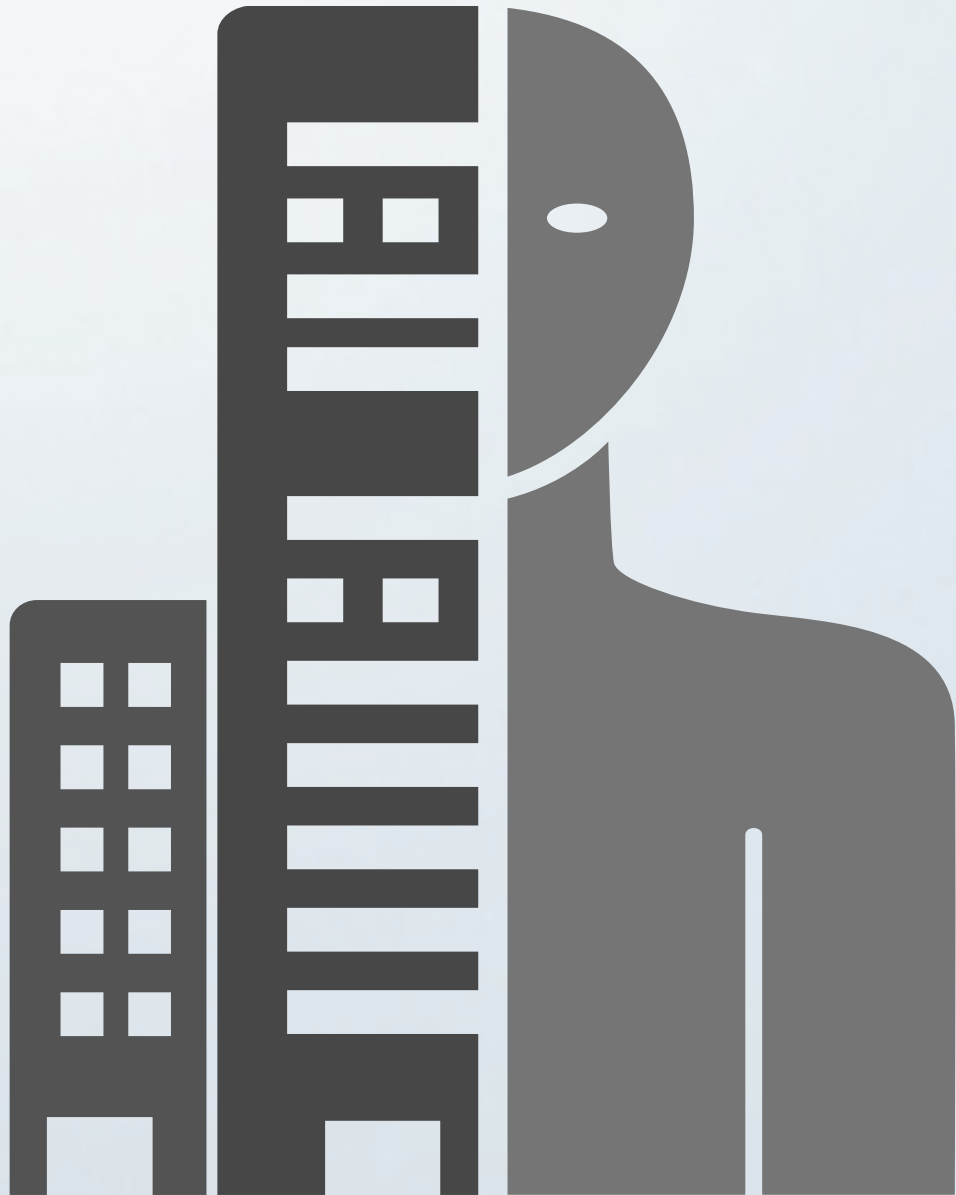




Safe Indoor Air: Top Experts Offer Advice For Future Pandemics

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- I. Presentation Slides: Buildings Are Our Best Medicine
- II. Presentation Slides: Ventilation in Buildings: To reduce exposure to infectious aerosols
- III. Presentation Slides: Hospital-grade air quality solutions



Buildings Are Our Best Medicine

Stephanie Taylor, M.D., M Arch.



Hello! I am honored to speak with you



HARVARD
MEDICAL SCHOOL

Research

- Massachusetts General Hospital Infection Control
- Harvard Medical InCite Health Fellow

ASHRAE



- Distinguished Lecturer
- Epidemic Task Force
- Environmental Health Committee
- Presidential Award Winner

Building4Health



- CEO and Founder

Stephanie Taylor, M.D., M Arch.



Acknowledgements



- **M. Colin Tasi, MD, MBA:** Massachusetts General Hospital, Brigham & Women's Hospital, Harvard Emergency Medicine Program
- **Stan Finkelstein, MD:** Harvard Medical School, Massachusetts Institute of Technology for Data, Systems & Society
- **Lisa Robinson, MPP:** Harvard T.C. Chan School of Public Health, Center for Health Decision Science
- **John Levy , PhD:** Boston University School of Public Health, Department of Environmental Health
- **Building4Health:** Peter Taylor, Olivia Saber, Yaron Yaniv, Francis Caruccio, Gene Lochart, Oliver Zimmermann

Presentation: Why we are all here today



Past

Protective structure



Present

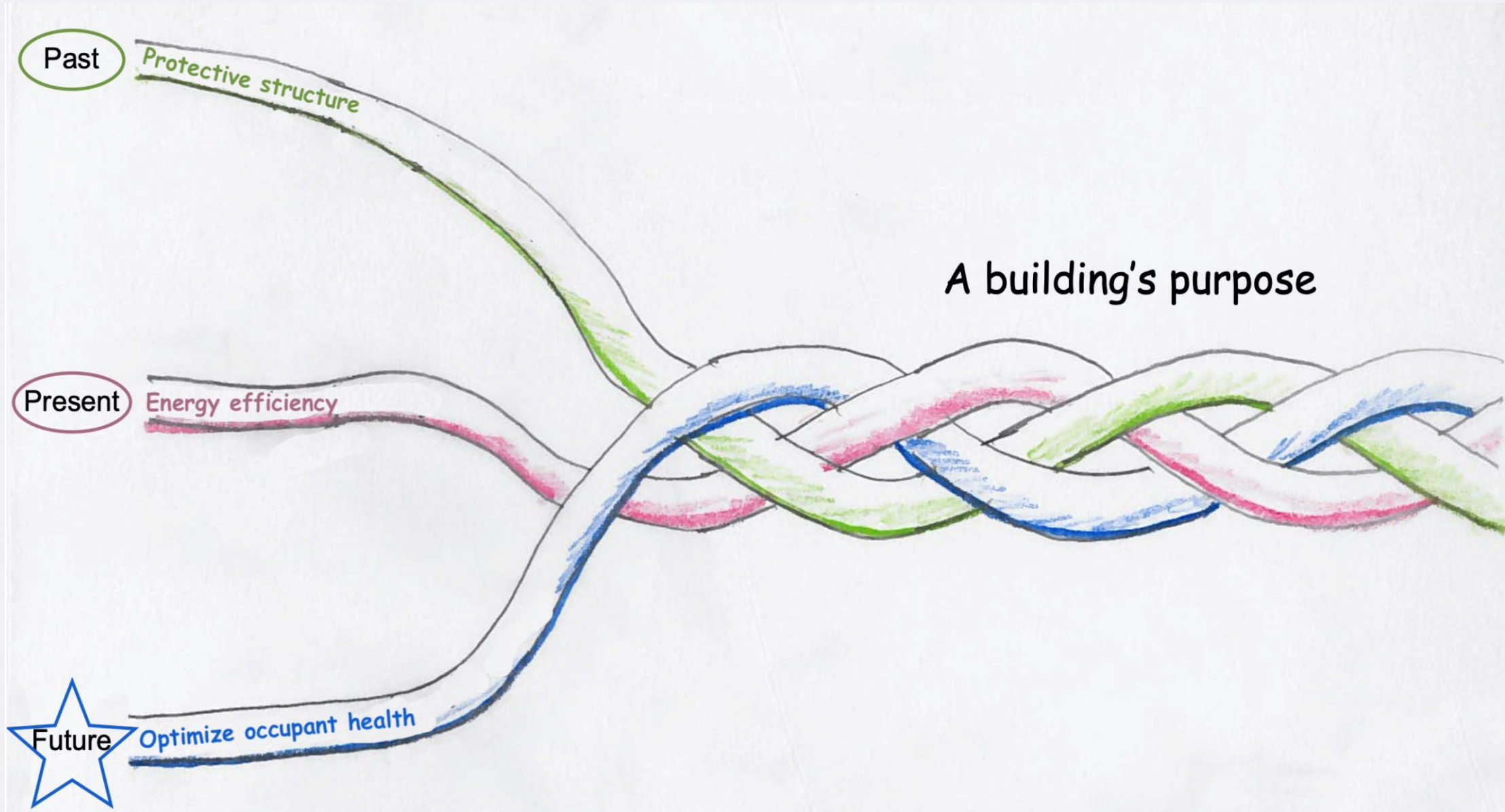
Energy efficiency



Future

Optimize occupant health

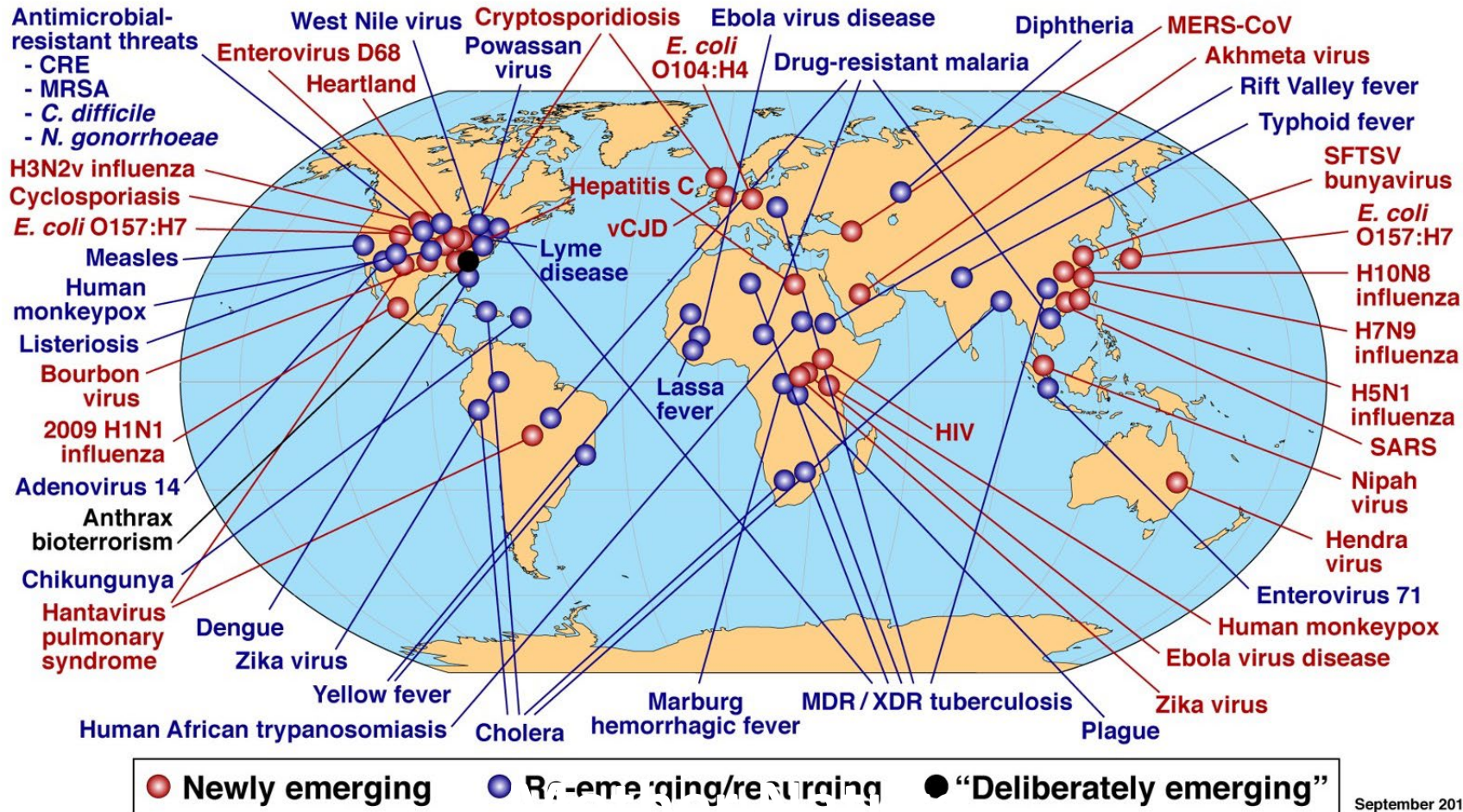
A building's purpose



I was not [that] surprised by this pandemic! Were you?



