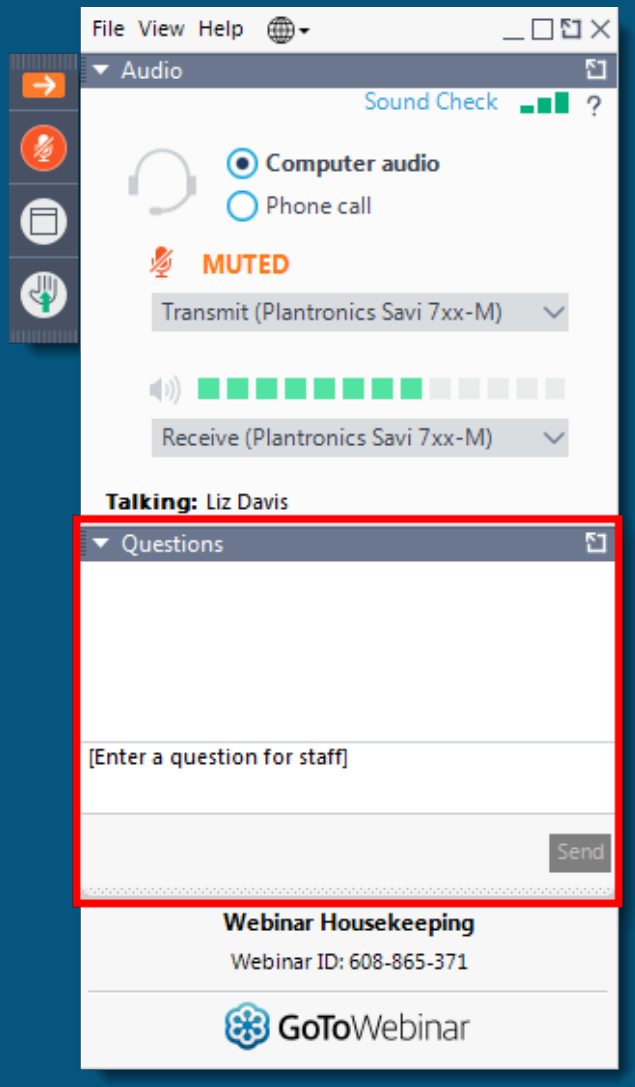
How to sustain indoor air quality and keep schools open

June 24, 2021

Housekeeping



At the end of the presentation, we will have a **Question and Answer** segment where we will try our best to answer all of your questions.

Please type your questions into the **Questions tab** of your Go To Webinar dashboard.

This is located on the **side of your screen**.

If you don't see the Webinar dashboard, it may be collapsed. Look for an **orange arrow** in the top right corner of your screen, click on that arrow and it will expand the dashboard.

2021 Improved Air Initiative

How to Sustain Indoor Air Quality (IAQ) and Keep Schools Open

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What We Will Cover Today

- What do we know about SARS COV-2 and its spread
- Science and Medical Management research
- **Indoor Air Quality (IAQ)** and its importance
- How to Improve Indoor Air Quality (IAQ)
- Critical tools and techniques
- Building readiness / HVAC strategy
- Ongoing monitoring
- Outcomes / Call to Action

R. Scott Altman, MD, MPH, MBA

- Emergency Physician, Retired, Level I Trauma/Stroke Center
- Current Hospital-based COVID Strike Team Lead
- Active International Medical Management Consultant (>20 countries)
- Former Faculty, Johns Hopkins and Northwestern
- Experience as Hospital CMO, Multispecialty Medical Practice VPMA, ED Medical Director

LifeWings PEAK PERFORMANCE

Mark H. Weir, EIT Ph.D.

THE OHIO STATE UNIVERSITY
COLLEGE OF PUBLIC HEALTH

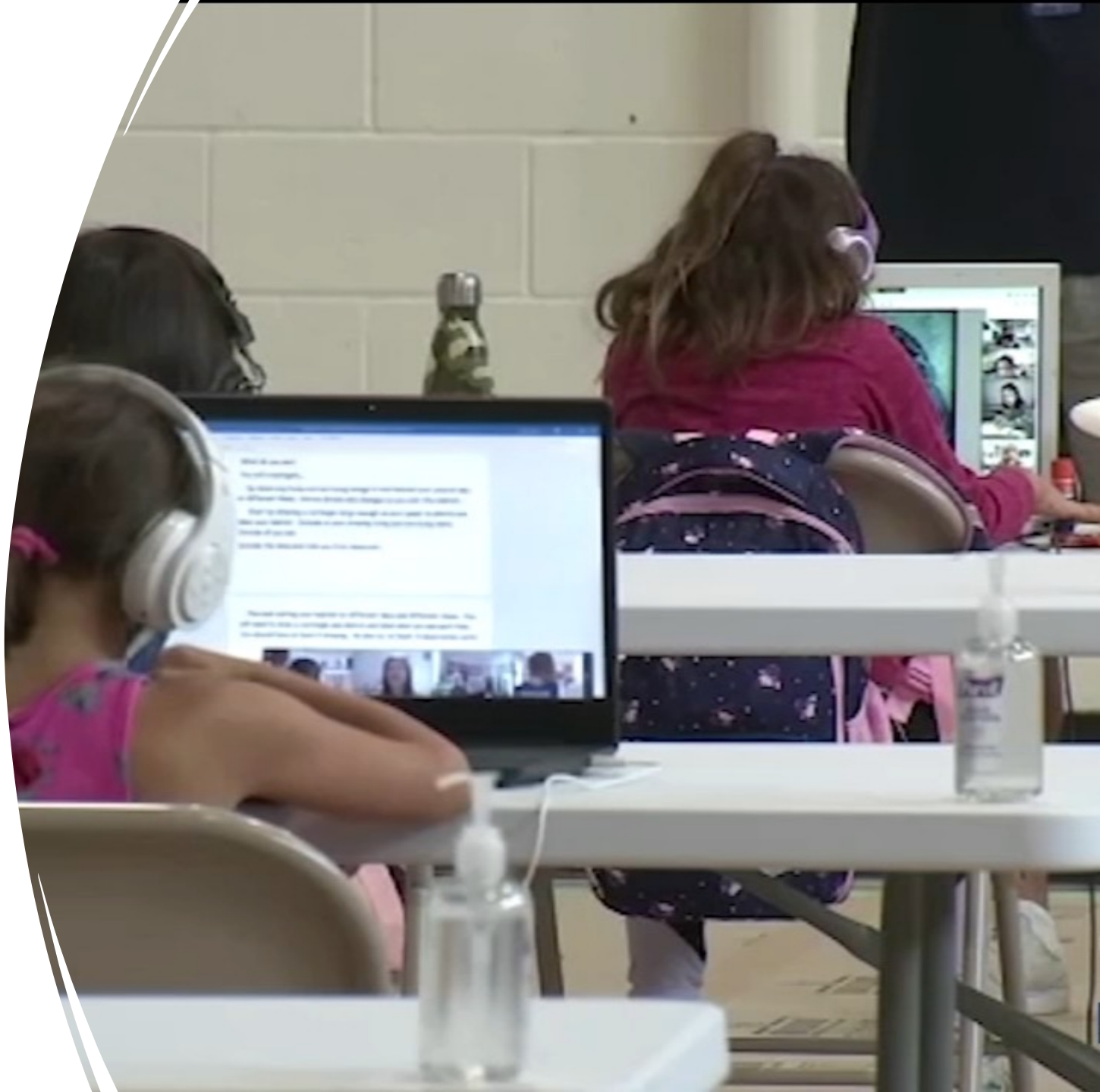
- 60 + Publications & Conf presentations re; Air/Water Quality and Risk
- International Public Health Risk Analysis Consortium (PHRAC)
  - Surface sampling and modeling initiation project
  - Development of Quantitative Microbial Risk Analysis (QMRA) best practices guidelines
- Healthcare Infection Transmission Systems (HITS)
  - First conference 2017 - 150 attendees, over 3 days
  - Establishment of working groups in 2017
- Quantitative Microbial Risk Assessment (QMRA) Wikki
  - Completion of microbial dose-response data and model compendium
  - Establishment of QMRA research and learning apps and tools

Randy Christenson, PE

- Over 25 years mechanical engineering experience
- Registered as PE in all 50 states
- Director of Commercial Engineering
- Led research and testing of air quality improvements

