MAYO CLINIC

2019 ASHRAE WINTER CONFERENCE
JANUARY 12–16 // AHR EXPO JANUARY 14–16

SMNR 56: Humidity IS Health

The Impact of Steam Humidification on Influenza Virus in Preschool Classrooms

Alex Generous

Mayo Clinic Graduate School of Biomedical Sciences

Generous.alex@mayo.edu

1

Learning Objectives

1. Understand the role of proper indoor humidification in improving health and cognitive functioning
2. **Understand that proper indoor humidification can be an intervention to prevent seasonal influenza spread in preschools**
3. Understand how to properly design a high-pressure fogging system for health-care applications both for humidification and energy saving
4. Understand how to estimate the break-even point of the most common steam and adiabatic humidification systems

2

Acknowledgements

InSciEd Out team
Jennifer Reiman, PhD
Chris Pierret, PhD
Stephen Ekker, PhD
Biswadeep Das, PhD
Mark Urban
Greg Sindberg, PhD
Jamie Lyman-Gingerich, PhD
Maddy Hammerlund
U of MN- Rochester work study students
Han Lee, PhD
Tyler Koep, PhD

DriSteem*: Phil Lilja

NIOSH

Mayo Colleagues
- Hind Fadel, MD, PhD
- Katie Spring
- Charlie Huskins, MD
- Bob Diasio Lab

Aldrich
- Kevin Ewing
- Students, parents and staff

Funding
Clinical and Translational Sciences Award (NIH)
Department of Pediatric and Adolescent Medicine
Infectious Diseases small grant program

*commercial brand (potential COI)

3

Where are you from?

4

Cost of Influenza

- $10.4 billion a year in direct medical expenses
- $16.3 billion in lost earnings annually
- $87 billion a year total economic burden

1. Molinari NA et al. 2007. Vaccine 25:5086-5096.

5

Where does flu come from?

Patient Zero

Student absences increase during winter and children are the main introducers of influenza into a household

6

Absences negatively impact education & learning

- Chronic absenteeism, missing ≥10% of school days within a year for any reason predicts low student achievement.[2]
- A study in North Carolina found 22% of chronic absences were due to respiratory illnesses.[3]

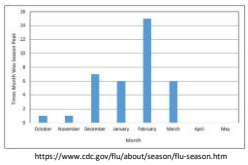
2. Henderson T, Hill C, Norton K. 2014.
3. Longini IM, et al. 1982. American Journal of Epidemiology 115:736-751.

7

Influenza avoids humidity

- Influenza A incidence peaks during winter in temperate regions
- Absolute humidity (AH) accounts for 50% of the variability in transmission and 90% of the variability in survival of influenza[4] (reanalysis of guinea pig data[5])

Peak Month of Flu Activity 1982-1983 through 2017-2018



https://www.cdc.gov/flu/about/season/flu-season.htm

4. Shaman J, Kohn M. PNAS 2009, 106(9):3243–3248.
5. Lowen AC et al. (2007). PLoS Pathog 3:1470–1476.

8

The Big Question

Unknown question:

Does low humidity in the winter increase transmission and survival of influenza in a classroom environment?

Hypothesis:

Increasing the relative humidity of classrooms to 40-60% will reduce the capacity of influenza to survive on classroom surfaces, or spread between classmates as aerosols.

9

Questions we sought to answer:

Impact of humidity on:

1) viral transmission (presence and quantity)
   - air particles
   - fomites (paper wrapped objects)
2) survivability of influenza
   - How infectious?
3) Influenza Like Illness (ILI) and absences of students

10

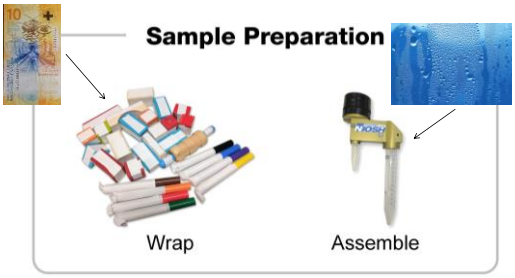
How do we do that?