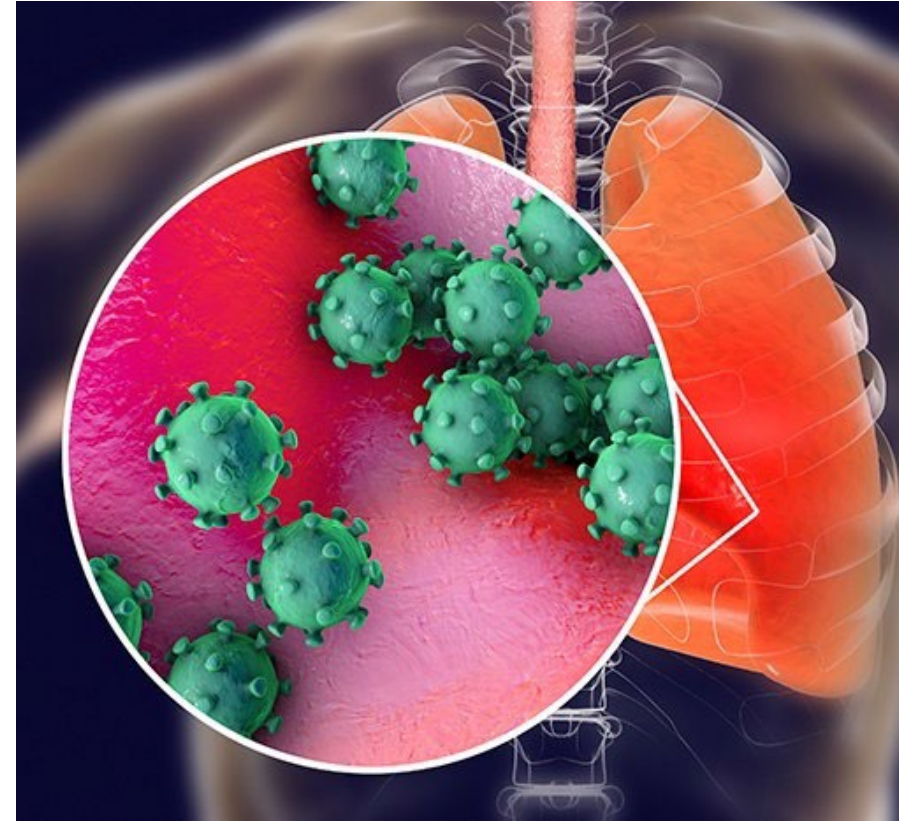
Global Examples of Emerging and Re-Emerging Infectious Diseases



Airborne viruses that can easily mutate to survive cause pandemics



Spanish Influenza 1918



COVID-19

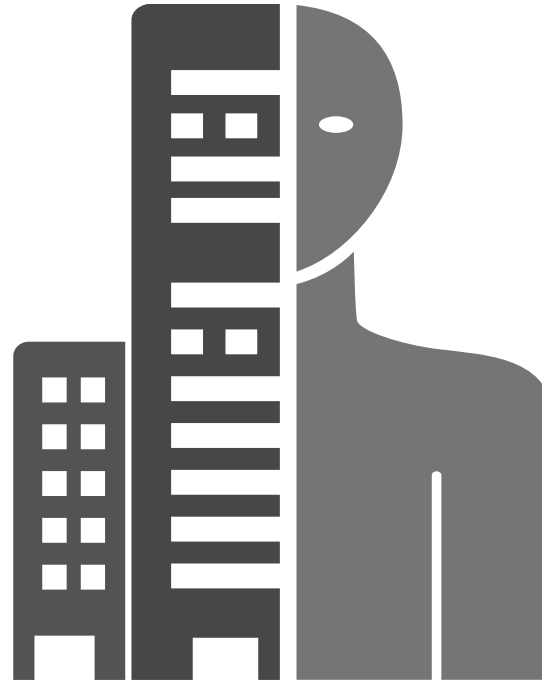
We must manage our buildings to both decrease pathogen infectivity and support human immunity

We need to unite indoor environmental management and medicine

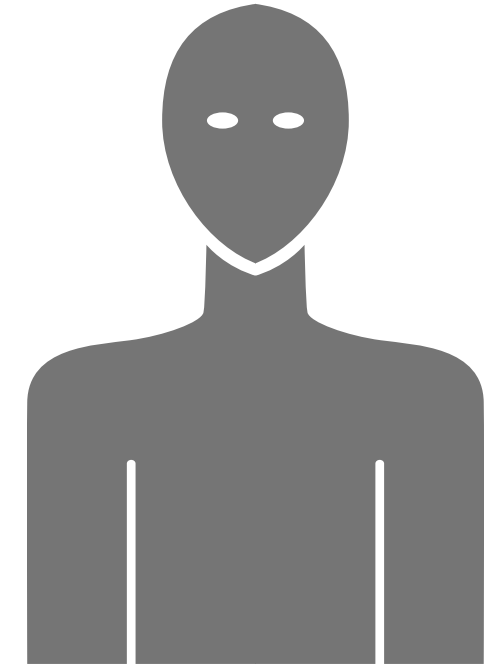


Building Management

- Reduce energy use
- Avoid disasters
- Follow best practices and coc



Occupant Health is key to building management



Medical Care

- Heal patients
- Follow clinical protocols
- Avoid lawsuits

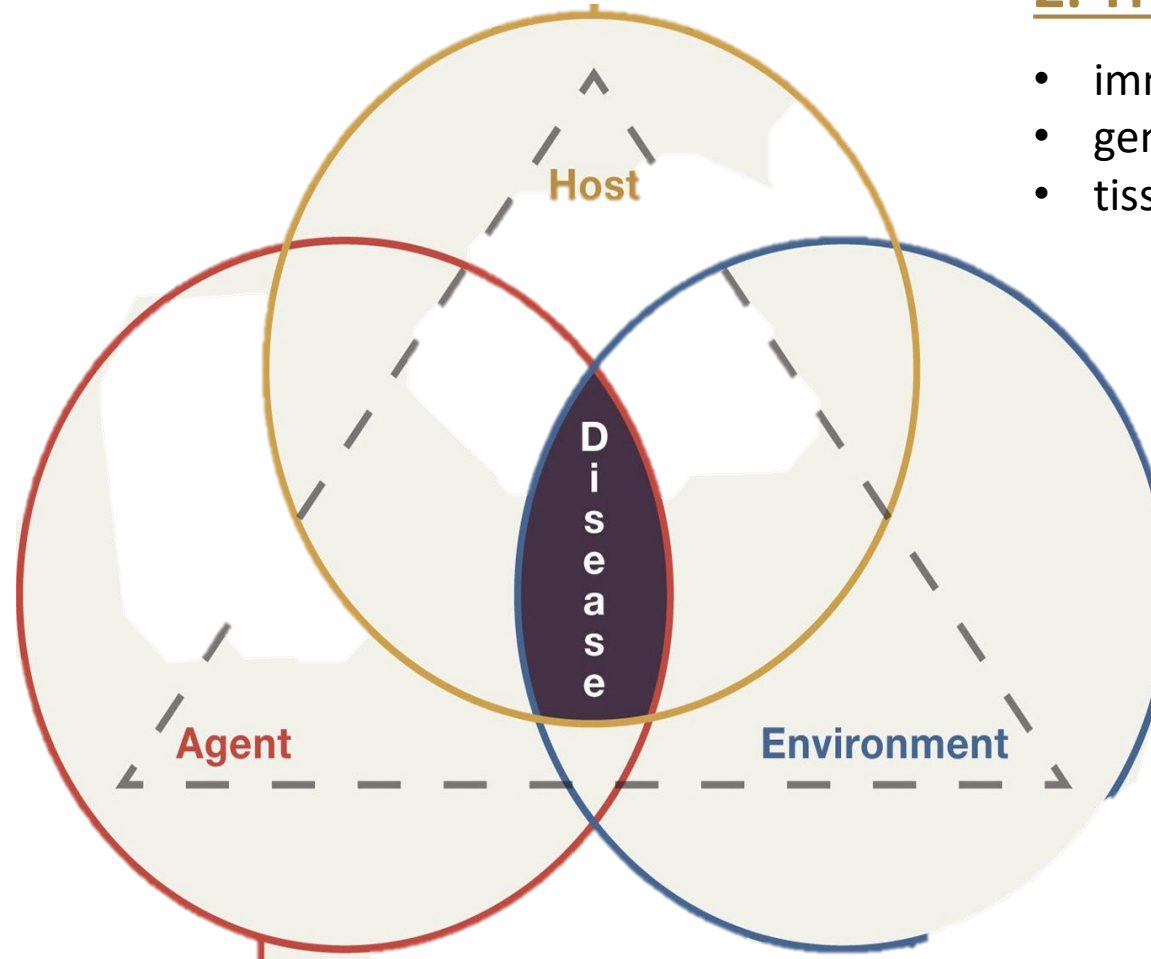


There are three components to diseases

IAQ influences all three components of infectious (and most) diseases!!

1. The agent (pathogen, particle, gas, etc.) that causes the disease:

- abundance
- virulence
- resistance to treatment



2. The human host:

- immune system function
- genetic stability
- tissue repair capacity

3. The environment where the agent interacts with the host:

- exposure to the agent(s)
- transmission route
- influence on penetration

We now have tools to take a closer look at humans and microbes



Microscope 1509

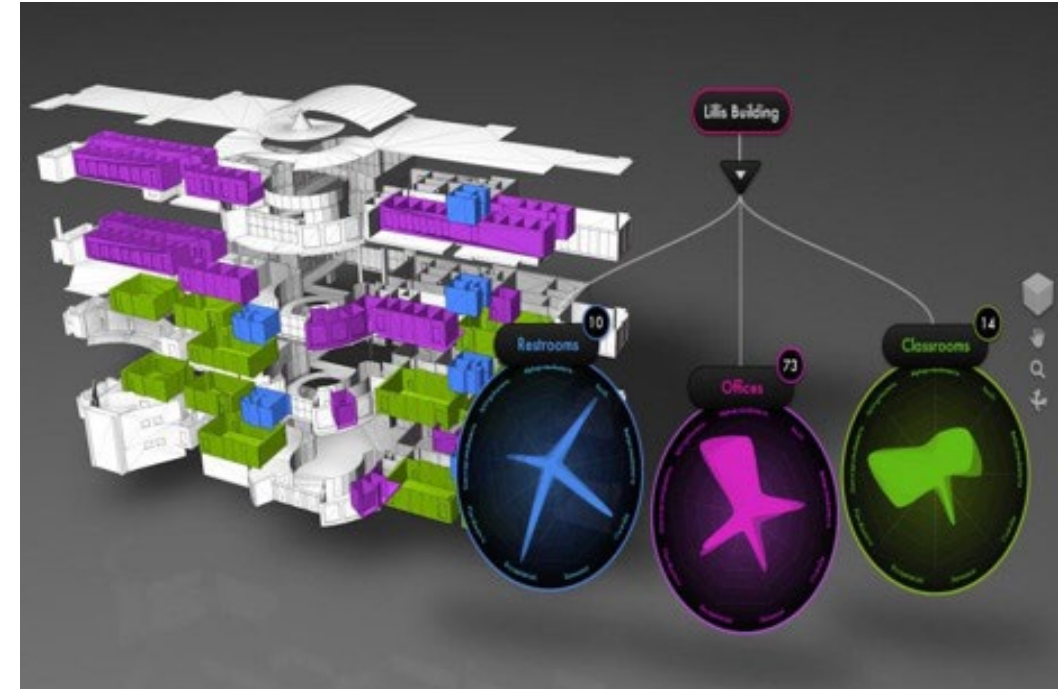
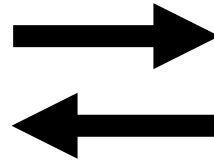
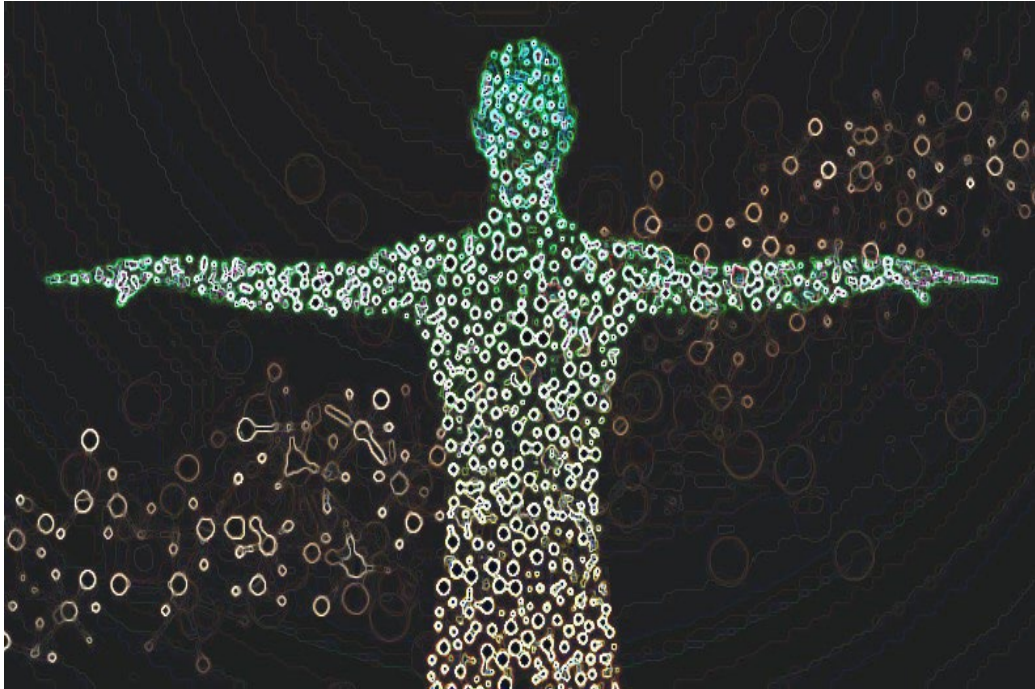