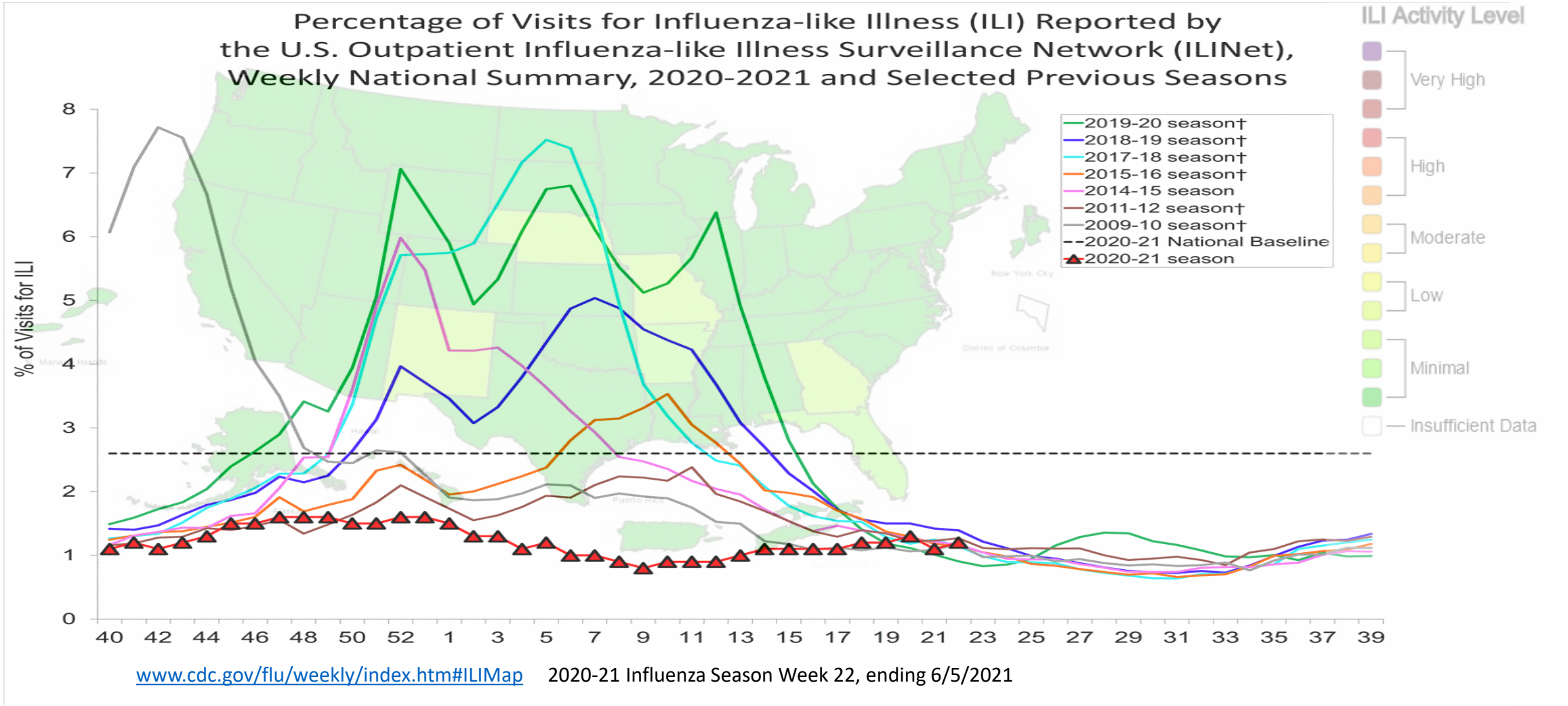
Airborne Respiratory Viruses

- Respiratory Illnesses Overall
- SARS-CoV-2
- Droplets, Aerosols, & Surfaces
- Distancing, Masking, and Hand-washing
- What are we missing?



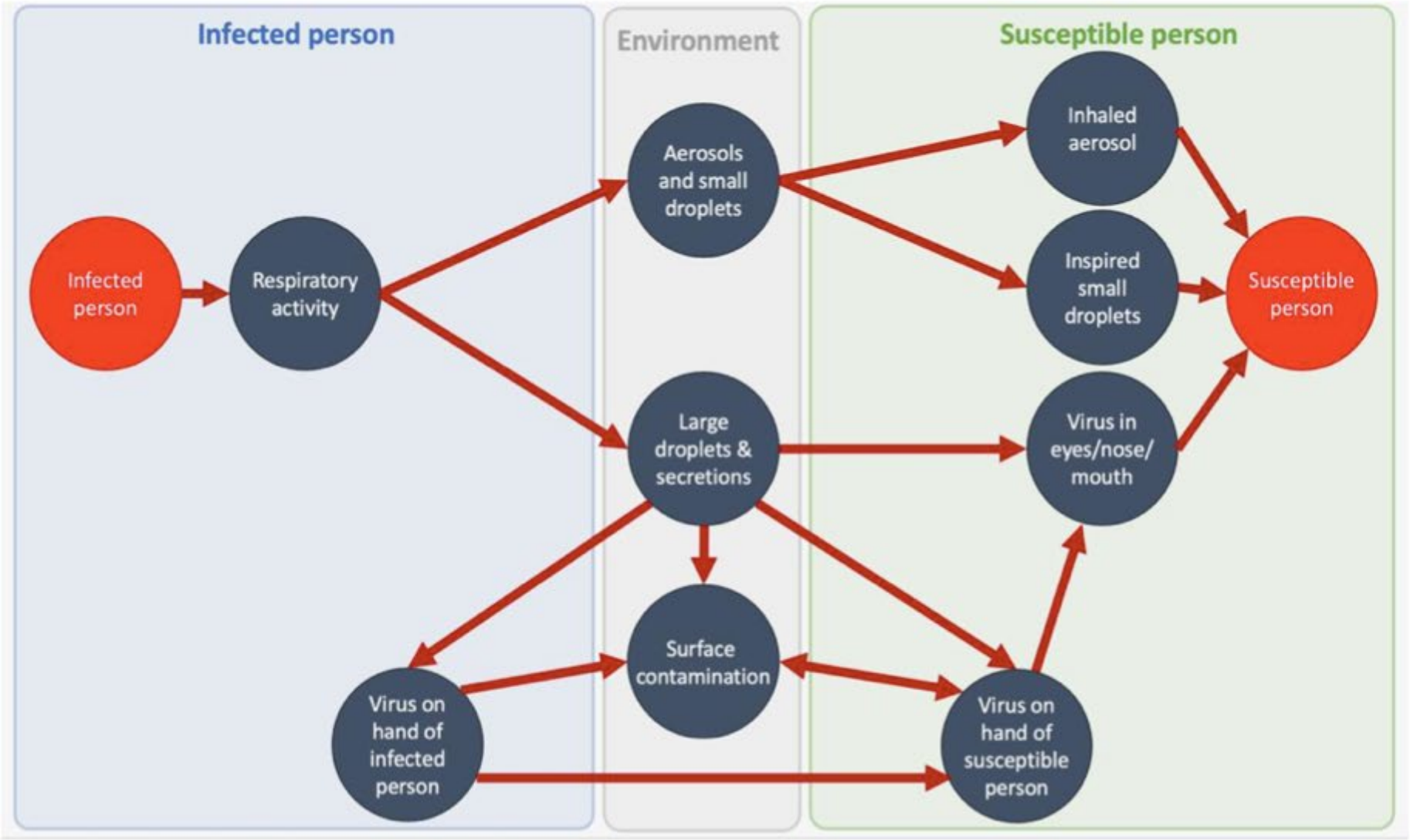
COVID is not “just another flu”
Neither will be the next pandemic

The common “cold” is usually (>50%) a rhinovirus - but it could be influenza (flu), parainfluenza, adenovirus, respiratory syncytial virus (RSV), or one of the other four coronaviruses that commonly infect humans.



www.cdc.gov/flu/weekly/index.htm#ILIMap 2020-21 Influenza Season Week 22, ending 6/5/2021

SARS-CoV-2 Transmission Routes



Airborne – via aerosols (>2m) in a shared room

Close range –via aerosols and droplets (<2m)

Surfaces - via contaminated hands

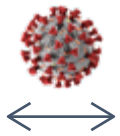
Building Engineering Service Association Webinar; **Role of Ventilation in Controlling SARS- CoV-2 Transmission** - Professor Cath Noakes, CEng, FIMechE, FIHEEM School of Civil Engineering, University of Leeds C.J.Noakes@leeds.ac.uk https://www.thebesa.com/media/1409295/covid-19-webinar-2-february.pdf

Size of Droplet/Aerosol is Critical

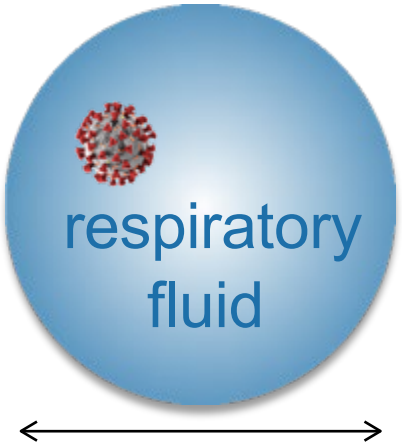
Rhinovirus (~0.16 micron), influenza (flu) (~0.1), parainfluenza, adenovirus (~0.1), respiratory syncytial virus (RSV) (~0.15), or coronaviruses (~0.12).

1. Airborne virus is not naked

2. Size of carrier droplet/aerosol defines transport



0.12 microns (µm)



3.SARS-CoV-2 vs. measles vs. other viruses:

(1) Viral load in different size droplets/aerosols,

(2) Inactivation rate in droplets/aerosols,

(3) location/dose to initiate infection

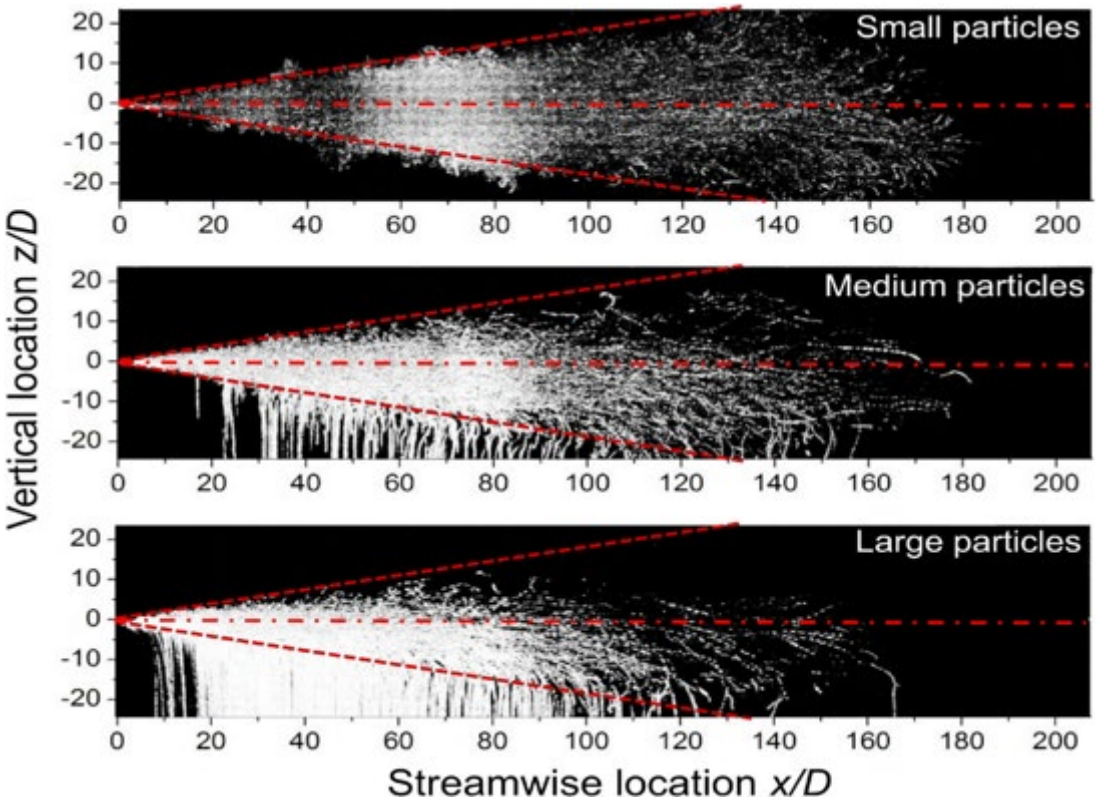
- How long it stays aloft
- How far it can travel
- How quickly it falls to surfaces
- Where it deposits in the respiratory system
- How efficiently it is removed by masks and filters
- Physics is the same for all viruses

