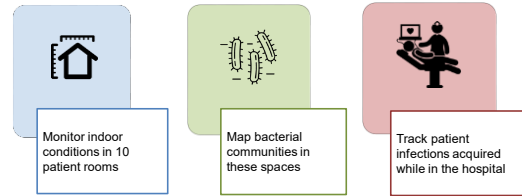
Hospitals are a perfect setting to study this



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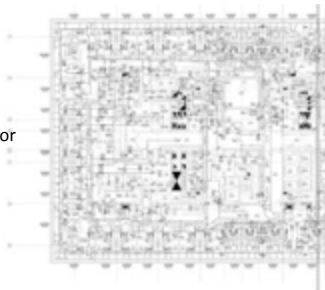
## Room conditions and patient outcomes



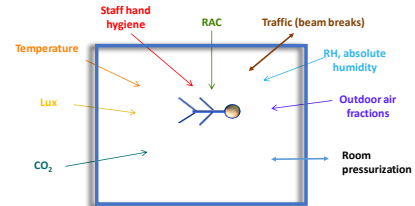
a 12 month study

## The hospital building

- Built 2013, LEED Silver
- 1.2 million sq. feet (111,484 sq. meters)
- 100,000 sq. feet per floor (9,290 sq. meters)
- 240 single-occupancy inpatient rooms
- Green roof



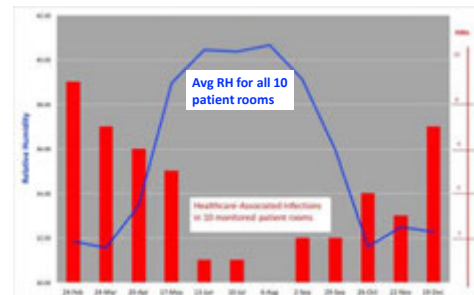
## Data collected from the patient room



## Examples of new patient infections

Patient	Room	Clinical symptoms	HAI Organisms (if indicated)
xx	xx	pneumonia, viremia	Pseudomonas, Epstein-Barr virus (EBV)
xx	xx	pneumonia	Staphylococcus aureus
xx	xx	open wound of head, neck, and trunk	
xx	xx	bacteremia, organism unspecified	Citrobacter infection
xx	xx	infection due to vascular device	
xx	xx	cellulitis	Staphylococcus aureus
xx	xx	sepsis, cellulitis, abscess	
xx	xx	bacteremia, organism unspecified	
xx	xx	pneumonia, organism unspecified	
xx	xx	fever; bacteremia, organism unspecified	
xx	xx	viremia	Cytomegalovirus (CMV)
xx	xx	wound infection after surgery	
xx	xx	urosepsis, organism unspecified	
xx	xx	sepsis following cardiac surgery	
xx	xx	pneumonia, organism unspecified	
xx	xx	infection of skin and subcutaneous tissue	
xx	xx	colitis and diarrhea	Clostridium difficile
xx	xx	wound infection after surgery	
xx	xx	urosepsis, organism unspecified	
xx	xx	diarrhea	salmonella enteritis

As indoor RH went down, the patient infection rate went up



## SPSS analysis of relationships between indoor conditions and infections

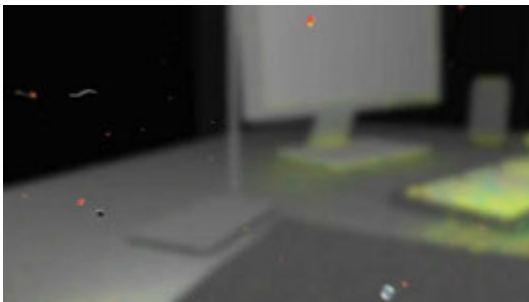
Model	Coefficients <sup>a</sup>		
	Beta	t	Sig.
1 (Constant)			
Avg RH	-9.060	-2.348	.023
Avg Temp	2.593	2.383	.021
Avg Hum Ratio	-7.563	-2.386	.021



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## The invisible world



## Low RH is harmful- Dry Building Syndrome

In air with 20% RH, an inactive 50 kg (110 lb) person loses 1 - 2% body weight in 8 hrs, becoming clinically dehydrated before thirst begins

This mild dehydration results in:



Impaired immunity,  
increased infections

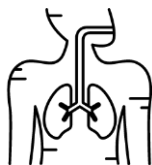


Breached skin  
barrier & delayed  
wound healing



Diminished brain  
function &  
performance

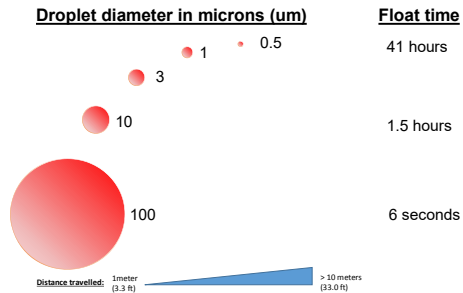
## Dry Building Syndrome increases infections