- Influenza is difficult to find in the environment
- But Swiss bank notes extend survival

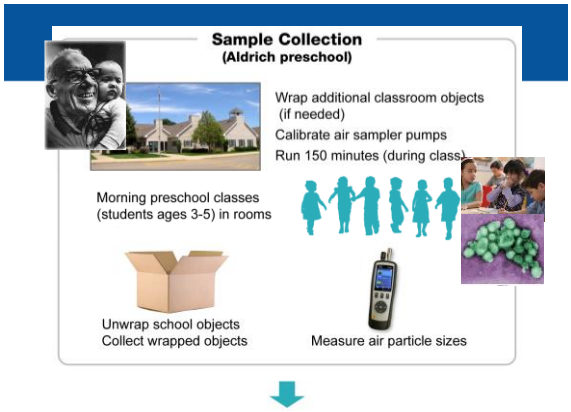
6. Thomas Y, Vogel G, Wunderli W, et al. Survival of influenza virus on banknotes. *Appl Environ Microbiol*. 2008;74(10):3002-7.

11

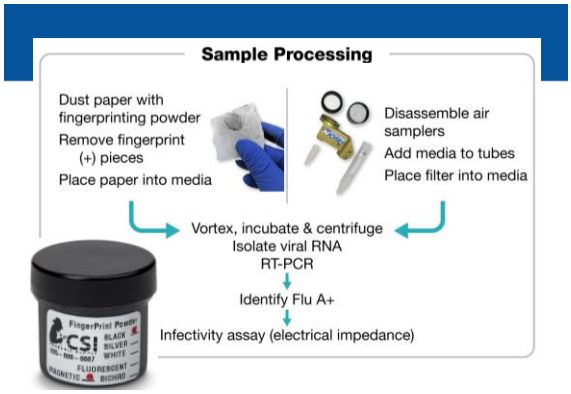
The Method



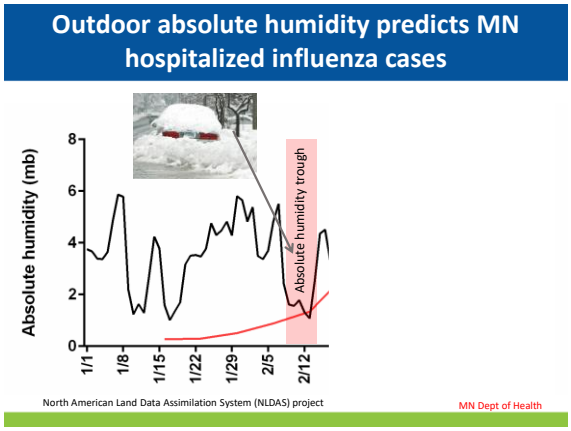
12



13

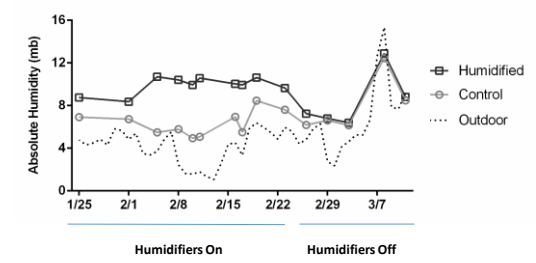


14



15

We were able to raise the absolute humidity of identical preschool classrooms



Control = not humidified

16

There were less Influenza A genomes in humidified rooms

Flu A positive	Control % positive	Humidified % positive	Odds Ratio * = real difference
Fomites	22.1	18.0	.51 *
Air (total)	18.3	11.7	.51 *