Aerosols are Generated When We Speak, Cough or Sneeze

Human Cough as a Two-Stage Jet and Its Role in Particle Transport, Jianjian Wei , Yuguo LiPublished: January 3, 2017 https://doi.org/10.1371/journal.pone.0169235

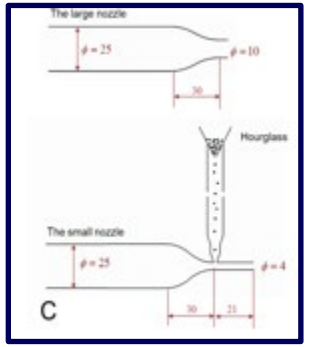
- "The travel distance of the cough airflow, taken with the dispersion characteristics of expired droplets, are of particular interest. Such information is essential for taking appropriate action to reduce or eliminate the probability of infection in both community and health care environments."

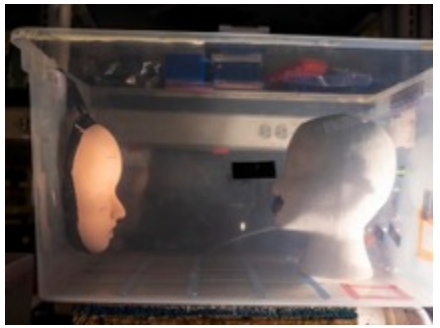
- A cough or sneeze does not result in a uniform ejection flow or size. There is **one peak** of the droplet number concentration **in the sub-micron range and another peak at over 10 microns**.



Experiment Using Glass Beads

Small (30–50 micron), Medium (210–250), Large (355–420)
(Remember: Viral particles are ~0.1 to 0.2 micron. The spray from a cough is > 5 micron.)





“It Is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19)”

Lidia Morawska, Donald K Milton

Clin Infect Dis, Volume 71, Issue 9, 1 November 2020, Pages 2311–2313, https://doi.org/10.1093/cid/ciaa939

- Received 6/20/20. Cosigned by 239 fellow scientists.
- “Studies by the signatories and other scientists have demonstrated beyond any reasonable doubt that viruses are released during exhalation, talking, and coughing in microdroplets **small enough** to remain aloft in air and pose a risk of exposure at distances beyond 1–2 m from an infected individual.”
- “Several retrospective studies conducted after the severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1) epidemic demonstrated that airborne transmission was the most likely mechanism explaining the spatial pattern of infections.”
- “We appeal to the medical community and to the relevant national and international bodies to recognize the potential for airborne spread of coronavirus disease 2019 (COVID-19).”

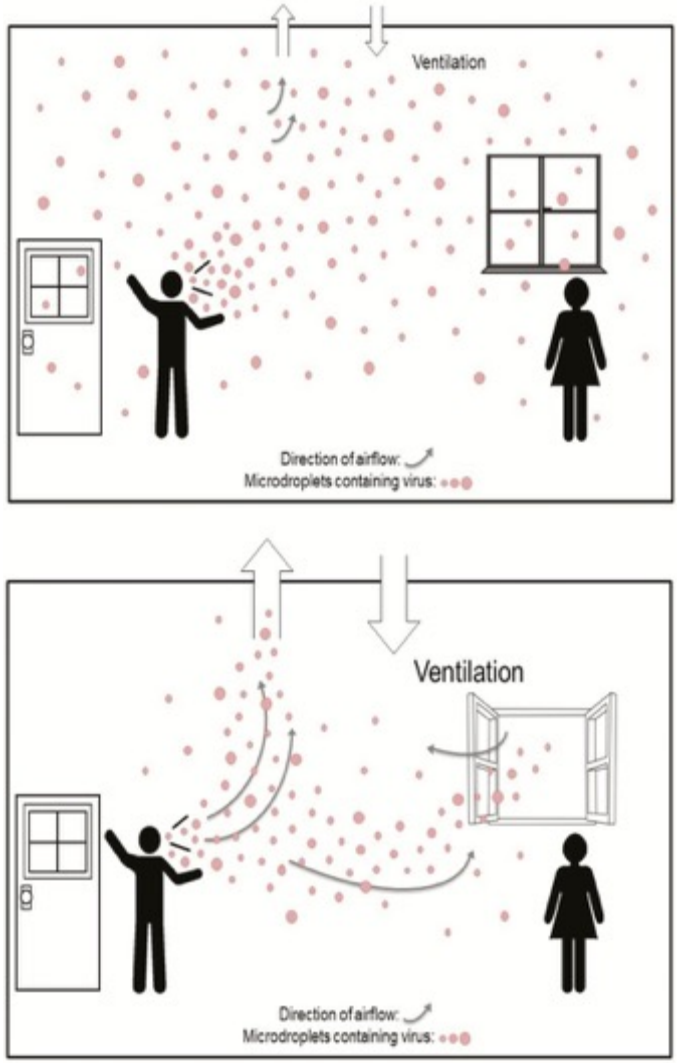


Figure 1. Distribution of respiratory microdroplets in an indoor environment with (A) inadequate ventilation and (B) adequate ventilation

OXFORD
UNIVERSITY PRESS

“The 60-Year-Old Scientific Screwup That Helped Covid Kill”

Megan Molteni – Wired Magazine

All pandemic long, scientists brawled over how the virus spreads. Droplets! No, aerosols! At the heart of the fight was a teensy error with huge consequences.

www.wired.com/story/the-teeny-tiny-scientific-screwup-that-helped-covid-kill/

- “The distinction between droplet and airborne transmission has enormous consequences. To combat droplets, a leading precaution is to wash hands frequently with soap and water. To fight infectious aerosols, the air itself is the enemy. In hospitals, that means expensive isolation wards and N95 masks for all medical staff.”
- “The WHO and the US Centers for Disease Control and Prevention also listed 5 microns as the fulcrum on which the droplet-aerosol dichotomy toggled.”
- “There was just one literally tiny problem: ‘The physics of it is all wrong.’”
- “On Friday, April 30, the WHO quietly updated a page on its website.”
- “In early May, the CDC made similar changes to its Covid-19 guidance, now placing inhalation of aerosols at the top of its list of how the disease spreads.”

Linsey Marr stands in front of a smog chamber in her laboratory at Virginia Tech. For years, she says, the medical establishment treated her as an outsider.

Photograph: Matt Eich

CDC

www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

- *"It is possible that a person could get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or eyes. Spread from touching surfaces is not thought to be a common way that COVID-19 spreads."*

- *"Infections occur mainly through exposure to respiratory droplets when a person is in close contact with someone who has COVID-19."*

- *"Some infections can be spread by exposure to virus in small droplets and particles that can linger in the air for minutes to hours. These viruses may be able to infect people who are further than 6 feet away from the person who is infected or after that person has left the space. This kind of spread is referred to as airborne transmission and is an important way that infections like tuberculosis, measles, and chicken pox are spread."*

WHO

www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-how-is-it-transmitted

- *Current evidence suggests that the main way the virus spreads is by respiratory droplets among people who are in close contact with each other.*

- *Aerosol transmission can occur in specific settings, particularly in indoor, crowded and **inadequately ventilated spaces**, where infected person(s) spend long periods of time with others, such as restaurants, choir practices, nursing homes, rehab centers, fitness classes, nightclubs, offices and/or places of worship.*

Added Bonus of Improved Indoor Air Quality (AIQ) => Improved Cognitive Function

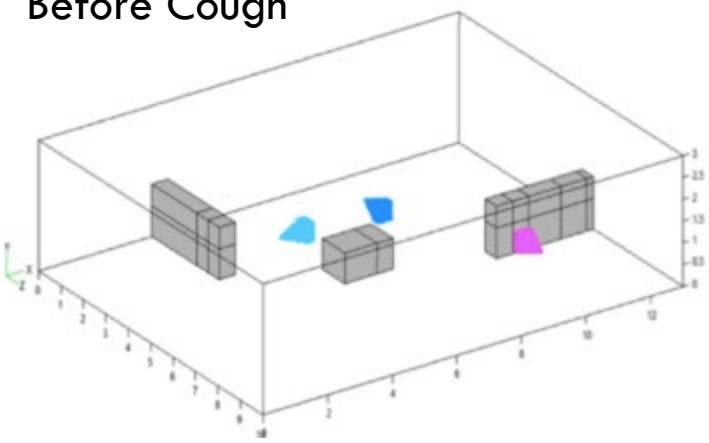
- Numerous studies - Offices and Schools
- Increased Attentiveness, Effectiveness, Productivity
- Improved Test Scores
- Landmark Harvard School of Public Health study

Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments Joseph G. Allen, Piers MacNaughton, Usha Satish, Suresh Santanam, Published:1 June 2016

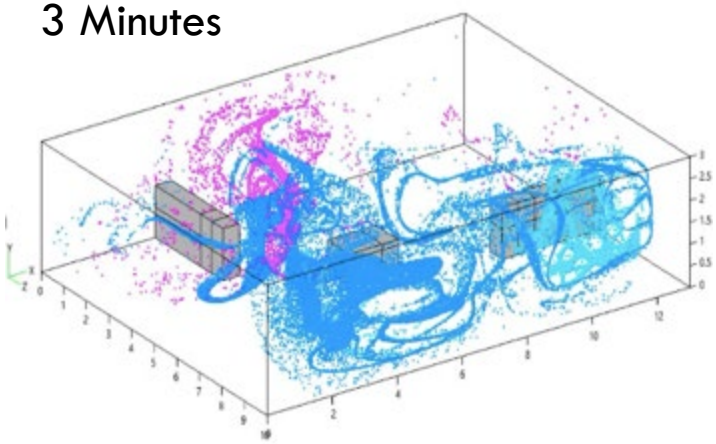
Shift from "Building Performance to Person Health"