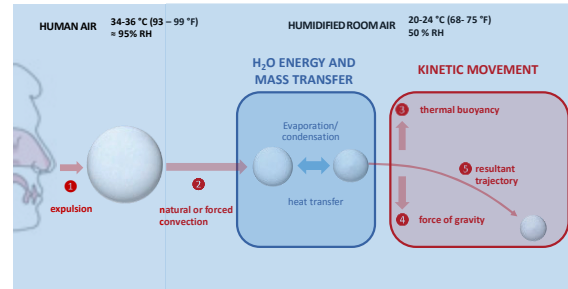
## Will this cough infect others?



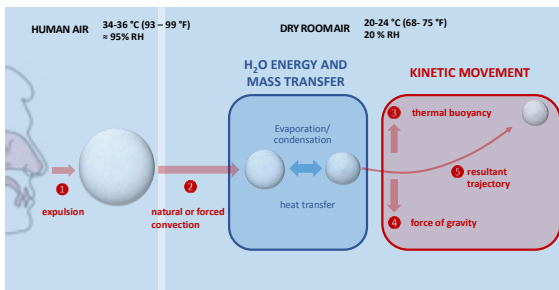
Low indoor RH shrinks aerosolized droplets, promoting greater pathogen spread



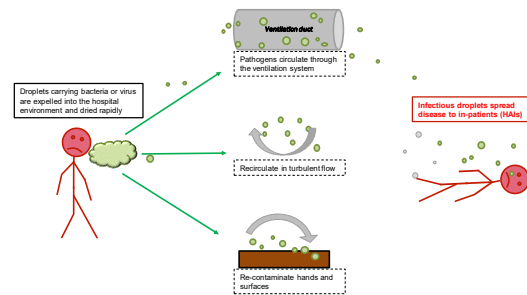
Thermodynamic and kinetic changes in infectious droplets



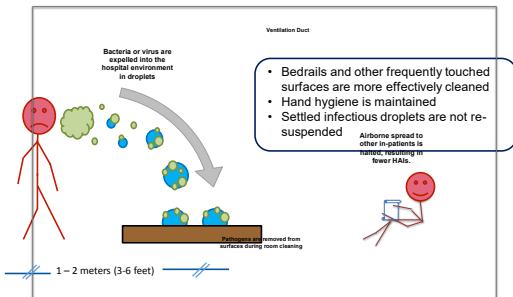
Thermodynamic and kinetic changes in infectious droplets



Indoor air with RH < 40% promotes pathogen transmission in tiny aerosolized droplets

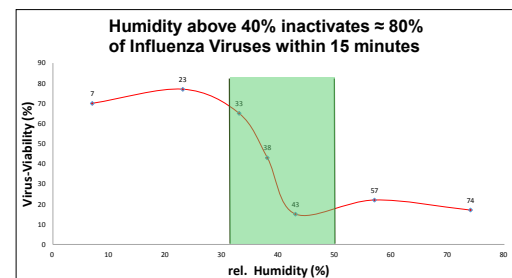


With RH of 40%–60%, infectious droplets settle out of the air within a short distance of the source

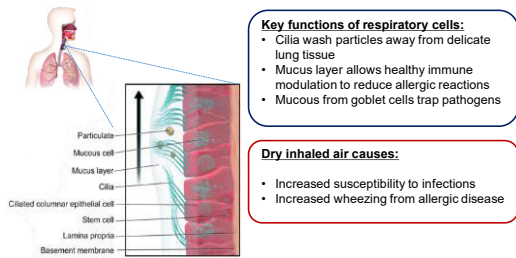


When the Patient Room RH is maintained at a comfortable RH of 40-60%, infectious

Viability of many pathogens is reduced in air with RH 40%–60%



## Appropriate humidity supports cell hydration needed for respiratory defense mechanisms



## Children and seniors are especially vulnerable to the ill-health effects of low RH

Children



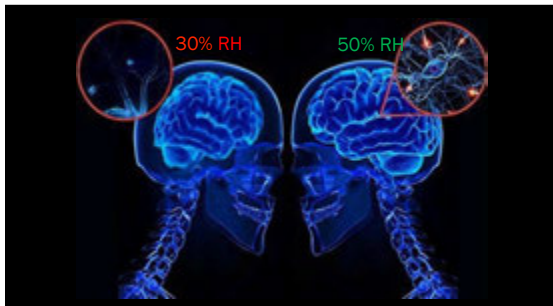
- Delicate fluid balance
- Higher water loss through skin
- No self-control over fluid input
- No control of clothing