Metagenomics 2018

Humans indoors



Not surprisingly, human and building microbes intermingle

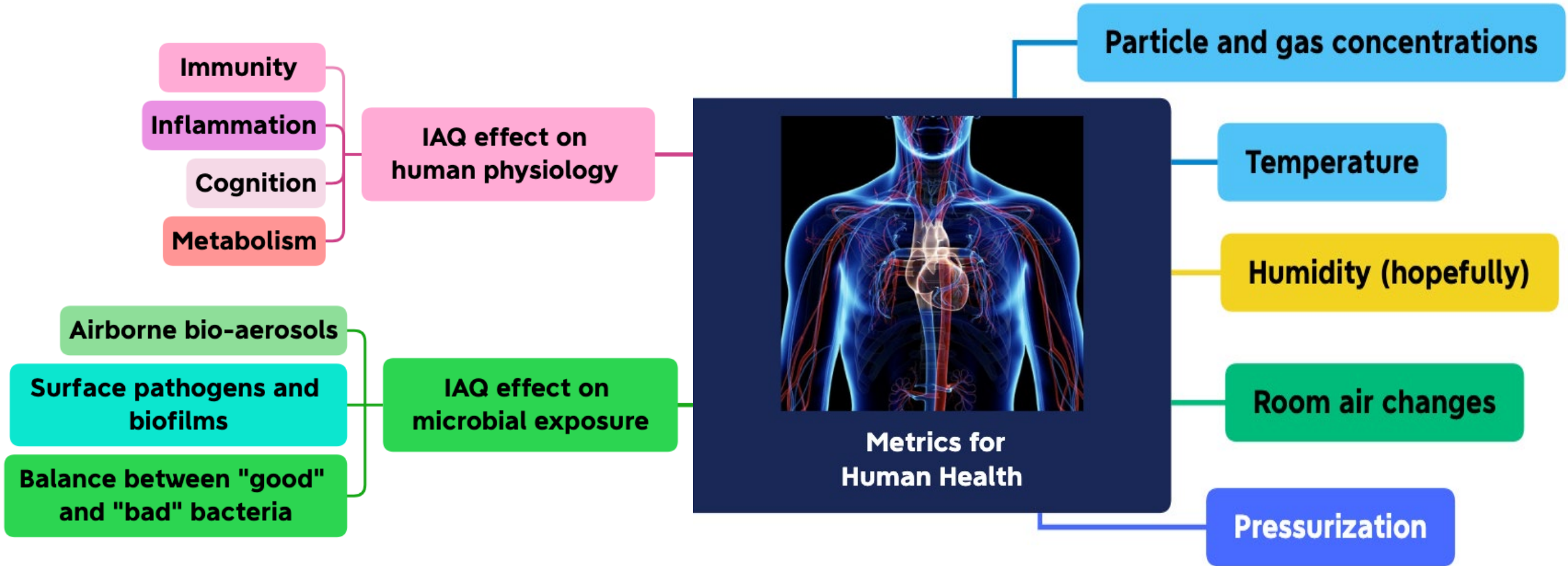


We send our microbes into buildings
(37 million microbes per person per hour)

The indoor environment selects
communities of bacterial, viral and fungal
microbes through “survival of the fittest”

Optimize occupant health

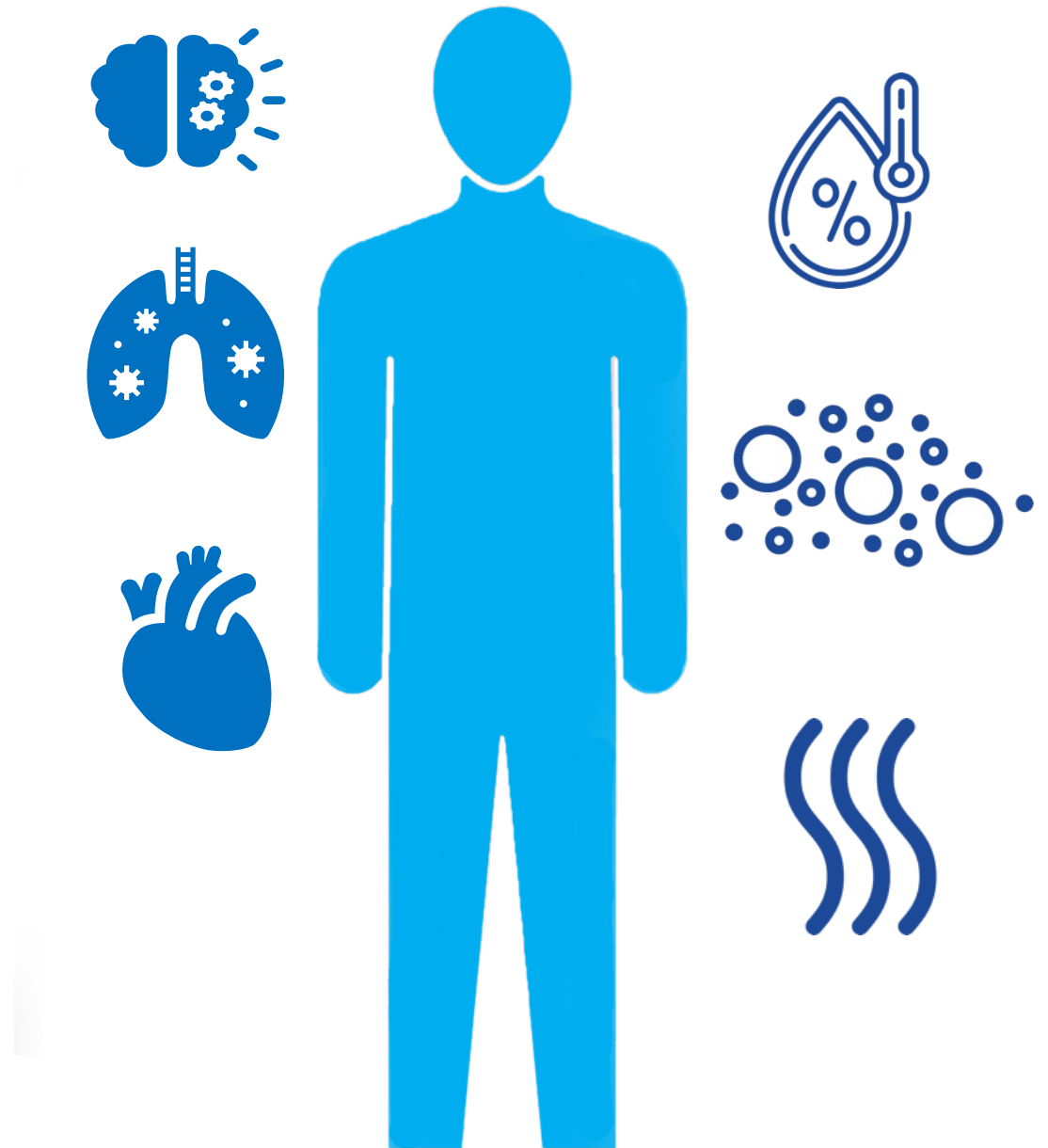
Optimize energy savings



Step 1: Identify essential IAQ components that impact health

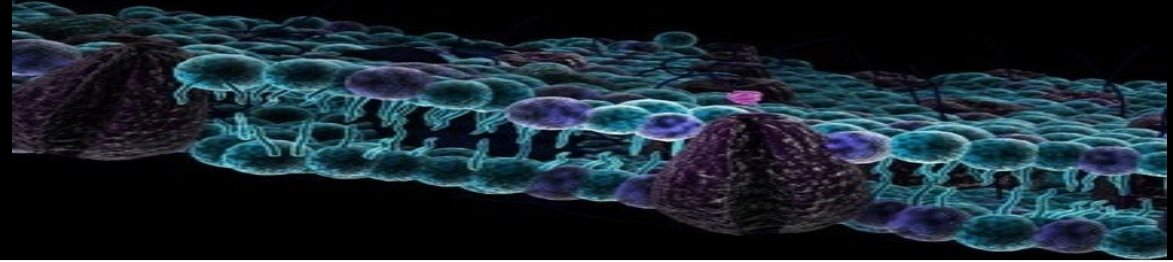
11 indoor metrics that alone and in combination have **quantifiable physiological impacts** on occupant health within a short time:

- Brain function and productivity
- Infections and inflammation
- Heart function and blood clotting
- Metabolism and hormones

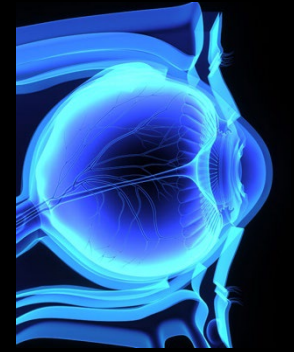
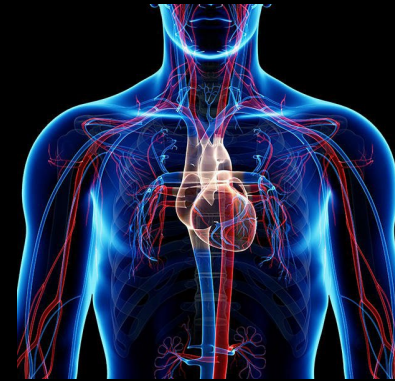


IAQ and human health

NO₂, SO₂, CO₂, carbon monoxide, particles, ozone, VOCs, etc. can penetrate cell membranes



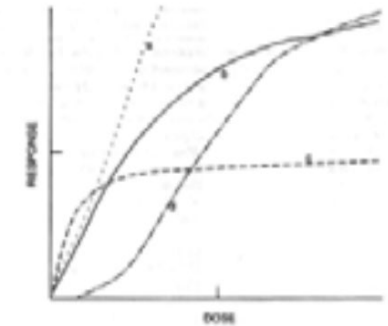
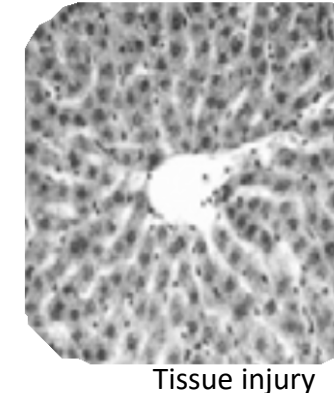
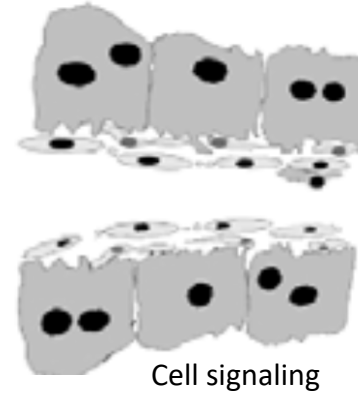
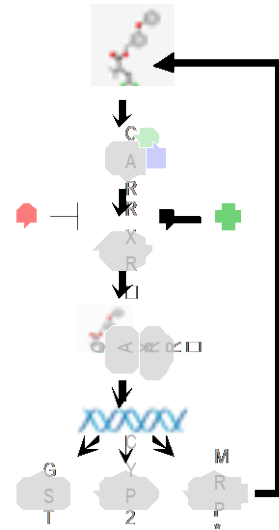
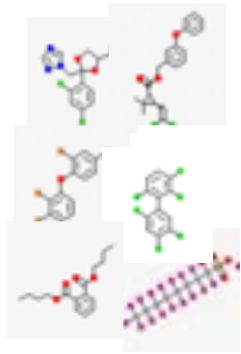
Affecting the brain, respiratory and cardiac system, skin and covering membranes



These biological effects then need to be quantified, reported and remediated



Steps to quantify the occupant health risk from indoor exposures



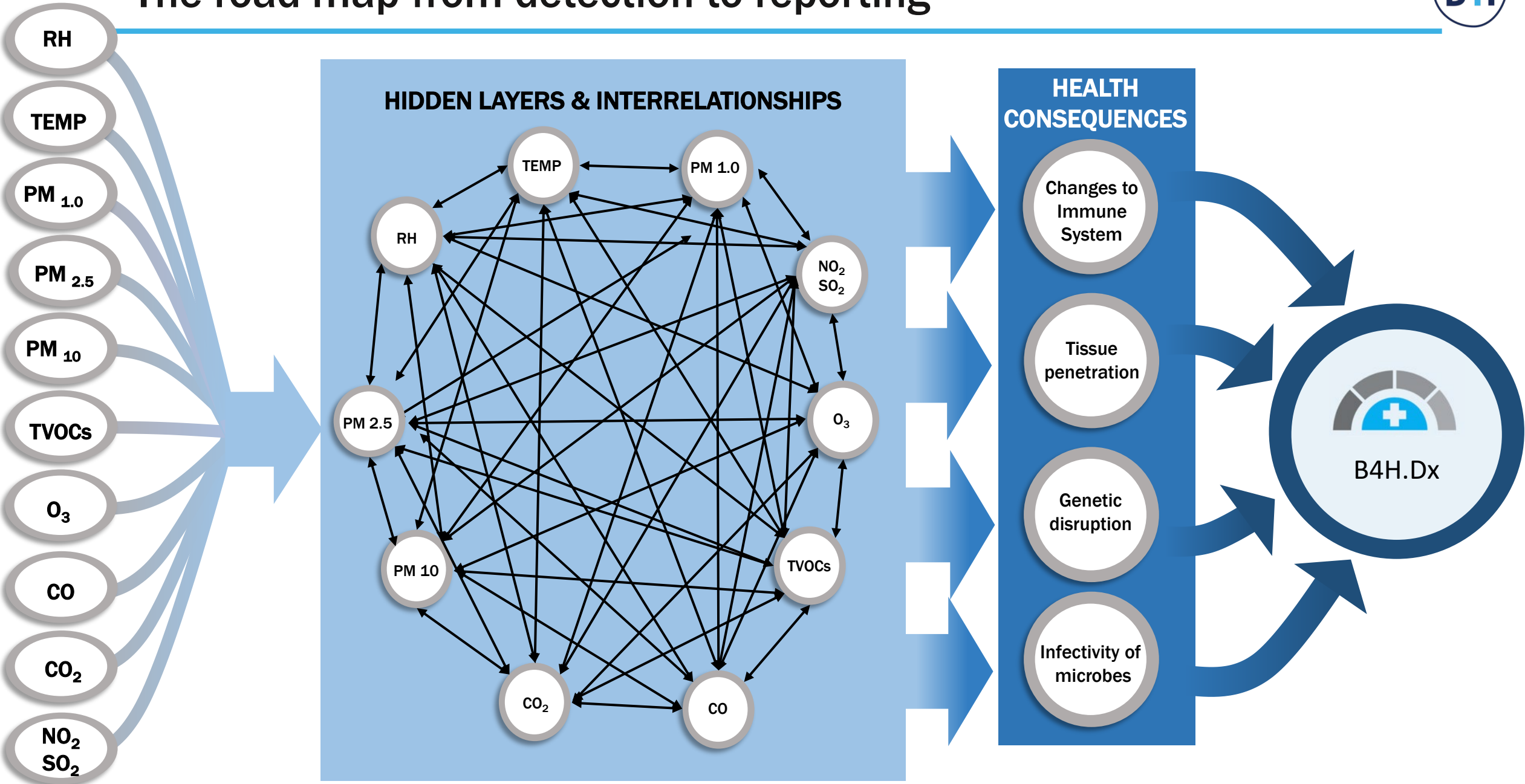
1. Measure human exposure to indoor compounds with sensors