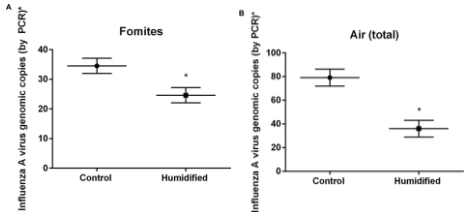
An odds ratio <1 means reduced likelihood of finding flu positive sample in humidified rooms compared to control rooms

Reduction in presence of flu in humidified classrooms for both fomites (surfaces) and air samples

Control = not humidified

17

Less flu is present on fomites and in the air in humidified rooms



* = differences between groups are real

Control = not humidified

18

Environmental samples from humidified rooms demonstrate less infectivity

		Control		Humidified		Control vs. humidified
Sample Type	Assay	% positive	n	% positive	n	OR, [95 % CI], P>|z|
Mixed (fomites and air)	Electrical impedance	48.1	27	16.7	18	LCS[a]

More virus is "alive" in the control room than in the humidified room

Control = not humidified

19

Does humidification result in less Flu like illness?

- During the period of elevated humidity (from 2/25) through end of study (3/31) there was a total of 10 influenza like illnesses from absent students
  - 7 were from control rooms
  - 3 were from humidified rooms

20

Summary

- We achieved elevated humidity in rooms with humidifiers compared to control rooms

Humidified rooms had:

- a significant decrease in % total air samples containing Influenza A
- trend toward decreased % of paper samples containing Influenza A
- a significant reduction in Influenza A presence for total air and paper samples

- Fewer samples that were infectious in cell culture (electrical impedance assay)
- Less flu like illnesses

21

Acknowledgements

InSciEd Out team
- **Jennifer Reiman, PhD**
- Chris Pierret, PhD
- Stephen Ekker, PhD
- Biswadeep Das, PhD
- Mark Urban
- Greg Sindberg, PhD
- Jamie Lyman-Gingerich, PhD
- Maddy Hammerlund
- U of MN- Rochester work study students
- Han Lee, PhD
- Tyler Koep, PhD

- DriSteem*: Phil Lilja

- NIOSH

Mayo Colleagues
- Hind Fadel, MD, PhD
- Katie Spring
- Charlie Huskins, MD
- Bob Diasio Lab

Aldrich
- Kevin Ewing
- Students, parents and staff

Funding
- Clinical and Translational Sciences Award (NIH)
- Department of Pediatric and Adolescent Medicine
- Infectious Diseases small grant program

*commercial brand (potential COI)

22

References

1. Molinari NA, Ortega-Sanchez IR, Messonnier ML, Thompson WW, Wortley PM, Weintraub E, Bridges CB. 2007. The annual impact of seasonal influenza in the US: measuring disease burden and costs. Vaccine 25:5086-5096.
2. Henderson T, Hill C, Norton K. 2014. The Connection Between Missing School and Health: A Review of Chronic Absenteeism.
3. Longini IM, Koopman JS, Monto AS, Fox JP. 1982. Estimating Household and Community Transmission Parameters for Influenza. American Journal of Epidemiology 115:736-751.
4. Shaman J, Kohn M: Absolute humidity modulates influenza survival, transmission, and seasonality. Proc Natl Acad Sci USA 2009, 106(9):3243–3248.
5. Lowen AC, Mubareka S, Steel J, Palese P (2007) Influenza virus transmission is dependent on relative humidity and temperature. PLoS Pathog 3:1470–1476.
6. Thomas Y, Vogel G, Wunderli W, et al. Survival of influenza virus on banknotes. *Appl Environ Microbiol*. 2008;74(10):3002-7.
7. Shaman J, Pitzer VE, et al: Absolute humidity and the seasonal onset of influenza in the continental United States. PLoS Biol 2010, 8(2):e1000316.
8. Morgan H McCoy, Eugenia Wang. Use of electric cell-substrate impedance sensing as a tool for quantifying cytopathic effect in influenza A virus infected MDCK cells in real-time. J Virol Methods. 2005. 130 (1-2):157-61.

23

Questions?

Generous.alex@mayo.edu

24