Aerosols Are Not all Filled With Virus

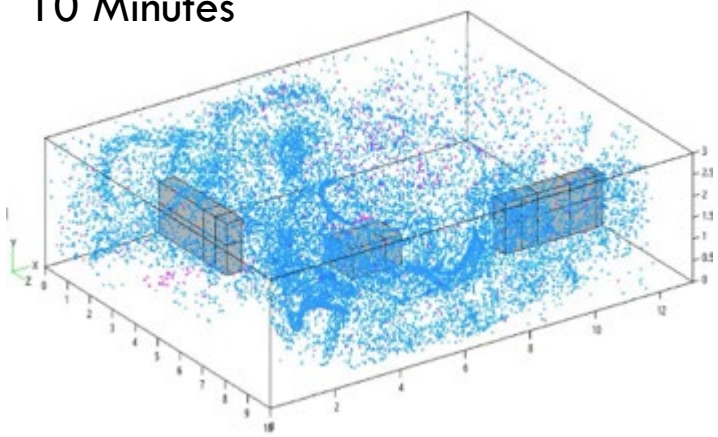
Before Cough



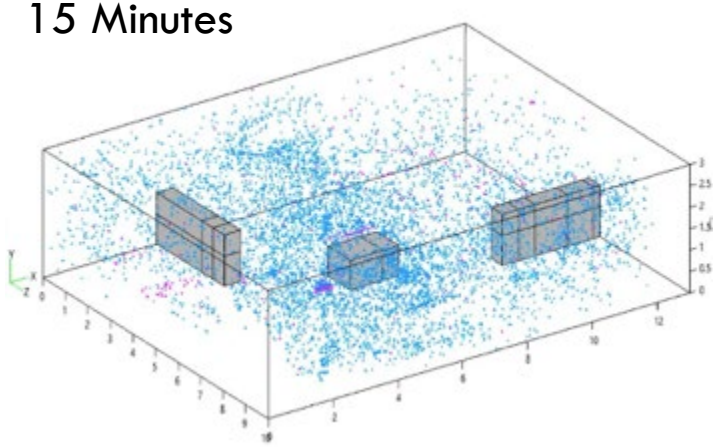
3 Minutes



10 Minutes



15 Minutes

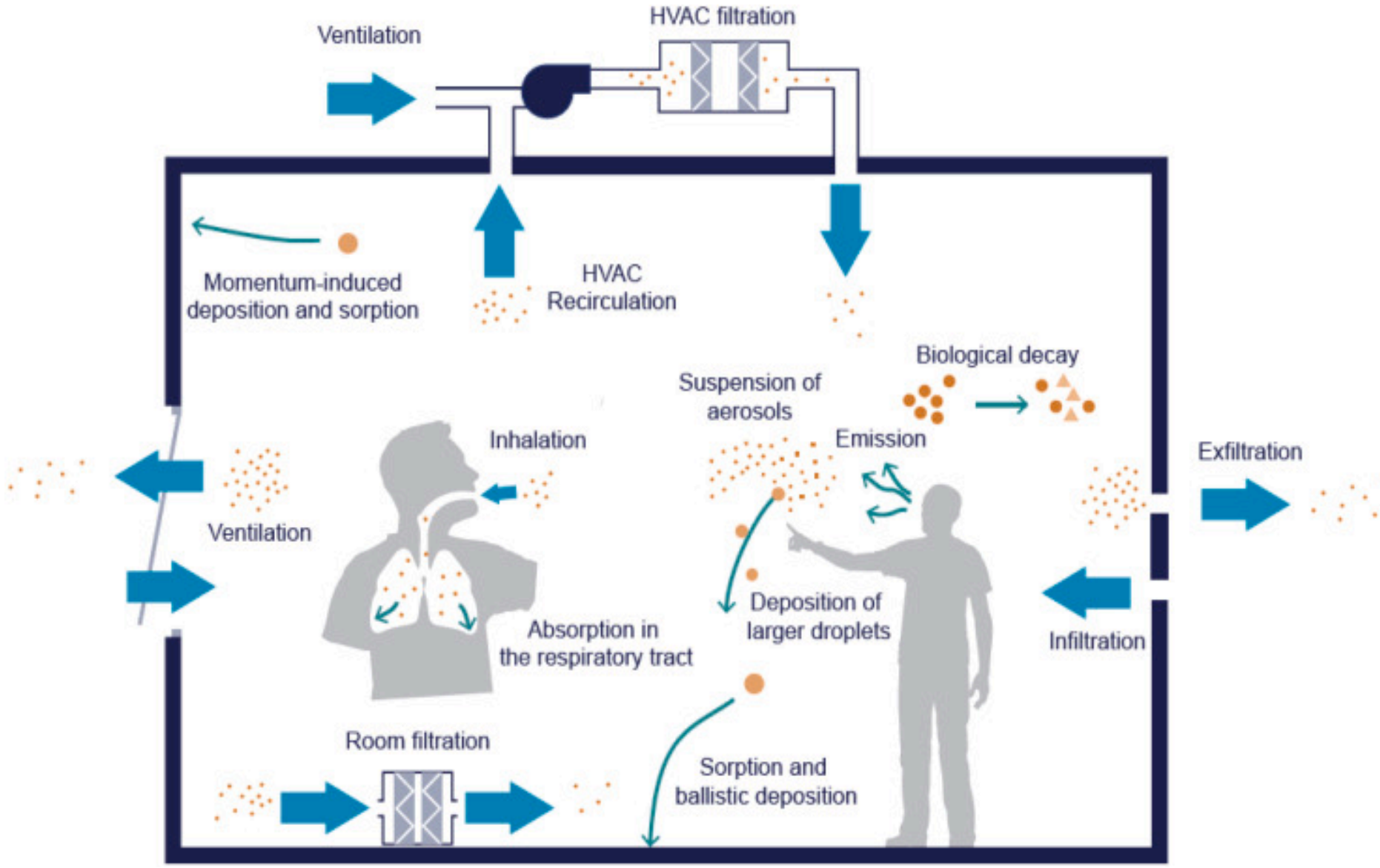


Modelling aerosol transport and virus exposure with numerical simulations in relation to SARS-CoV-2 transmission by inhalation indoors, VilleVuorinen, MiaAarnio, MikkoAlava, VilleAlopaeus, et al. , https://www.sciencedirect.com/science/article/pii/S0925753520302630

Aerosols do spread far, but not all aerosols are viruses. The dots you see shows aerosols not viruses. They move around us all the time without us knowing and we have means of controlling them

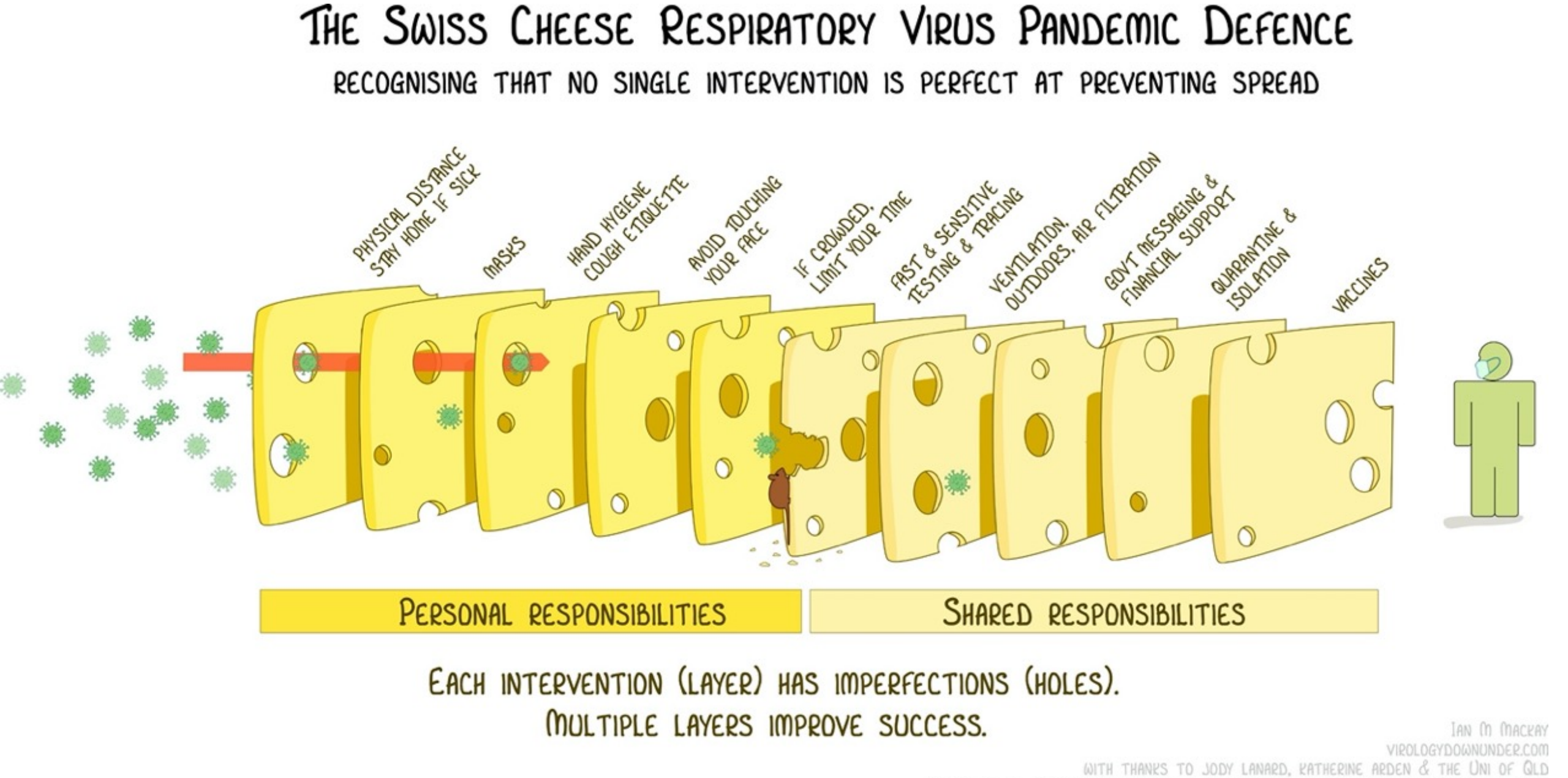
Modeling Aerosol Exposure

- Mass balance models estimate concentration in air with ventilation rate for given emission
- Exposure from inhalation rate and time
- Simple spaces assume fully mixed flow
- Reasonable estimate
- >2m from source
- Can include filtration, deposition, air cleaners