2. Quantify capacity of compounds to penetrate membranes, damage cells through oxidative stress, and disrupt DNA/RNA replication

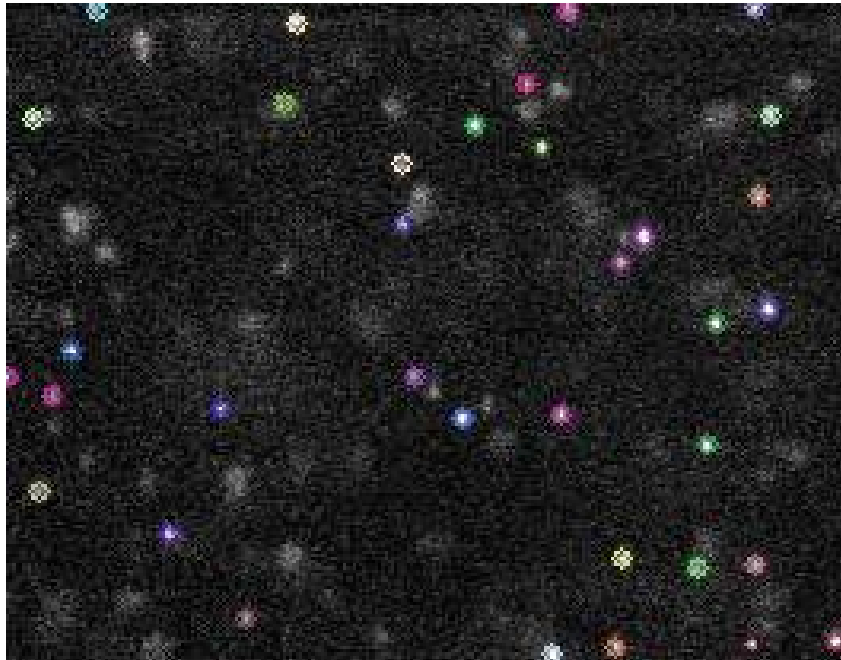
3. Predict health impact from pathway interruptions

4. Determine the dose response for the mix of indoor constituents

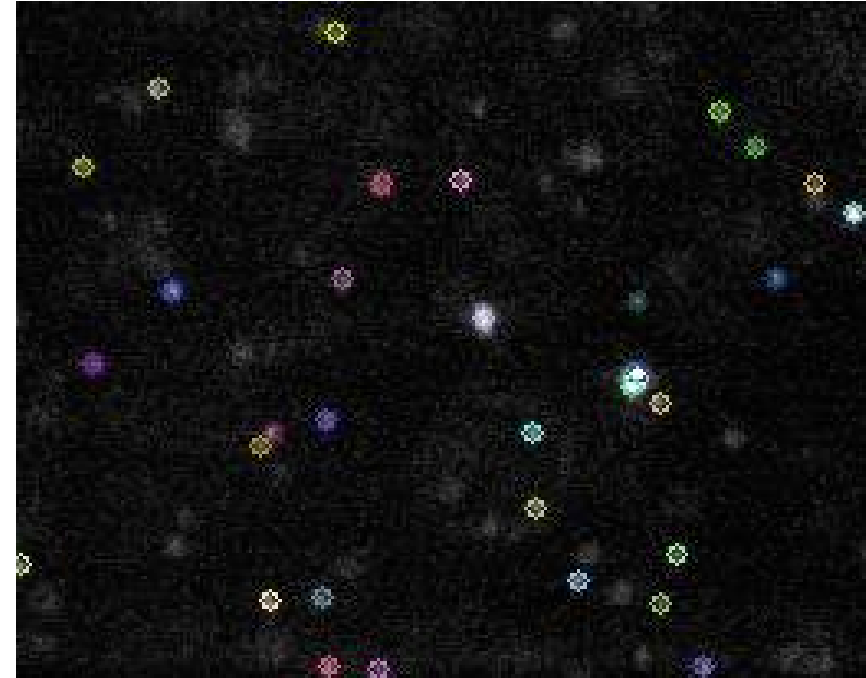
The road-map from detection to reporting



Video-microscopy of muco-ciliary clearance in mice trachea



mice after 5d exposure to **10-20% RH**,
20°C in climate chamber



mice after 5d exposure to **50% RH**, 20°C in
climate chamber



mucus speed reduction
12µm/s → 4 µm/s

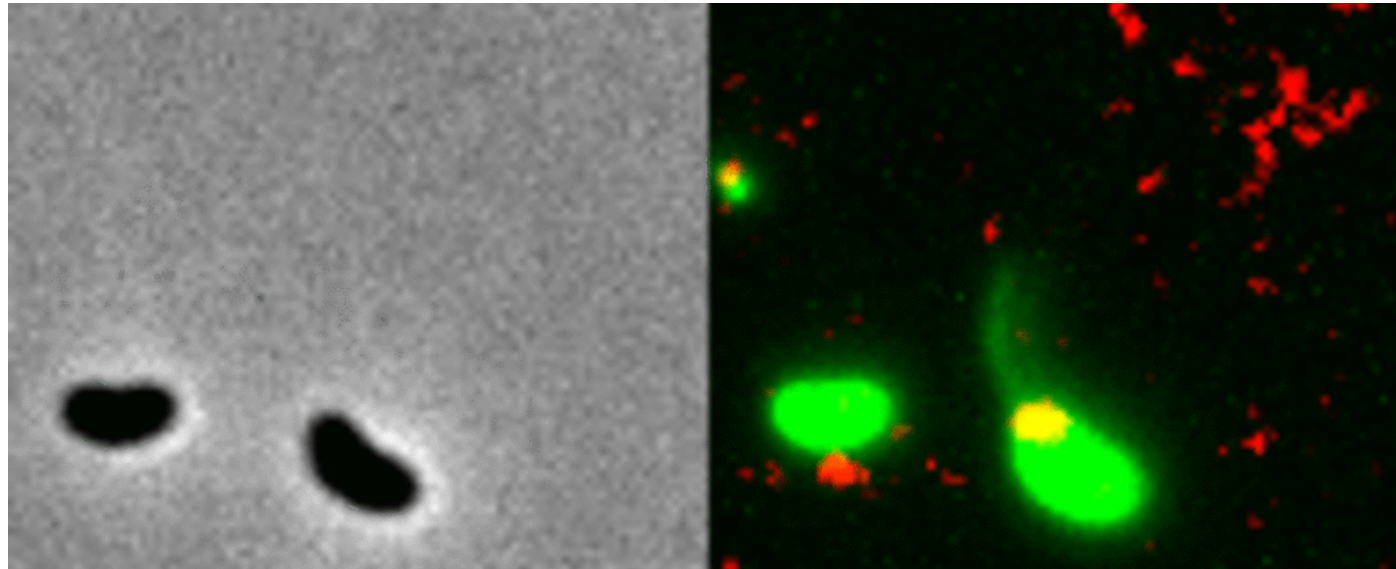
After exposure to aerosolized Influenza viruses, all mice kept in low relative humidity died within 5-10 days

This was a startling and very important finding



"Antibiotic Resistance Can Spread Through The Air, Scientists Warn, And
Yes - You Should Be Terrified"

July 26, 2018



Poor air quality increases the airborne transfer of antibiotic resistance genes

Scoring was based on quantification of:

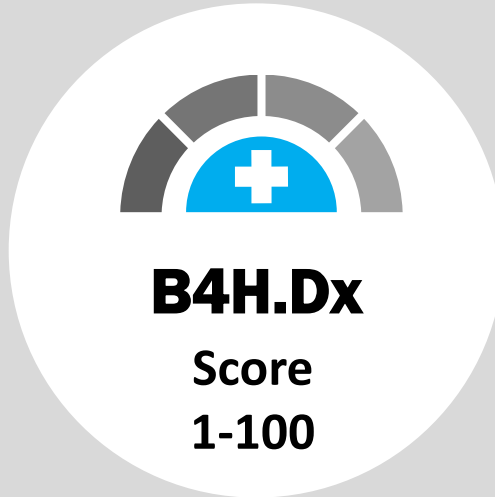
- Penetration into respiratory, central nervous system, circulatory and skin structures
- Alteration of immune function
- Inhibition or stimulation of immunological or inflammatory mediators through DNA &/or RNA methylation
- Degree of oxidase activity and resulting reactive oxidation species production
- Environmental selection of bacterial, viral, fungal species

The process



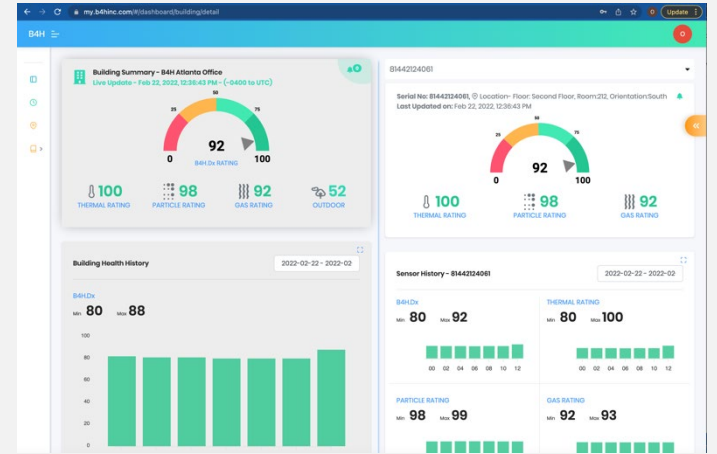
1

Sensors give precise, real-time measurement of 11 key variables necessary to understand the impact of the indoor environment on occupant health.



2

A patented algorithm integrates building measurements and medical research to produce an actionable score.



3

The dashboard displays a real time indoor health index and provides reports, alerts, and remediation recommendations to improve your score if necessary.

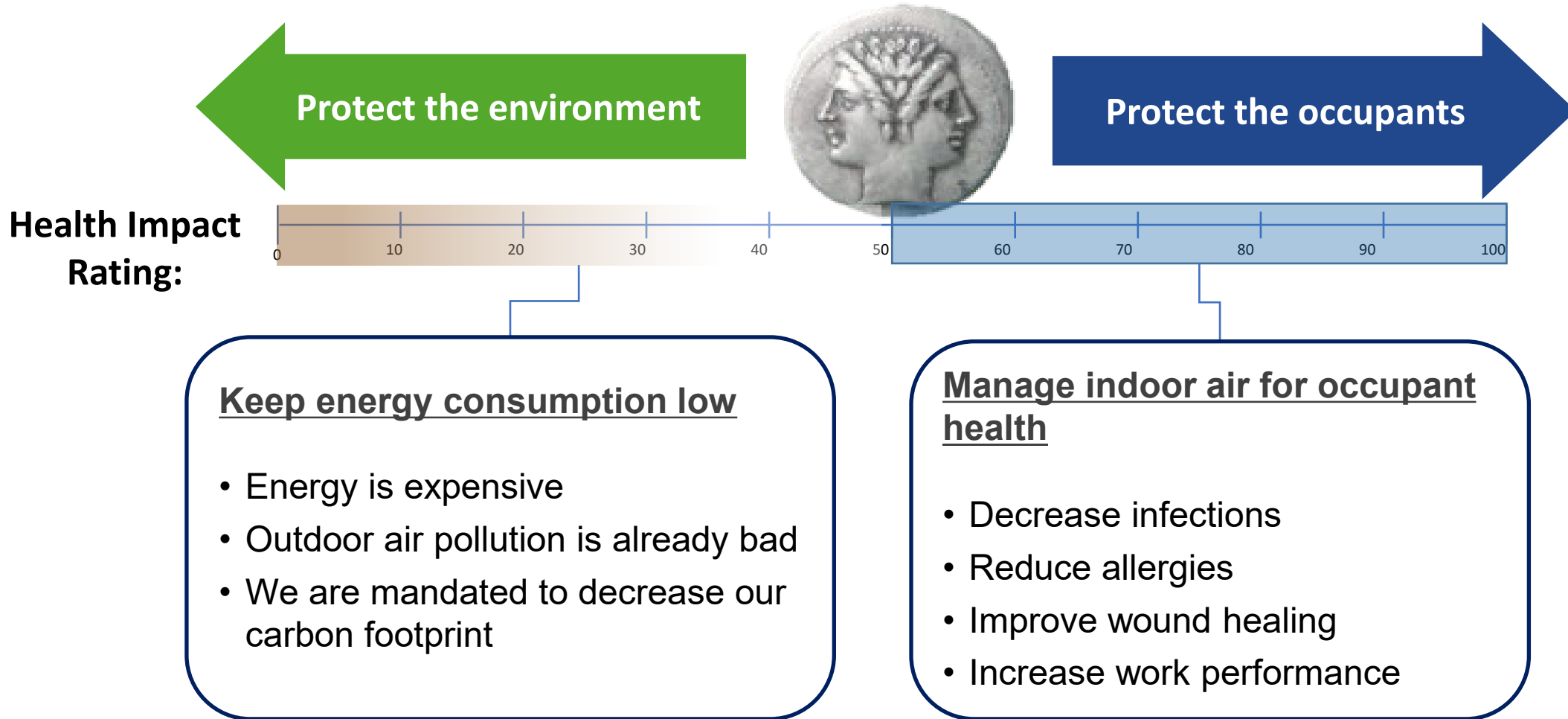
The B4H.Dx Score



The resulting **B4H.Dx** Score is a single score from 0 to 100

- A score of 50 and above indicates an environment that supports human health. Components of the score have been correlated with reduced risks of viral infection, respiratory and other diseases, and impaired cognition. **Consequently, a high score reflects short and long-term health benefits**

How can we resolve this tug-of-war?



