Low Ambient Humidity Impairs Barrier Function and Innate Resistance Against Influenza Infection

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Learning objective

- Provide a data-driven description of indoor environmental factors that are associated with occupant health
- Explain the application of energy-saving and hygienic approaches to active humidification when supplementation is necessary as an intervention for dry air
- Provide building owners a cost-benefit analysis of occupant health as a building performance metric
- Identify the relationship between water in the liquid and vapor state and the human body

Acknowledgements

The Howard Hughes Medical Institute
The Condair Group
The Naito Foundation
National Institutes of Health Grants

Seasonal influenza and winter months

Influenza epidemic happened after dramatic reduce of humidity.

Humidity is correlated with influenza epidemic and transmission.

(Shaman et al, Plos Biol 2010)

Learning objective

- Understand the importance of humidity for protection against influenza infection
- Understand the effect of humidity for immune system

Influenza virus

- Influenza is an infectious respiratory disease by influenza virus.
- Negative-sense single-strand RNA viruses with a segmented genome.
  - Influenza virus A
  - Influenza virus B
  - Influenza virus C
- Main cause of the seasonal influenza epidemic
- Infects 5-10% of adults and 20-50% of children globally every year
- Annual epidemics of influenza result in ~1 billion infections, 3–5 million cases of severe illness and 300,000–500,000 deaths.
- Symptoms: fever, sore throat, runny nose, cough, headache, muscle pain, pneumonia
How do we remove influenza virus from our body?

The host immune defense against influenza

- Physical barrier: Mucus production and ciliary clearance
- Innate immune responses: Type I IFN and Interferon stimulated genes (ISGs)
- Adaptive immune response: Producing antibody and cytokine from T cells and B cells

Purpose: The impacts of humidity on host response to flu infection and disease outcome

Can high humidity protect influenza virus infection and disease in mice model?

How does humidity protect influenza virus infection?

Environmental chamber model system: Humidity

Condition: Mouse room: 20-22°C, 50% relative humidity (RH).

Experimental design:
- Flu virus challenge
- Monitor: Weight Loss, Survival
- hvPR8 (IAV) influenza infection by intranasal or aerosol inoculation

First line of defense against pathogen.
Low humidity leads to more severe disease

Low humidity impairs influenza virus clearance

Antiviral resistance and disease tolerance in influenza

Low humidity impairs tissue repair in mice trachea

Low humidity leads to more severe disease thorough caspase1/11

Low humidity decreases mucociliary clearance (MCC)
Single cell RNA-sequencing provides the expression of individual cells.

- 10 or 50%RH
- 2 days
- +/- flu
- single cell
- Digest and single cell
- cDNA Library
- Sequencing
- Gene expression of individual cells
- 2,000 cells/mouse lung (N=2)

There are 22 distinct cell types in whole lung.

10% uninfected 10% infected
50% uninfected 50% infected

Low humidity decreases ISGs expression.

10% RH 50% RH
Uninfected Infected Uninfected Infected
Mx1 Ifn3 Ifn2 Bx2 Isg15 Raz2 (Viperin)
Z23nav1 (Zap)

50% humidity highly express antiviral response genes.

IFN-induced Mx1 were suppressed in both infected- and uninfected cells.

Summary
1. Low humidity increased susceptibility to infection and more severe disease.
2. Low humidity decreased epithelial turnover after influenza infection.
3. Low humidity attenuated mucociliary clearance of influenza virus.
4. Low humidity suppressed antiviral response such as IFN-induced Mx1.

Increasing ambient humidity may be a viable strategy to reduce disease symptoms and to promote more rapid recovery in influenza-infected individuals.

How to control humidity in our life

Wearing face mask
Control humidity by humidifier

Humidity control is necessary in hospital, school, office and airplane.
Bibliography

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10905-10910

Questions?

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