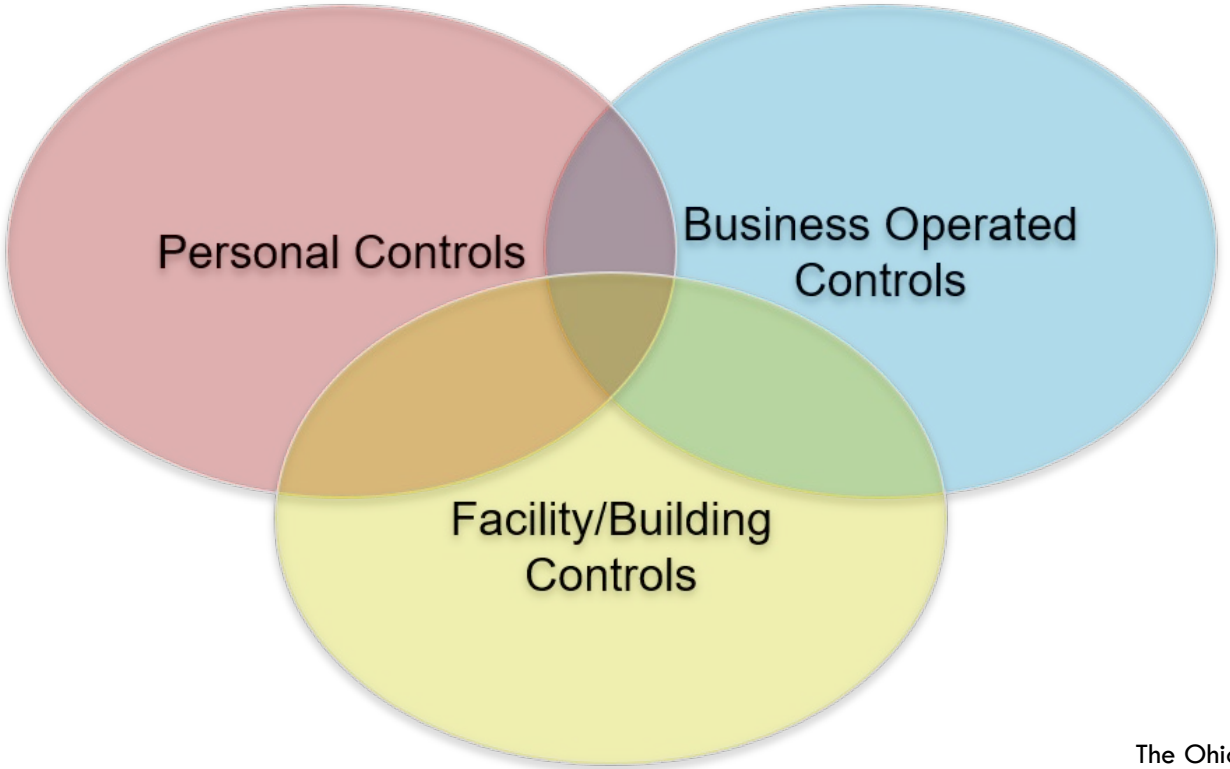
Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission in well mixed indoor air
Benjamin Jones 1, Patrick Sharpe 1, Christopher Iddon 2, E Abigail Hathway 3, Catherine J Noakes 4, Shaun Fitzgerald 5 https://pubmed.ncbi.nlm.nih.gov/33495667/

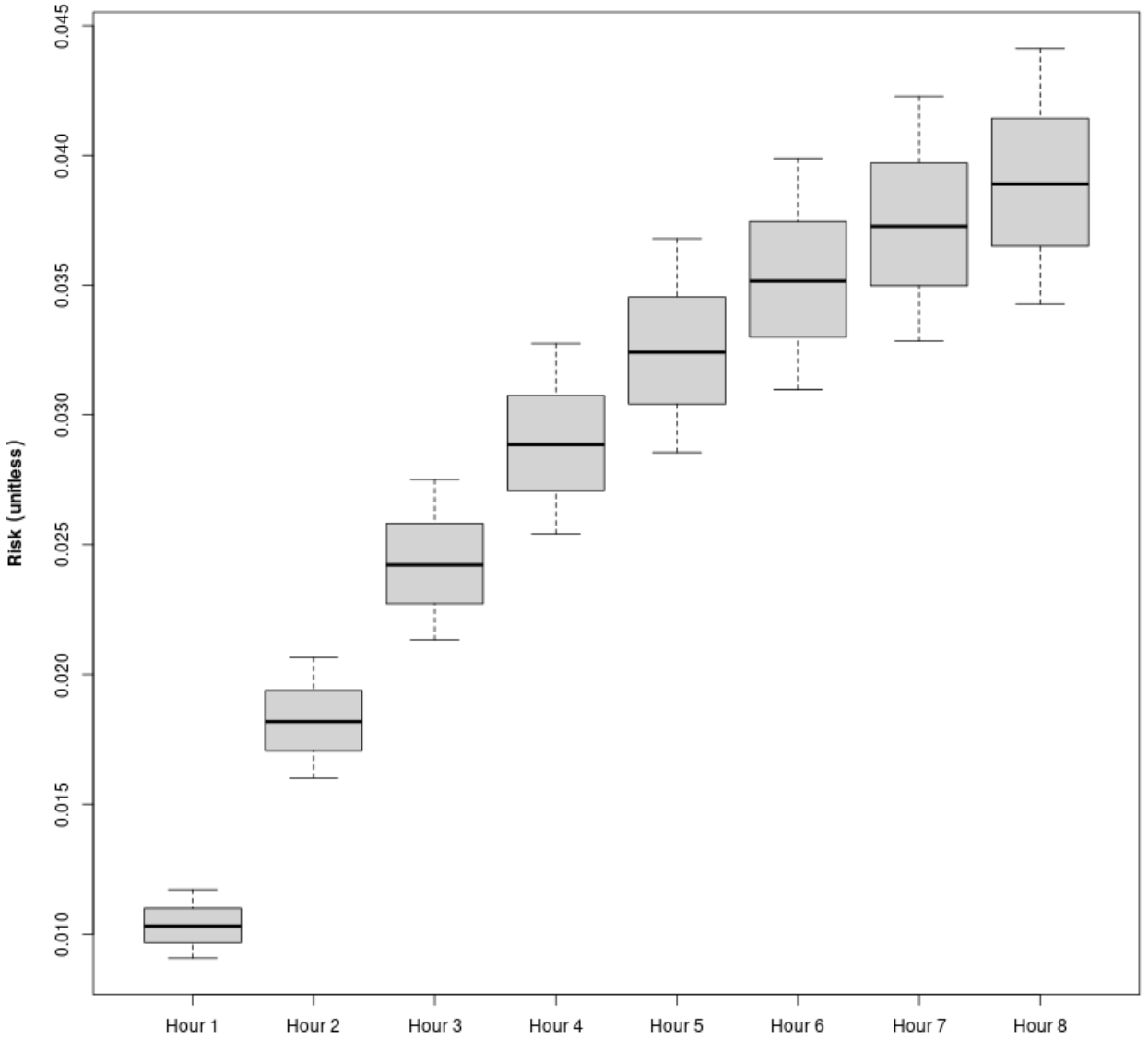
Layered/Multiple Barrier Strategy of Prevention: Not one action sufficient