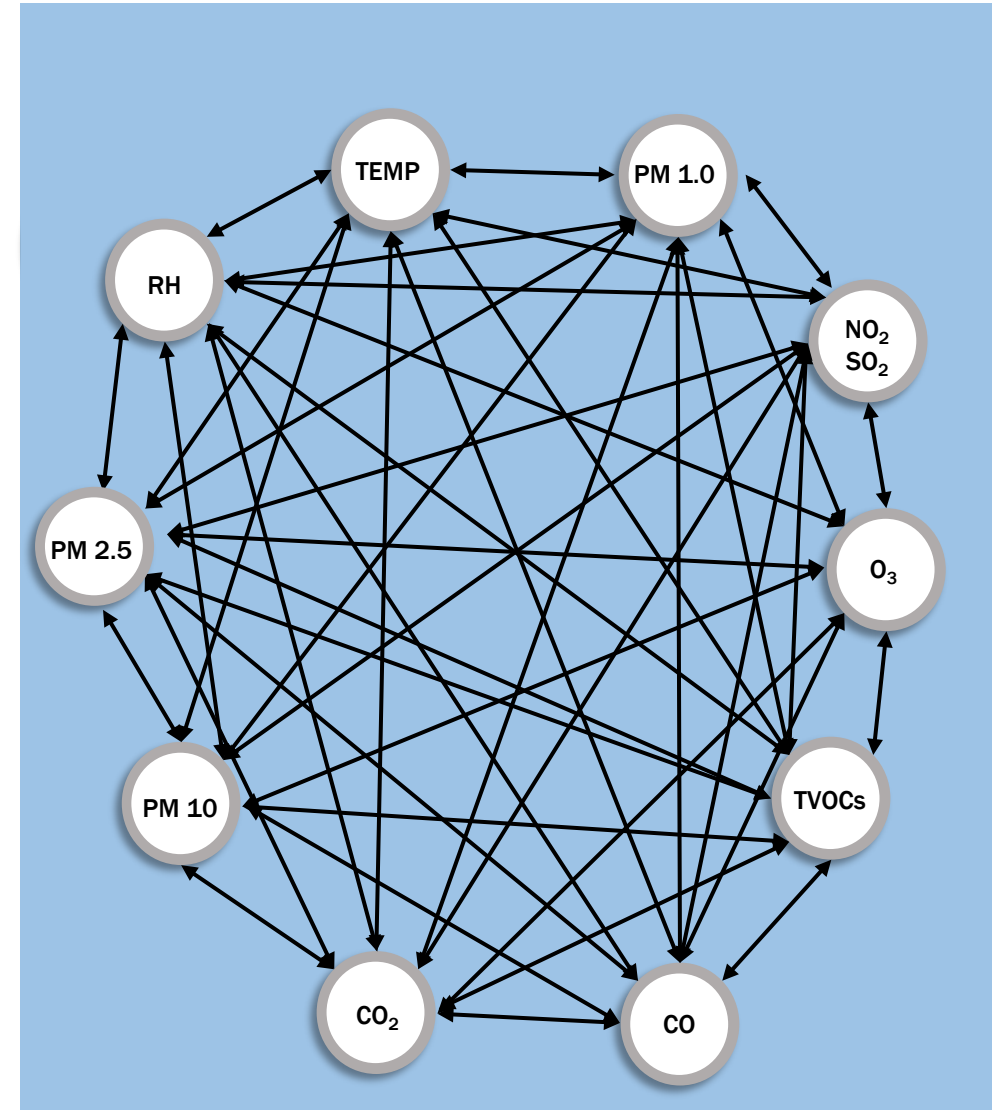
An actionable IAQ Health Standard can guide HVAC operations according to real-time conditions



Remediation for health incorporates flexible interventions



These inter-relations allow for both flexibility and precision in where and when remediation is needed. This means a clearer idea of what is needed, and fewer expensive and high-energy fixes.



We must manage IAQ for occupant health!



NEW & EXISTING PANDEMICS

Decrease infectivity of SARS-CoV-2, Polio, Monkeypox, Tuberculosis, Antibiotic resistant mutations.



TECHNOLOGY

The technology to create healthier indoor environments and better occupant health exists, and should be used.



HEALTH EQUITY

Prioritizing health equity requires action to protect underserved and vulnerable populations.



THE CLIMATE CRISIS

Addressing the climate crisis requires using all available tools to decrease our carbon footprint and energy use.



The cost/benefit of managing buildings for healthy occupants



Sickness and disease create immeasurable direct and indirect costs including:

- *Loss of productivity*
- *Absenteeism*
- *Higher healthcare costs*



Buildings managed for health create confidence in occupants.

Increase in occupancy = increase in profits



Safely reduce energy use without causing harmful health impacts to building occupants.



Comply with ESG goals proactively and tangibly.



Use real-time data to manage expensive and potentially unnecessary building modifications.

Test before you invest!

- By giving visibility to the health impact of the indoor environment, we have a scientific basis for managing IAQ to support occupant health, productivity and learning
- By knowing the interactive chemistry, attainable remediation can diminish the harm of interacting indoor pollutants
- Humidification to RH 40%–60% is a foundational step in supporting health
- Healthy people increase the profitability of businesses and the success of our species

Please contact me if you:

- ✓ Have questions?
- ✓ Want to monitor your building with the B4H platform
- ✓ Would like help setting up a cost/benefit study for buildings managed for occupant health

stephanie@B4Hinc.com

www.B4Hinc.com

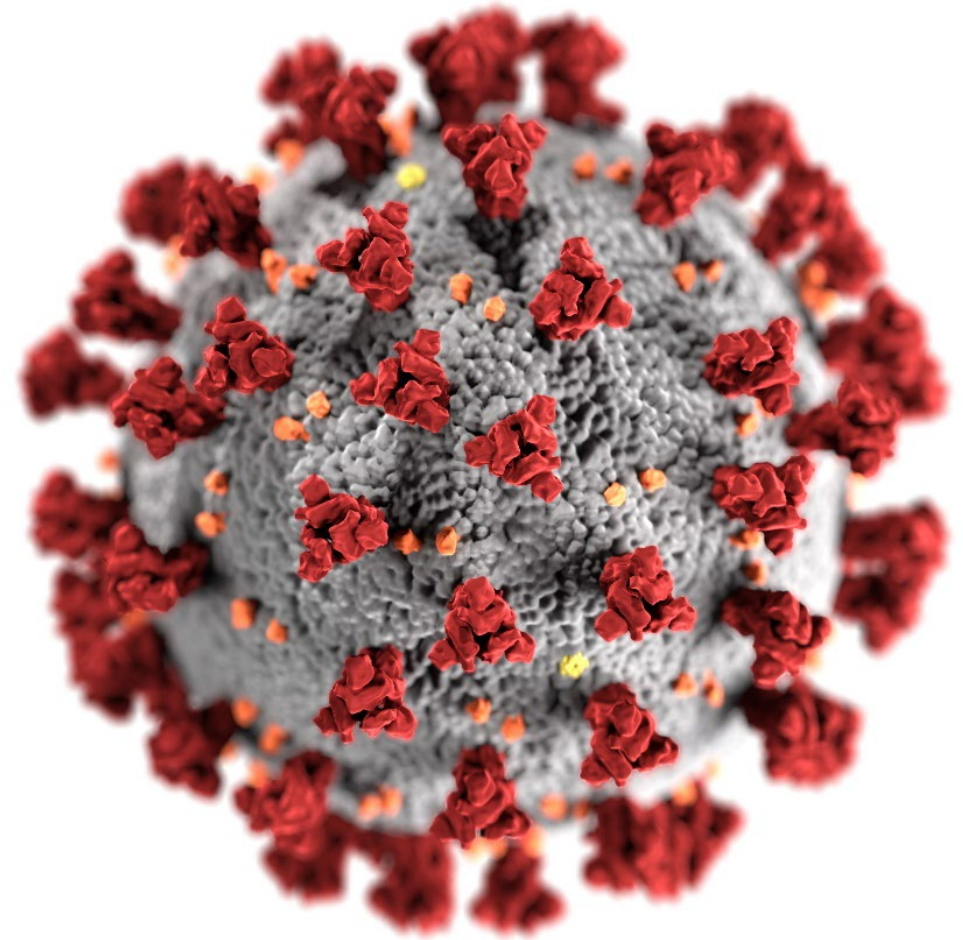


Building Clarity | Building Confidence | Building4Health



Ventilation in Buildings: To reduce exposure to infectious aerosols

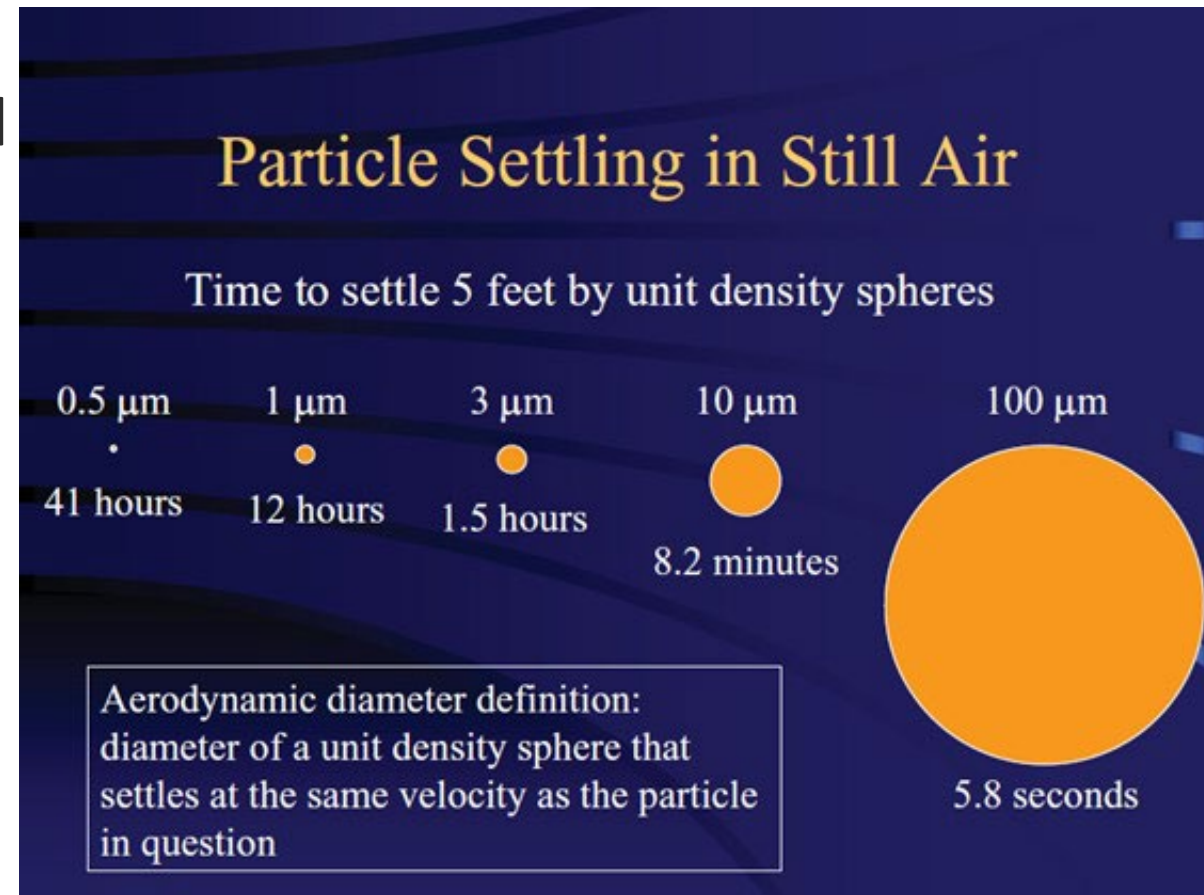
Kenneth R. Mead, PhD, PE
Division of Field Studies and Engineering
National Institute for Occupational Safety and Health (NIOSH)



cdc.gov/coronavirus

Do not get distracted by terminology

- Different professions (clinicians, aerosol scientists, engineers, industrial hygienists, microbiologists) do not always use consistent terminology.
- Regardless of the name, if it is small enough to float in air, then ventilation interventions can help prevent its distribution and reduce individual exposure.