Seniors



- Sense of thirst is reduced and thus unreliable in preventing dehydration
- Bedridden people have little autonomy
- Seniors often limit drinking in order to reduce toilet visits
- Non-active people often forget to drink

## Dry Building Syndrome affects our brain

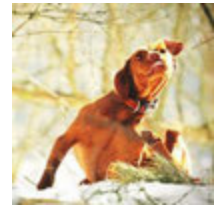


## Dry Building Syndrome harms our skin



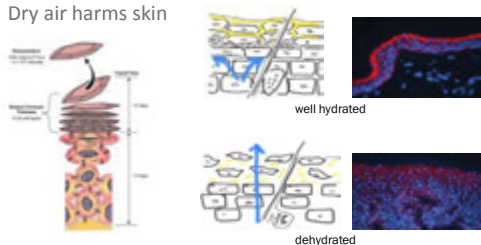
### Skin functions are impaired:

- wound healing
- immune system training
- protection from injury
- protection from infections
- preserving internal water



## Dry Building Syndrome harms our skin

### Dry air harms skin



## Dry weather reliably predicts meningitis outbreaks



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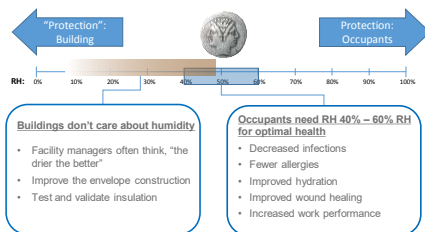
- Bacteria spread when the outdoor humidity is low
- Once the humidity exceeds 40%, the epidemic ends



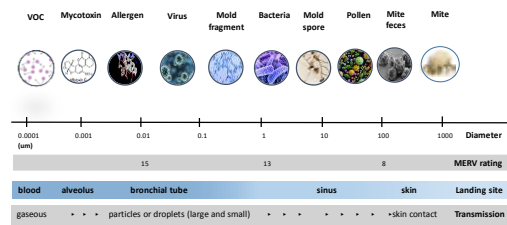
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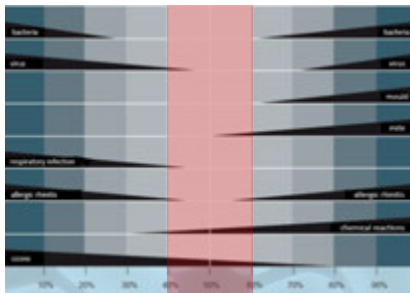
## The optimum indoor air RH: 40 is the new 20!



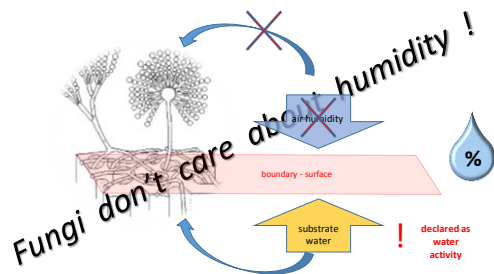
## Things in the air that affect our health

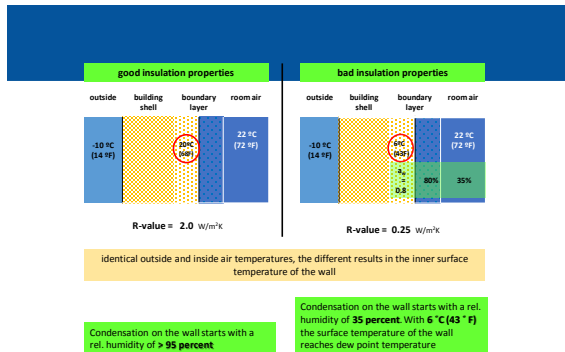


## We need to maintain maximum AND minimum RH!



## They care about water activity !





## Conclusions:

- New data correlates low indoor RH with occupant illness and decreased productivity
- Building codes should enforce both minimum and maximum indoor RH levels

## Bibliography

- John D. Noti, Francoise M. Blachere, Cynthia M. McMillen, William G. Lindsley, Michael L. Kashon, Deniz R. Slaughter, Donald H. Beezhold. 2013. High Humidity Leads to Loss of Infectious Virus from Simulated Coughs. University of Illinois.
- Kempton MJ, Ettinger U, Foster R, Williams SC, Calvert GA, Hampshire A, Zelaya FO, O'Gorman RL, McMorris T, Owen AM, Smith MS. 2011. Dehydration affects brain structure and function in healthy adolescents. National Center for Biotechnology Information, U.S. National Library of Medicine.
- E.M. Sterling, A. Arundel, T.D. Sterling. 1985. Criteria for Human Exposure to Humidity in Occupied Buildings. ASHRAE Transactions. Vol. 91. Part 1.

## QUESTIONS?

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