Model the Environment – Support the Decisions

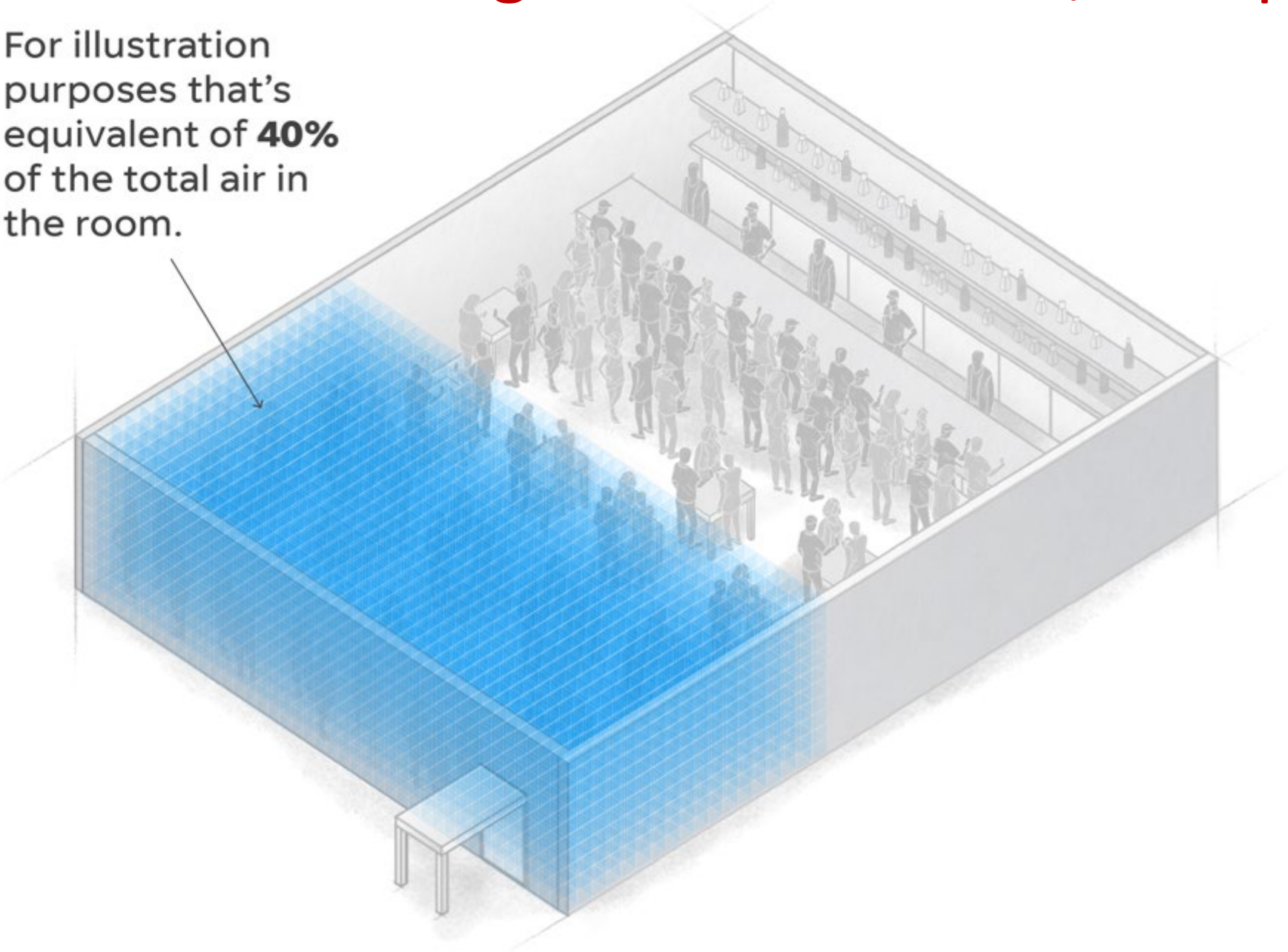
- A model is a faithful representation of the real world
- Allows us to consider “what ifs”
- Supports and gives decision options





The Ohio State University School of Public Health air sampling study, Mark Weir PhD. Et, al, , May 2021

Large Common areas, Hotspots



https://www.usatoday.com/in-depth/graphics/2020/07/16/why-bars-hotspots-covid-19-transmission/5389988002/ and **Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1**, April 16, 2020, N Engl J Med 2020; 382:1564-1567, Neeltje van Doremalen, Ph.D., Trenton Bushmaker, B.Sc., Dylan H. Morris, M.Phil.

COVID HVAC and Mechanical, Electrical (MEP) Plumbing Solutions

"Proceed with Caution"

Indoor Air Quality (IAQ) Standard Measures; Reduce Volatile Organic Compounds (VOC), Formaldehyde, CO, CO2, Humidity, overall particulates

In a crisis, you often make quick and/or tough decisions. Being responsible means knowing all the options.

- Establish what you need. Don't make random equipment changes
- More research on the virus - COVID 19 behaves in ways that we have not seen with other viruses
- Some solutions less effective, harmful to building/occupants
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and American Society of Healthcare Engineers (ASHE) – multiple studies underway – ***including Design, Airflow, Filtration, Installation, Maintenance*** as essential elements

Projecting the transmission dynamics of SARS-CoV-2 through the post-pandemic period,, 1† 2† 2 1 Stephen M. Kissler , Christine Tedijanto , Edward M. Goldstein , Yonatan H. Grad , Marc Lipsitch*2 https://www.medrxiv.org/ content/10.1101/2020.03.

Defining the Epidemiology of Covid-19 — Studies Needed, Defining the Epidemiology of Covid-19 — Studies Needed, Marc Lipsitch, D.Phil., ,David L. Swerdlow, M.D., and Lyn Finelli, Dr.P.H, https://www.nejm.org/doi/full/1 0.1056/NEJMp2002125?query=recirc_top_ribbon_article_1

Sources; Clearstream, EPA, Daniel Loverby, Financial Times, News Medical, Science Direct, Susan Sokolowski, Petroclear, US Dept of Energy

- The COVID particle is very small
- The virus attaches itself to water droplets or aerosols – 1 micron range

Types of HVAC Systems

- Steam or Hot Water radiation
- Overhead or underfloor distribution
- Displacement ventilation
- Demand controlled ventilation
- Heat or Energy Recovery systems

Possible Ventilation Issues

- Total airflow in the space
- Airflow in the breathing zone
- Amount of outside air
- Filtration level
- Contaminants in the air - CO2, Particulates, Total Volatile Organic Compounds (TVOC)

Building Readiness Plan
HVAC System Evaluation

HVAC strategies

- Air handling systems and HVAC zone plans
    - Create negative pressure or isolation areas
- Ventilation Management matrix
- Recommendation for improvement & costs related to changes/upgrades
    - Increased Ventilation
    - Increased Filtration
    - Air Cleaning Technology

Methods To Improve IAQ

- Existing and new, innovative technology can improve air quality
- Approaches vary for every building based on several factors such as;
  - Building use
  - HVAC system type, Age
  - Airflow distribution
  - Occupant density and activity

FILTERS – MERV Rating Table

MERV Rating	Air Filter will trap Air Particles size .3 to 1.0 microns	Air Filter will trap Air Particles size 1.0 to 3.0 microns	Air Filter will trap Air Particles size 3 to 10 microns	Filter Type ~ Removes These Particles
MERV 1	< 20%	< 20%	< 20%	Fiberglass & Aluminum Mesh ~ Pollen, Dust Mites, Spray Paint, Carpet Fibres
MERV 2	< 20%	< 20%	< 20%	
MERV 3	< 20%	< 20%	< 20%	
MERV 4	< 20%	< 20%	< 20%	
MERV 5	< 20%	< 20%	20% - 34%	Cheap Disposable Filters ~ Mold Spores, Cooking Dusts, Hair Spray, Furniture Polish
MERV 6	< 20%	< 20%	35% - 49%	
MERV 7	< 20%	< 20%	50% - 69%	
MERV 8	< 20%	< 20%	70% - 85%	
MERV 9	< 20%	Less than 50%	85% or Better	Better Home Box Filters ~ Lead Dust, Flour, Auto Fumes,Welding Fumes
MERV10	< 20%	50% to 64%	85% or Better	
MERV 11	< 20%	65% - 79%	85% or Better	
MERV 12	< 20%	80% - 90%	90% or Better	
MERV 13	Less than 75%	90% or Better	90% or Better	Superior Commercial Filters ~ Bacteria, Smoke, Sneezes
MERV 14	75% - 84%	90% or Better	90% or Better	
MERV 15	85% - 94%	95% or Better	90% or Better	
MERV 16	95% or Better	95% or Better	90% or Better	
MERV 17	99.97%	99% or Better	99% or Better	HEPA & ULPA ~ Viruses, Carbon Dust, <.30 pm
MERV 18	99.997%	99% or Better	99% or Better	
MERV 19	99.9997%	99% or Better	99% or Better	
MERV 20	99.99997%	99% or Better	99% or Better	

Illustration Provided by LakeAir / www.lakeair.com

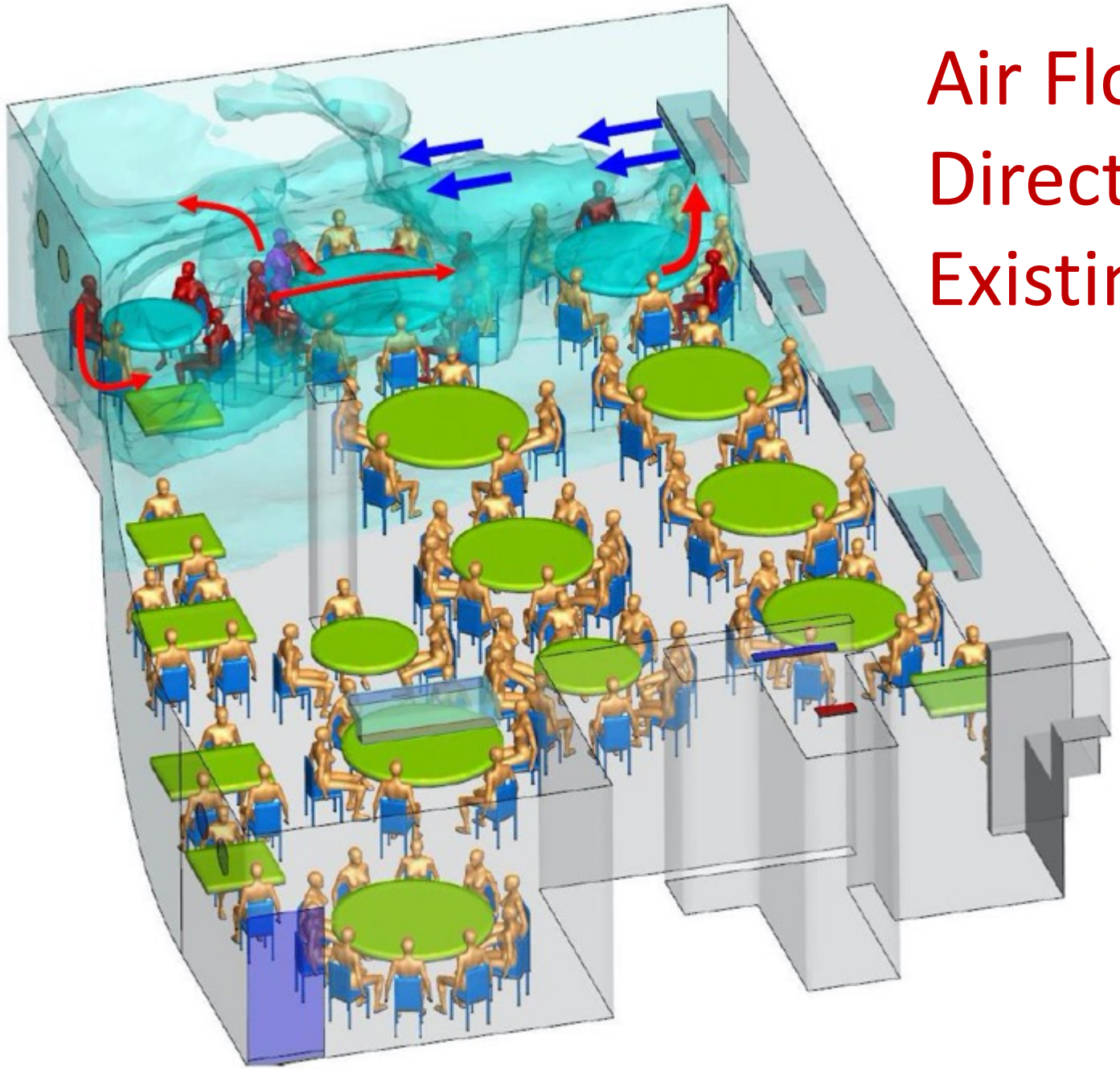
KFI Office Study

Implemented and Tested our research in our office

- Used Sidestream High Efficiency Particulate Air Filter (HEPA) Filtering
- Needlepoint Bi-polar Ionization
- UV technologies
- Baseline for ozone, TVOC's, Ion and particle counts