Graphic: https://www.cdc.gov/niosh/topics/aerosols/pdfs/Aerosol_101.pdf

Ventilation in Buildings

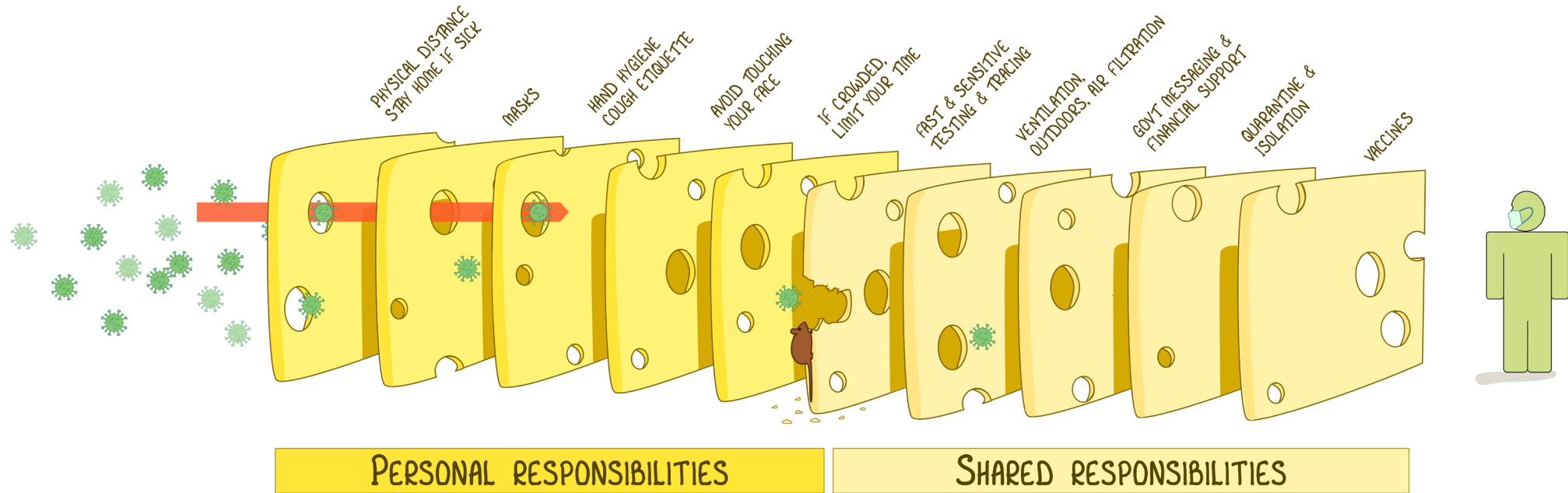
Reference: <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>



CDC recommends a layered approach to reduce exposures to SARS-CoV-2

THE SWISS CHEESE RESPIRATORY VIRUS PANDEMIC DEFENCE

RECOGNISING THAT NO SINGLE INTERVENTION IS PERFECT AT PREVENTING SPREAD



EACH INTERVENTION (LAYER) HAS IMPERFECTIONS (HOLES).
MULTIPLE LAYERS IMPROVE SUCCESS.

Graphic Credit: Ian W. McKay, virologydownunder.com



Note: The interventions shown are not all-inclusive and are not depicted in any meaningful order.

SARS-CoV-2 viral particles are more readily spread between people indoors than outdoors

- Outdoors: Even a light 1 mph [88 feet per minute (fpm)] wind can rapidly reduce airborne contaminant concentration.
- Indoors: Protective ventilation practices and interventions can reduce the airborne concentration of the virus and reduce the overall viral dose to occupants.



Graphic: Getty Images

Are you Code Compliant?

- Often – ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality (current version 2019) [www.ashrae.org]
- Code compliant = aligns with year building constructed or most recently renovated/upgraded
- Applies to outdoor air % of HVAC delivery only (per person & per sq-ft approach by room type)
- At a minimum, encourage consideration of upgrading existing systems to current code.
 - Establishes a strong baseline from which to consider future improvements



Steps beyond code-compliant minimums

- Ventilation system upgrades or improvements can increase the delivery of “clean” air and dilute potential contaminants.
 - Consult experienced heating, ventilation, and air conditioning (HVAC) professionals.
 - CDC guidance presents a list of ventilation interventions, “tools in the mitigation toolbox,” that can help reduce the concentration of viral particles in the air.
 - Each tool can contribute towards a reduction in risk.
 - Implementing multiple tools at the same time is consistent with CDC’s layered approach and will increase overall effectiveness.



Steps beyond code-compliant minimums (cont.)

- Using these tools can reduce the risk of exposure to the virus and the spread of disease but will not eliminate risk completely.
 - Tools can be universally applied across indoor environments but choosing which tools to apply can be challenging.
 - The specific combination of tools used at any point in time can change.
 - The building owner or operator (with expert consultation as needed) should identify which exposure reduction tools are appropriate for each building throughout the year.
- In addition to buildings, ventilation improvements can be applied to vehicles, including public transportation.



Tools to Improve Ventilation



Tools to improve ventilation

- Some interventions are based on COVID-19 [Technical Resources](#) published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).
- Not all interventions will work in all scenarios.
- Local conditions may drive adoption preferences for specific tools.



Graphic: Getty Images

ASHRAE Technical Resources: <https://www.ashrae.org/technical-resources/resources>



Increase the natural introduction of outdoor air

Open Windows and Doors:

- When the weather allows.
- Increases outdoor air flow.
- Even slightly opened windows can introduce beneficial outdoor air.
- Do not open if it poses a safety or health risk (e.g., risk of falling or triggering asthma).



Graphics: Getty Images

Use fans to supplement open windows and doors

- Increases efficiency of outdoor air delivery.
- Placement is important; will vary with room configuration.
 - Avoid directing potentially contaminated air from one person to another.
 - Place fans safely and securely in windows or doors **to exhaust** air outdoors.
- Similar results can be achieved in larger spaces with gable fans, roof ventilators, etc.



Graphics: Getty Images

Increase the HVAC system's supply of outdoor air

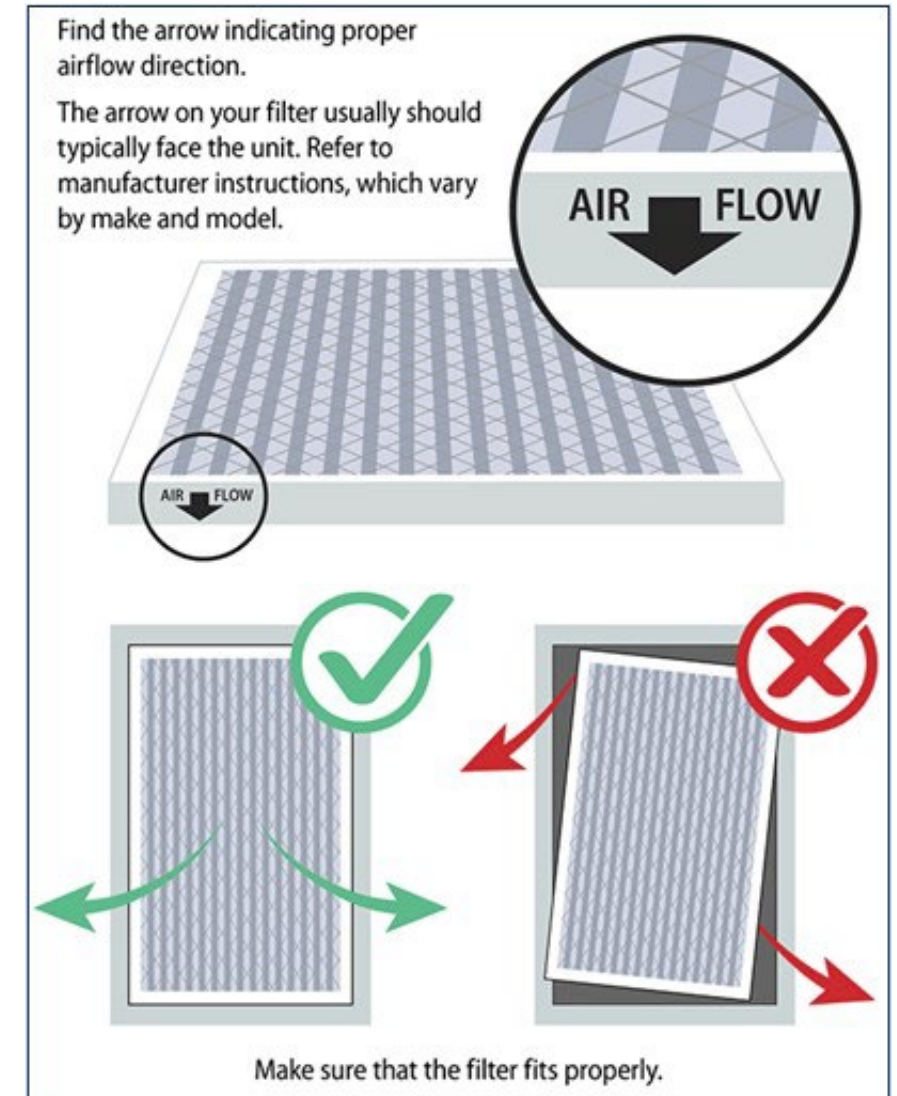
- Open HVAC outdoor air dampers beyond minimum settings.
- Eliminate or reduce HVAC air recirculation.
- Will not affect thermal comfort during mild weather; may be more difficult in cold, hot, or humid weather.
- May require consultation with an experienced HVAC professional.



Graphic: Getty Images

Improve central air filtration

- Increase air filtration to as high as possible without significantly reducing design airflow.
- Increased filtration efficiency is especially helpful when enhanced outdoor air delivery options are limited.
- Make sure air filters are properly sized and within their recommended service life.
- Inspect filter housing and racks to ensure appropriate filter fit and minimize air that flows around, instead of through, the filters.



Graphic: CDC

HVAC system recommendations

- Ensure ventilation systems are operating properly and provide acceptable indoor air quality for occupants.
- Rebalance or adjust systems to increase total air flow to occupied spaces.
- During occupied hours, turn off demand-controlled ventilation (DCV) controls that are designed to:
 - Reduce the air supply based on occupancy levels or temperature.
 - Save energy.

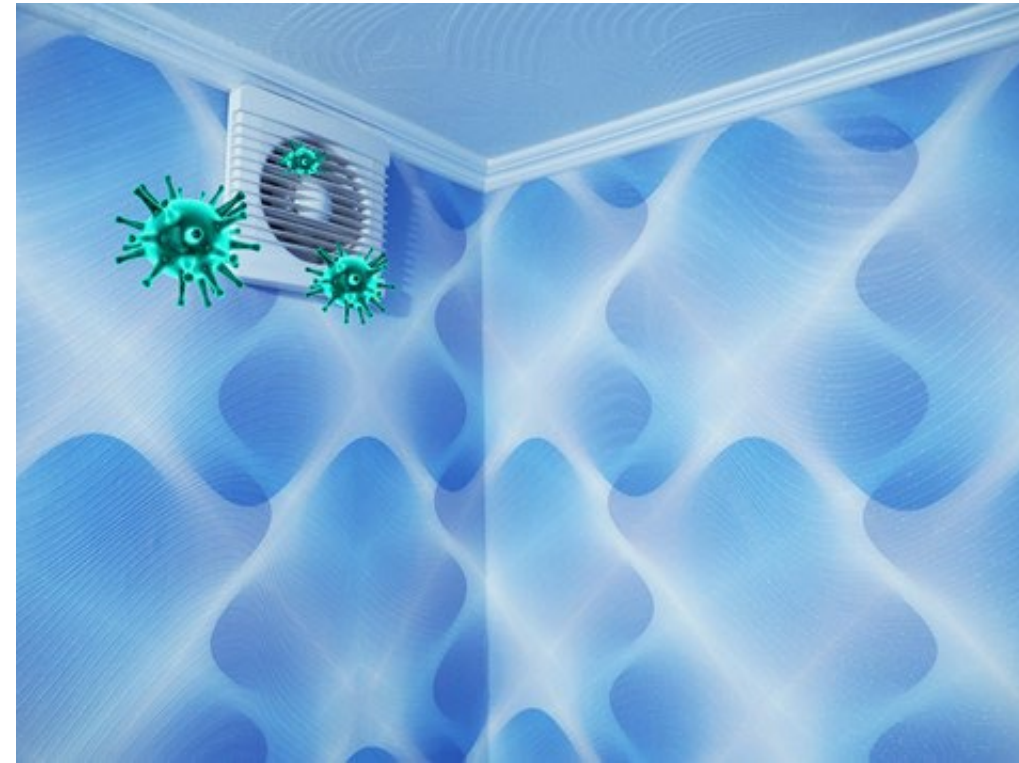


Photo: Getty Images

For systems controlled by a simple thermostat, set the fan to “ON” instead of “AUTO”, which will operate the fan continuously.

Operate exhaust fans during building occupancy

- Ensure restroom exhaust fans are functional, operating continuously, and at full capacity when the building is occupied.
- Inspect and maintain exhaust ventilation systems in kitchens, cooking areas, etc.
 - Operate these systems any time these spaces are occupied.
 - Consider operating them even when the specific space is not occupied, to increase overall ventilation within the occupied building.



Graphic: Getty Images

Consider portable HEPA* fan/filtration systems

- These systems provide additional air cleaning.
- Especially useful in higher risk areas.
 - Workplace medical clinics.
 - Areas frequently occupied by people with a higher likelihood of having COVID-19 and/or an increased risk of getting COVID-19.
- Note: Portable air cleaners that use filters less efficient than HEPA filters can contribute to room air cleaning.
 - Units should be clearly labeled as non-HEPA.
 - Effect on overall air cleaning needs to be understood.



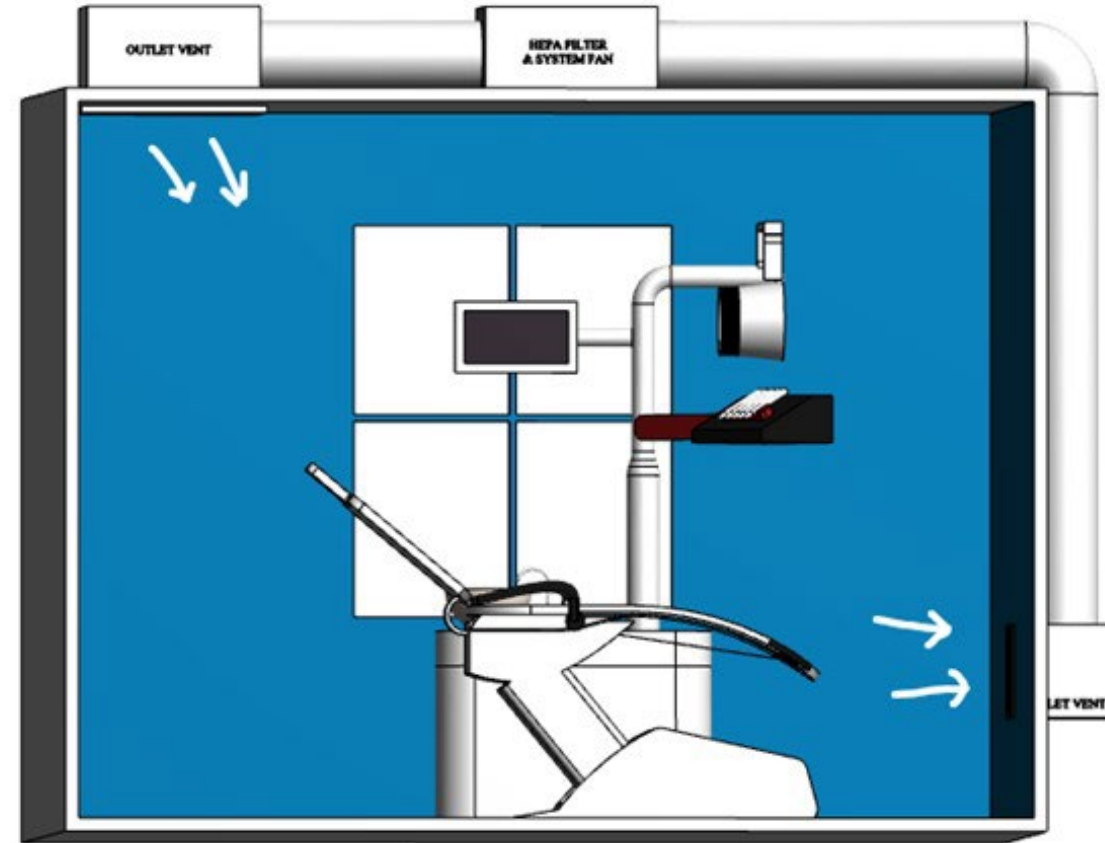
Graphic: Getty Images



* HEPA = High Efficiency Particulate Air

Generate clean-to-less-clean air movement

- Can be achieved using central HVAC system or portable HEPA units.
 - For central HVAC systems:
 - As necessary, reposition the supply air louvers, exhaust air grilles, and adjust damper settings.
 - Easier with ceiling grid systems.
 - For portable HEPA units:
 - Easier with flexible ductwork connections.
 - Can be done with temporary partitions.

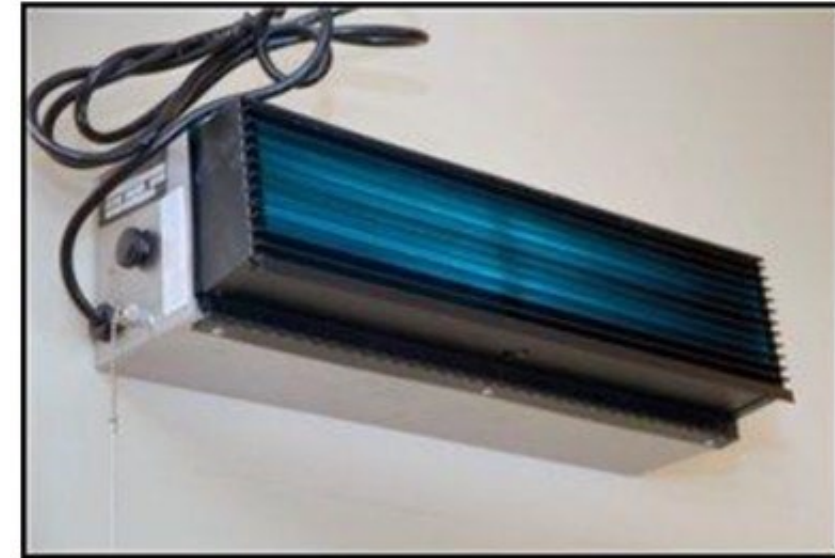


Graphic: CDC

Consider ultraviolet germicidal irradiation (UVGI)

[a.k.a. Germicidal Ultraviolet (GUV)]

- Should not be used alone, but as a supplemental treatment to inactivate SARS-CoV-2.
- Especially useful if options for increasing room ventilation and filtration are limited.
- Three types:
 - Upper-room UVGI systems provide air cleaning within occupied spaces.
 - In-duct UVGI systems can enhance air cleaning inside central HVAC systems. More powerful than typical coil cleaning systems.
 - Far UV systems (emerging technology).



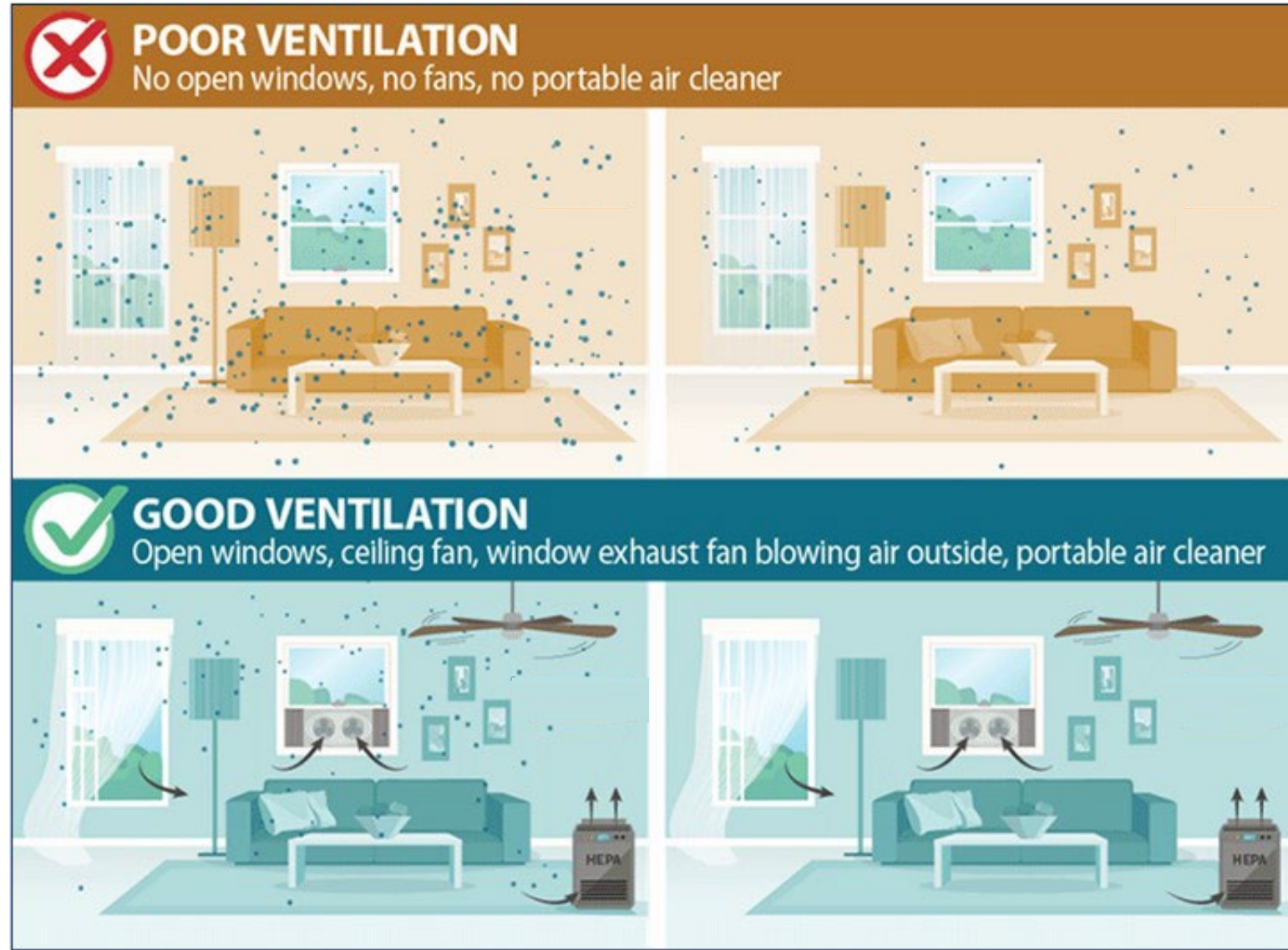
Ultraviolet Germicidal Irradiation UVGI

Photo: CDC.gov



Flushing with air

- Consider running the HVAC system to flush the building air after the building is occupied.
- Not applicable to residential buildings.



Graphic: cdc.gov

Costs

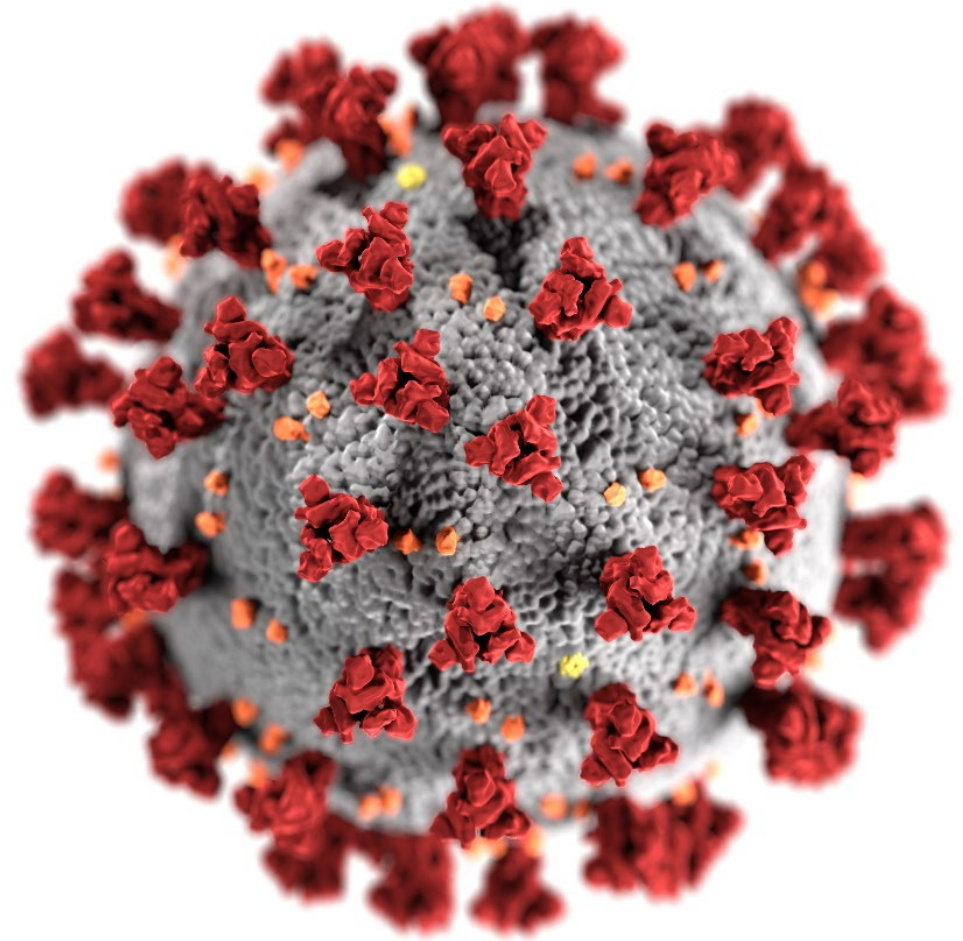
- Tools come with a range of initial costs and operating costs, which along with risk assessment factors, may affect the selection of tools.
 - No cost: opening windows; inspecting and maintaining dedicated exhaust ventilation; disabling Demand-Controlled Ventilation (DCV) controls; repositioning outdoor air dampers.
 - Less than \$100: using fans to increase effectiveness of open windows; repositioning supply/exhaust diffusers to create directional airflow.
 - \$500 (approximately): portable HEPA systems.
 - \$1500 to \$2500 (approximately): upper room UVGI.