What We Have Learned

- Do your research - Understand the difference between myth and facts
    - Not all new technology has been tested
    - Not all equipment is the same
- Understand the life cycle cost of each system – installation, operation, and maintenance
- There is not one magic fix
- Hire experienced firm to perform testing, assessments, and training

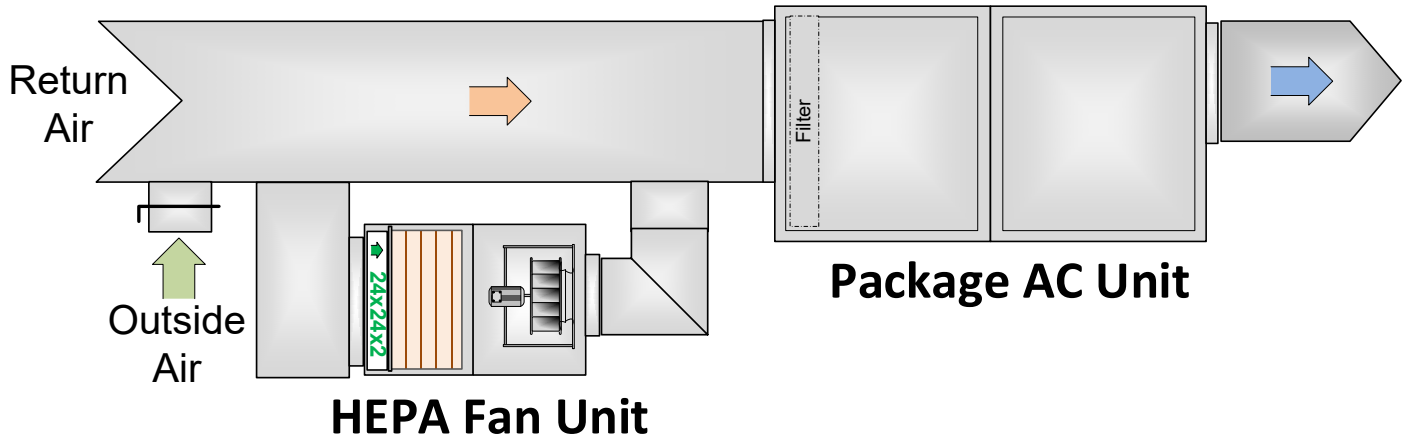


Air Flow Distribution & Direction and Infection Risk of Existing Spaces

Design for Protection in New Spaces

DESIGN for FILTRATION

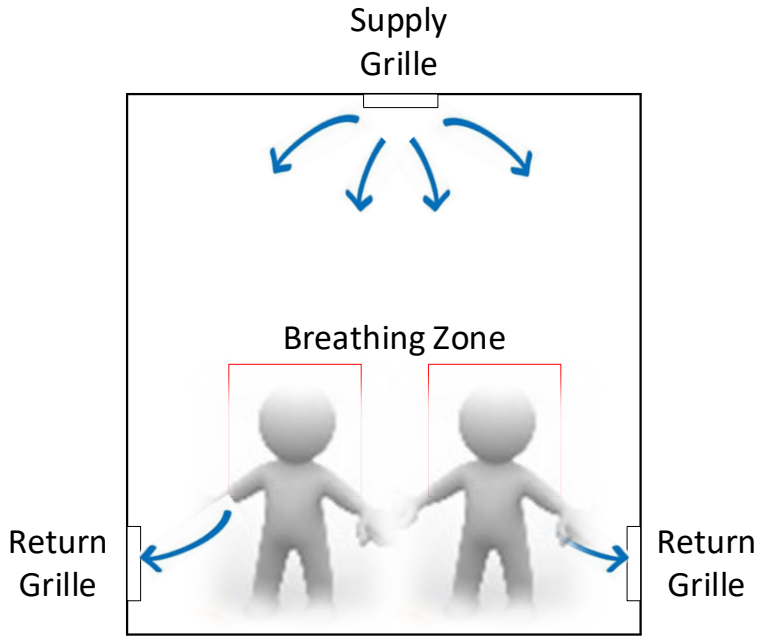
a. All Air Handling Units (AHU) and Air Conditioning (AC) unit designed for MERV 13-15 filters
   i. Design unit pressure for filter at 300 feet-per-minute (FPM) maximum velocity
b. All outside air intakes should be designed with pre-filters MERV 5-8 to extend the life of the final filter from dust storms
   i. Design Outside Air (OSA) filters for easy changeout since they will be changed more often
c. For package units that cannot provide adequate pressure for MERV 13 filters utilize a HEPA side stream filter system
   i. KFI used 20% side stream capacity units that removed 65% of particles above 3 microns



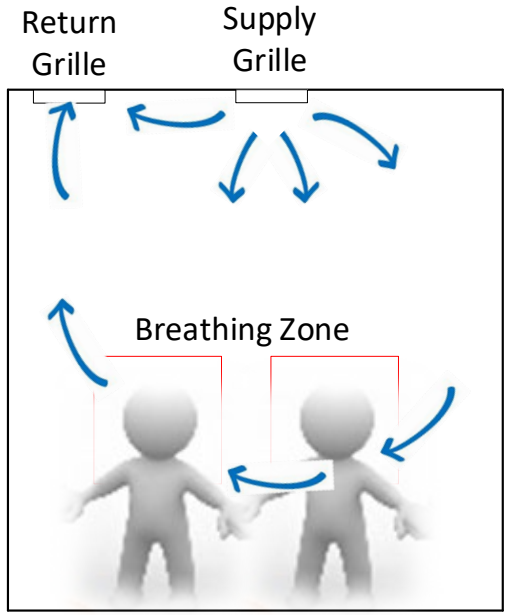
Design for Protection in New Buildings

Design for Air Direction of Flow

a. Air Distribution and Direction of flow become important



Good Air Distribution



Normal Air Distribution

Air Monitoring and Types

Types of Monitoring available and under review

- Continuous, real time – Local and cloud based using Internet-of-Things (IOT)
- Intermittent, periodic handheld
- What to measure and monitor ?
    - ✓ CO, CO2, VOC, Temp-humidity, Ionization and more
- Challenges with accuracy and calibration to consider

Safer, Improved Air Outcomes and ROI

Air Quality Studies have shown:

- 10%-20% REDUCTION in Student/Teacher Absences
- 10%-30% REDUCTION in Substitute Teacher costs
- LOWER Medical and Health insurance claims
- 3-6% IMPROVEMENT in academic achievement scores and results
- LOWER Workers compensation claims/costs

Studies available upon request: rdoss@lifewingspp.com

Call to Action: What should I do now?

Part 1: Clinical and Human Factors assessment of your facility's policies, procedures, and protocols. Determine necessary procedures for facility "Defense in Depth."

1.Determine Hardwired Safety Tools (HST) required to meet identified deficiencies, highest areas of risk

2.Needed equipment briefings, Indoor Air Quality (IAQ) monitoring checklists, emergency response & safety protocols

Expertise required - Experience developing human factors-based standard work such as checklists, procedures, protocols, and algorithms for high-reliability industries and healthcare

Skillset required - Human factors expert, Physician, or Medical Director

Call to Action: What should I do now?

Part 1: Clinical and Human Factors assessment continued ……

3. Review maintenance and facilities team skills, build versatility matrix

Expertise required – Experience developing maintenance skills training, On-the-job training, and Total Productive Maintenance (TPM) for trades

Skillset required - Process and system monitoring; standard operations and identification of upset conditions for different HVAC/mechanical systems.

4. Determine scripting and coaching tools needed to hold teams accountable to daily/weekly/monthly routines (for Standards & Condition Monitoring)

Expertise required - Experience developing and delivering change management, leadership development, Crew training, and Team-based decision making

Skillset required - Maintenance systems leadership practices for routines, procedures, and frequencies to monitor and evaluate HVAC systems, identifying upset conditions

Call to Action: What should I do now?

Part 2: Engineering Assessment of your facilities building systems characteristics for filtration, outside airflow, air-cleaning devices, room airflow and distribution patterns

1. Reviewing critical exhaust systems and outside air flows of all air handling units

2. Creating a ventilation management matrix in compliance with ASHRAE 62.1

3. Review of all existing testing and balance reports (TAB)

Expertise required - NEBB Certified Commissioning engineer (certified with high performing building systems) or Licensed Mechanical Engineer

Skillset required - Experience with analysis, design, and implementation of different types of HVAC systems over the years

4. Conduct ambient air testing for VOC, particulate, formaldehyde, ozone

Expertise required - - Commissioning agents and mechanical engineers, various Air Quality tools for testing

Skillset required - Experience with different types of air monitoring and testing systems, including extensive history with calibration and balancing of air handling systems

Call to Action: What should I do now?

Part 2: 3rd party Engineering Assessment of your facilities continued…….

5. Evaluation of all activities for compliance with ASHRAE 170

6. Develop Air Handling Unit (AHU) zone plans indicating new outside airflow values

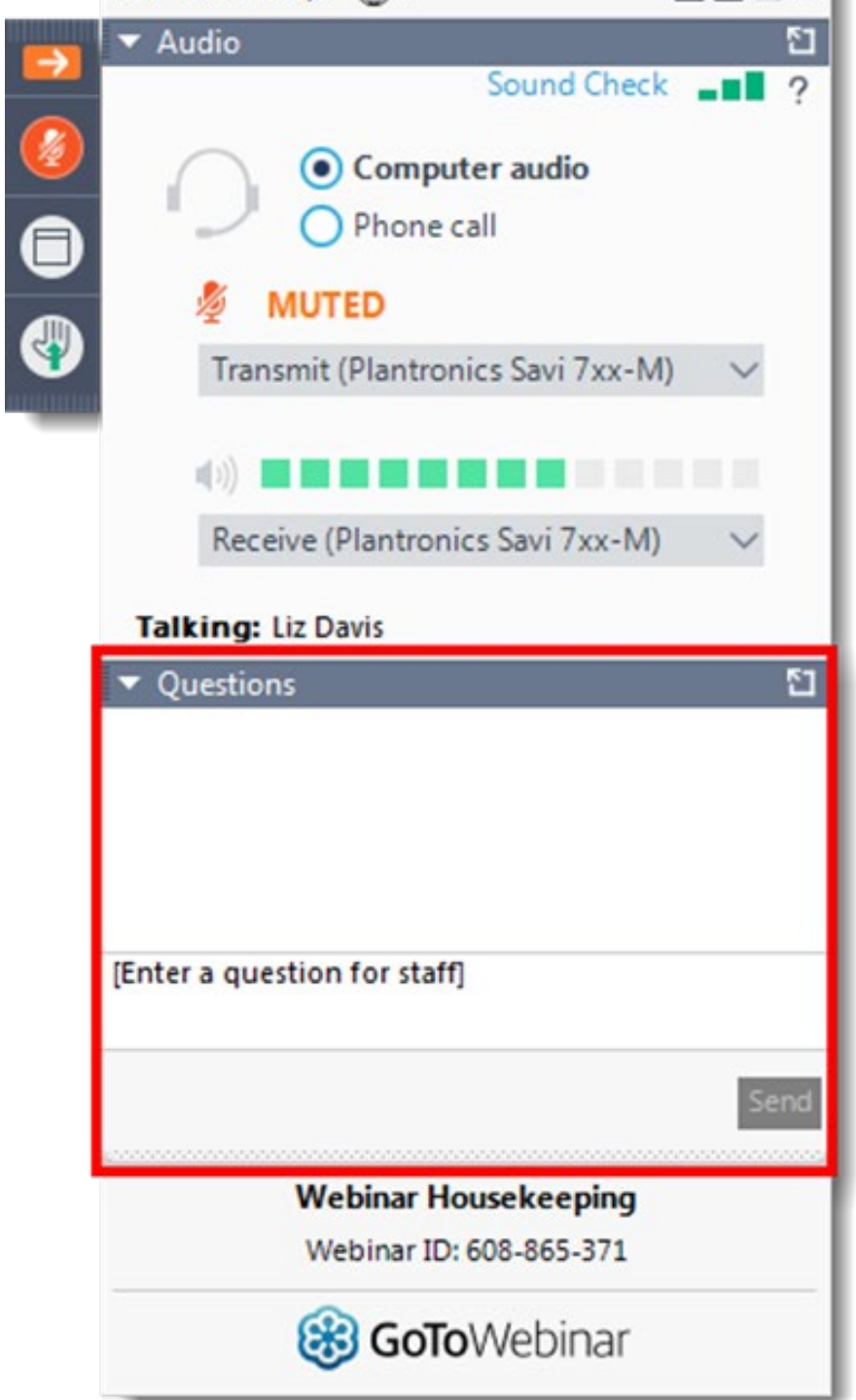
7. Review drawings showing system changes or adjustments for correct COVID-19 response

8. Conduct strategic Air Monitoring review

Expertise required - NEBB Certified Commissioning engineer, Licensed Mechanical Engineer

Skillset required - Experience with analysis, design, and implementation of different types of HVAC systems, including monitoring strategies for different Climatic zones, indoor air systems, outdoor air, building age or type

Questions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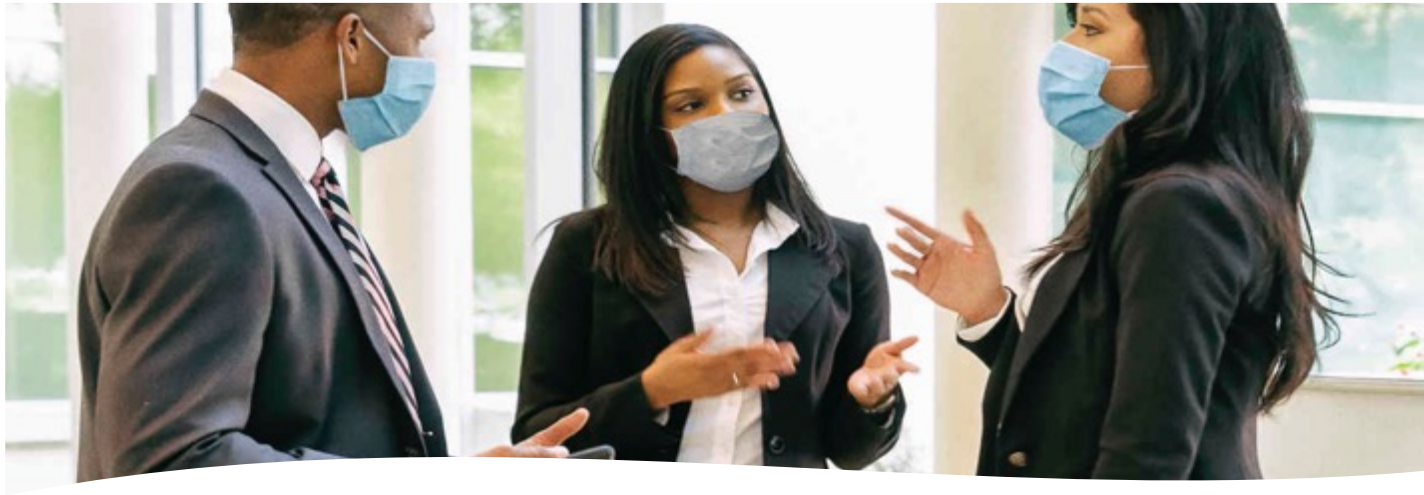
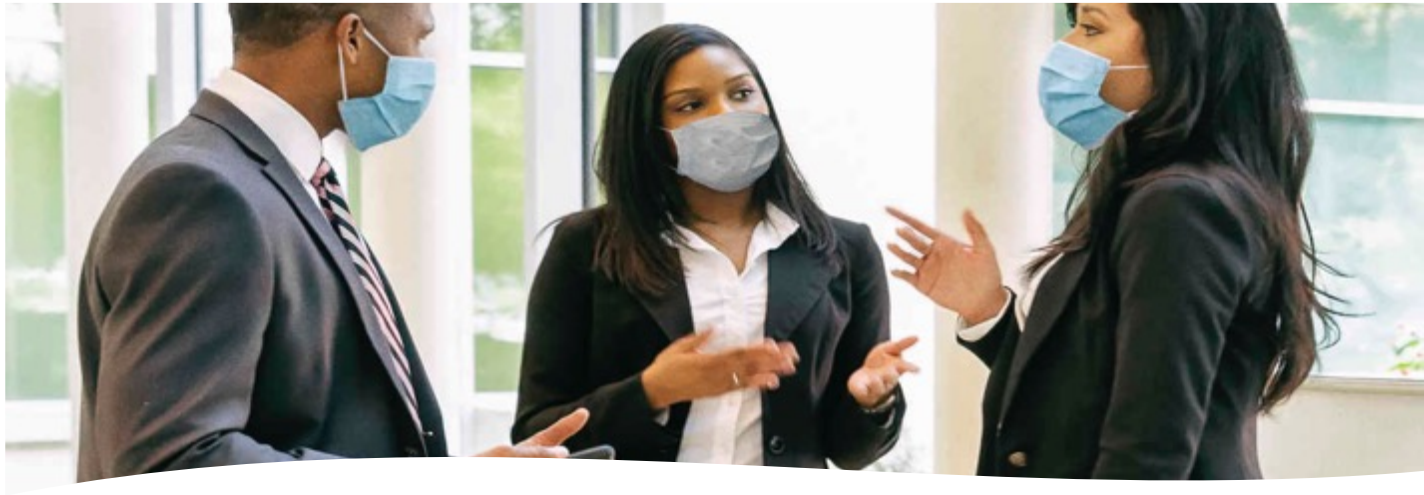
Conclusion and Wrap-up



In Summary: Protect you from breathing in what I breathe out

- We talked about anchoring and how hard it is to overcome
- We looked at the permanence of respiratory viruses
- We identified the three types of spread
- We discussed the importance of aerosols that float and linger in the air
- We figured out how we missed the aerosol spread, and how the WHO & CDC belatedly came to accept its importance
- We learned that aerosols spread much farther than the anchored six-feet and cannot be removed by washing and wiping
- We concluded with what that means - and what we should do to create safer indoor spaces

Conclusion and Wrap-up



Immediate Next Steps

1. Review or develop your HVAC maintenance plan & team
2. Ensure you have the skill set on the team to do the plan
3. Review or develop your HVAC checklists and schedules.
4. Develop standing update meetings to hard-wire ongoing oversight and ensure compliance
5. Arrange a professional engineering assessment of your indoor spaces and equipment as soon as possible, including air testing
6. Make a plan to bridge the identified gaps before school starts in the fall

Thank you

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Other Questions About These Key Points?

- Indoor Air Quality (IAQ) and its importance
- How to Improve Indoor Air Quality (IAQ)
- Critical tools and techniques
- Building readiness/HVAC strategies
- Ongoing monitoring

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