Graphic: Getty Images

Ventilation in Buildings

Stephen B. Martin, PhD, PE
Respiratory Health Division
National Institute for Occupational Safety and Health (NIOSH)



cdc.gov/coronavirus

Ventilation Guidance Applied To School Settings:

Ventilation in Schools and Childcare Settings, February 26, 2021

(“Community” website)

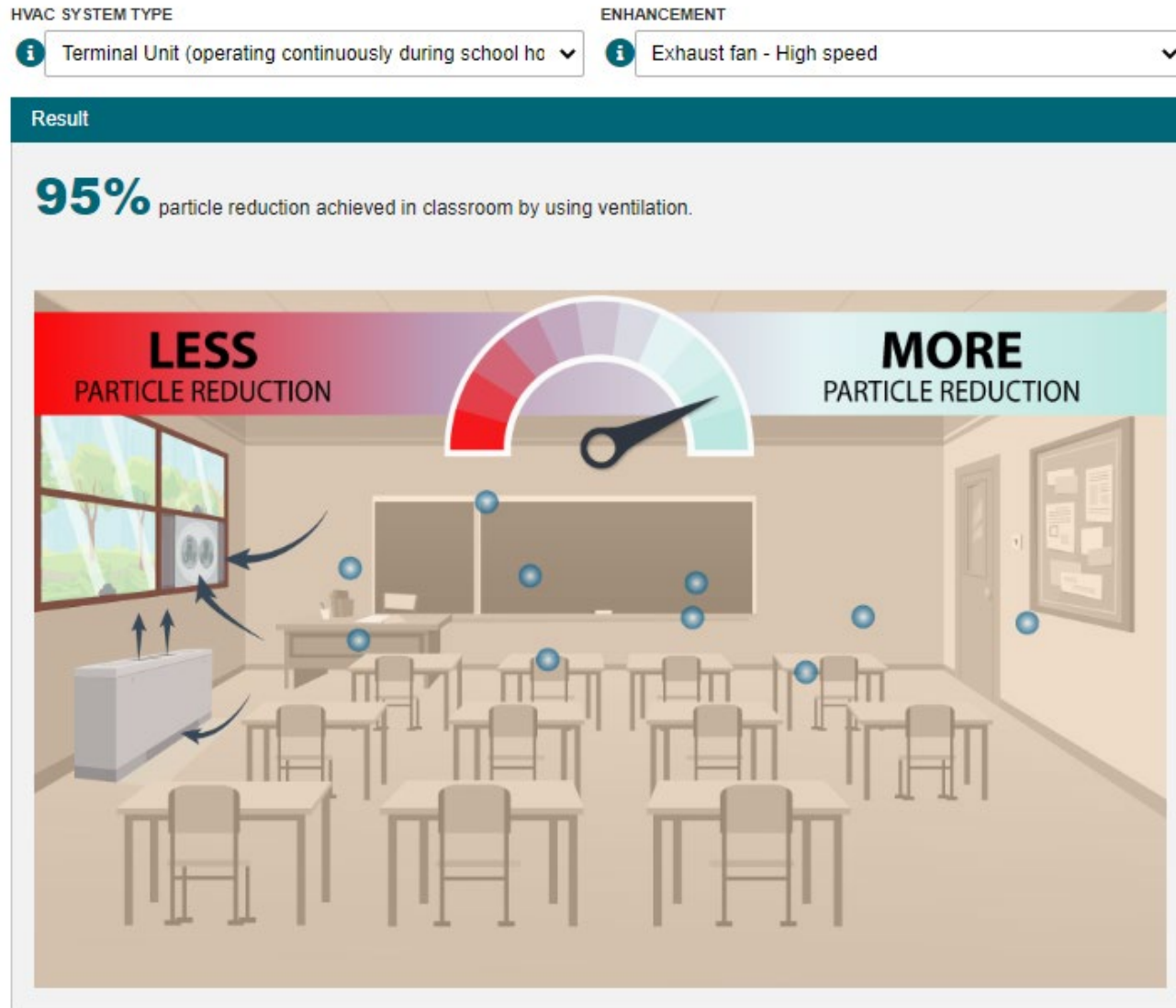


Opening windows, using portable air cleaners, and improving building-wide filtration are ways you can increase ventilation in your school or childcare program.



<https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html>

Interactive School Ventilation Tool:



How can I decrease the level of particles during the school day?

Select the options to see how particle levels change as you adjust ventilation settings. [\(To see the effects of these ventilation settings on different room sizes and HVAC system types, see this report from the National Institute of Standards and Technology.\)](#)

Interactive Home Ventilation Tool:

HVAC OPERATION

i Off/Not applicable

FILTER (SKIP IF NO HVAC SYSTEM)

i Premium (MERV 13)

PORTABLE HEPA AIR CLEANER

i Yes

OPEN WINDOW

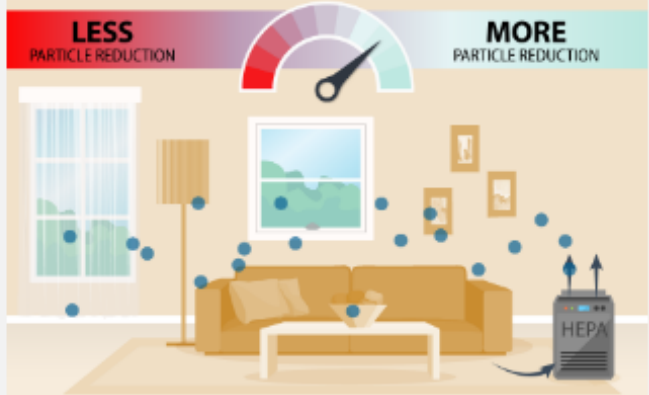
i No

EXTRA HOUR OF VENTILATION

i Yes

End of 4-hour visit


82% particle reduction achieved in your home by using ventilation.



The illustration shows a living room with a brown sofa, a white coffee table, a floor lamp, and a window. A HEPA air cleaner is on the floor. A gauge above the room shows a needle pointing to 82% on a scale from 0% to 100%. The scale is labeled 'LESS PARTICLE REDUCTION' on the left and 'MORE PARTICLE REDUCTION' on the right. Blue dots representing particles are shown being drawn into the HEPA cleaner.

1 Hour Later

97% particle reduction achieved in your home by using ventilation. You can decrease particles even more by continuing to ventilate for an extra hour.



The illustration shows the same living room as the previous panel. The HEPA air cleaner is still on the floor. The gauge above the room now shows a needle pointing to 97% on the same scale. There are fewer blue dots in the room, indicating further particle reduction.



Ventilation FAQs



Ventilation FAQs

<https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>

Ventilation FAQs

1. Can COVID-19 be transmitted through HVAC (ventilation) systems? ∨

2. How long will it take to dilute the concentration of infectious particles in a room once they are generated? ∨

3. Can ventilation filters effectively capture SARS-CoV-2 viral particles? ∨

4. What is meant by “directional airflow?” How and where should it be used? ∨

5. What is a HEPA filter and why use a portable HEPA air cleaner? ∨

6. Does ultraviolet germicidal irradiation (UVGI) kill SARS-CoV-2? ∨

7. What types of ultraviolet germicidal irradiation (UVGI) devices are available for cleaning and disinfection in the workplace? ∨

8. Many new air disinfection devices are marketed for their ability to inactivate SARS-CoV-2. How can I tell if they work as advertised? ∨

9. Can carbon dioxide (CO₂) monitors be used to indicate when there is good ventilation? ∨

10. Should indoor temperature and humidity be used to help reduce the risk of COVID-19 transmission? ∨

11. Can fans be used to decrease the risk of COVID-19 transmission indoors? ∨

12. Will using protective barriers interfere with improved ventilation? ∨



DIY Air Cleaners

Do-it-yourself (DIY) air cleaners are indoor air cleaners that can be assembled from box fans and square HVAC (or furnace) filters. They are sometimes used during wildfire events when air quality is poor and other filtration options are unavailable. There have been questions about whether DIY air filters can be effective in reducing virus particles in indoor environments. DIY air cleaners may provide some benefits for reducing concentrations of viruses and other indoor air pollutants, but research is limited and there are several important considerations explained below.

EPA does not recommend the routine use of DIY air cleaners as a permanent alternative to products of known performance (such as commercially available portable air cleaners). The performance of different DIY air cleaners will vary and cannot be reliably assessed without specialized instruments. Commercial devices have been tested for performance and can be chosen to match the size of a room.

EPA and Underwriter Laboratories evaluated the use of DIY air cleaners and the risk of fire. Fans that were built since 2012 and met UL standard 507 did not pose a fire hazard under the conditions tested in the study. (See [Research on DIY Air Cleaners to Reduce Wildfire Smoke Indoors](#) for more information.)

<https://www.epa.gov/coronavirus/air-cleaners-hvac-filters-and-coronavirus-covid-19>



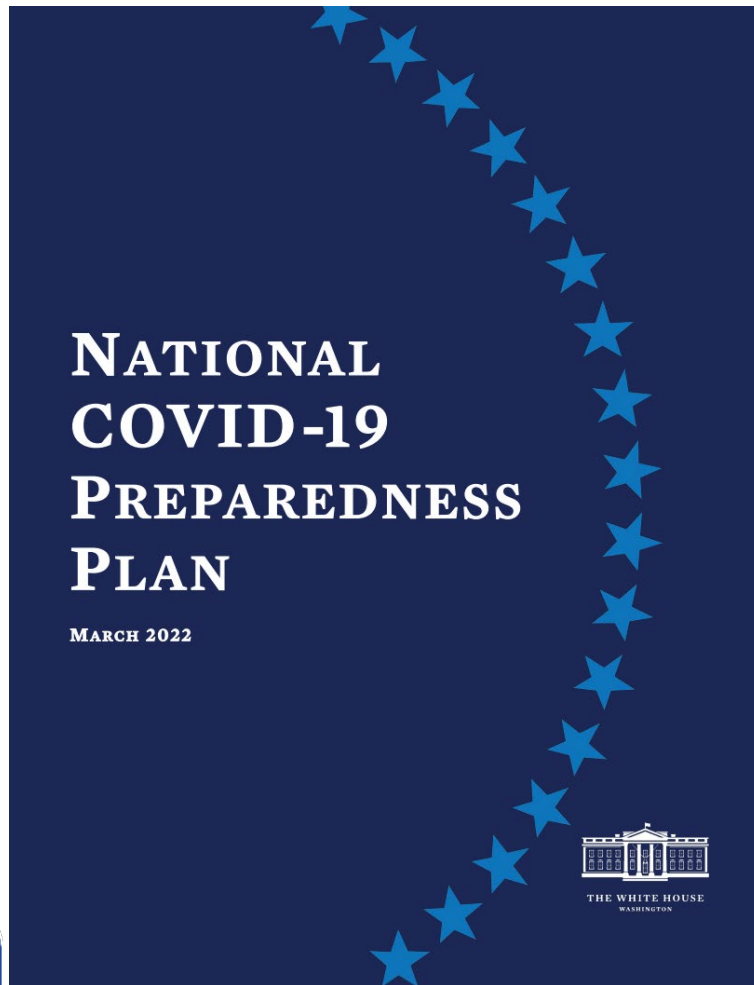
Source: media.ford.com



Source: en.wikipedia.org



New Opportunities

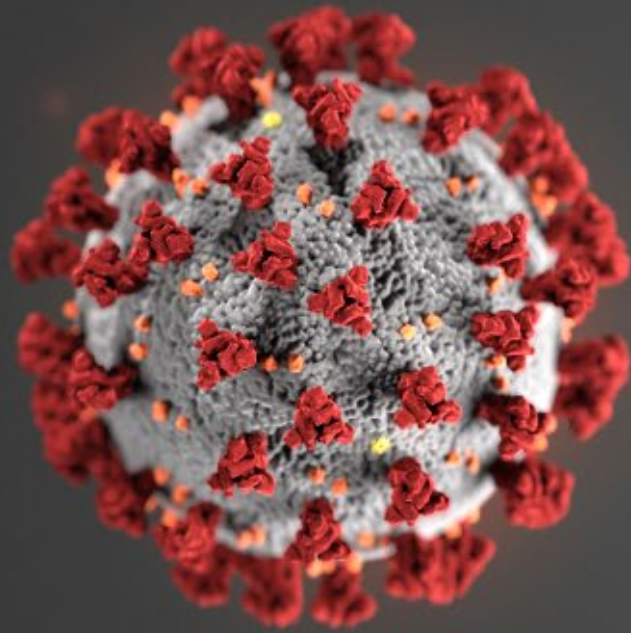


Clean Air In Buildings Challenge

1. *Create a clean indoor air action plan* that assesses indoor air quality, plans for upgrades and improvements, and includes HVAC inspections and maintenance.
2. *Optimize fresh air ventilation* by bringing in and circulating clean outdoor air indoors.
3. *Enhance air filtration and cleaning* using the central HVAC system and in-room air cleaning devices.
4. *Engage the building community* by communicating with building occupants to increase awareness, commitment, and participation.



https://www.epa.gov/system/files/documents/2022-03/508-cleanairbuildings_factsheet_v5_508.pdf



For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.



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- WHY INDOOR AIR QUALITY (IAQ) MATTERS

"We expect to have *clean water* from the taps.

We expect to have *clean and safe food* when we buy it in the supermarket.

In the same way, we should expect *clean air* in our buildings and any shared space."



People spend more than 90% of their time indoors



Indoor air quality can be 2 to 5 x worse than outdoor quality



Indoor air pollution is ranked as one of the top 5 environmental risks to public health



50% of illnesses are caused by aggravated indoor air pollution

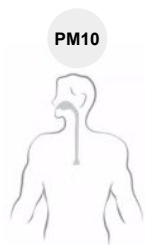
- IAQ: AIRBORNE POLLUTANTS AND THE IMPACT ON THE BODY

The size of a particle determines its capacity to penetrate into the body

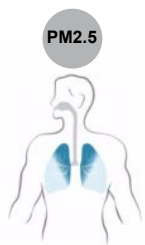
Particulate Matter damage to the lungs will impact their ability to properly oxygenate blood.

Poor blood oxygenation impacts the performance of vital organs in the human body.

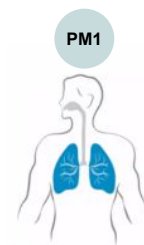
Airborne **Pathogens** (Viruses and Bacteria) cause illnesses and transmit diseases between people.



COARSE PARTICLES
UPPER RESPIRATORY TRACT



FINE PARTICLES
LOWER RESPIRATORY TRACT



VERY FINE PARTICLES
ALVEOLUS

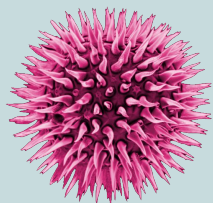


ULTRAFINE PARTICLES
BLOOD/WHOLE BODY

POLLEN

10-100 µm

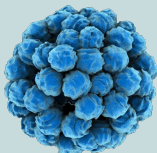
A fine powder from plants that aggravates allergies and makes it hard to breathe indoors.



MOLD

3-100 µm

A fungus that reproduces by forming airborne spores that settle onto other organic material and form into new clusters.



DUST

0.03-1000 µm

Particles that result from the disintegration of earth, sand and other matter.



PET DANDER

0.1-5 µm

Microscopic flecks of skin shed by pets and other animals with fur and feathers.



PM2.5

Up to 2.5 µm

Particulate matter up to 2.5 micrometers in size, such as fine dust, bacteria, viruses and mite feces. Major sources are traffic, candles, cooking and smoking.



SMOKE

0.01-1 µm

Particles containing a mixture of harmful substances that result from burning wood, tobacco or candles. Can be found indoors or outdoors, but produced on a massive scale in wildfires.



VIRUSES

0.005-0.1 µm

A small infectious agent that can infect all types of life form.



GASES

0.0003-0.001 µm

Toxic gases such as nitrogen dioxide, ozone and VOCs.



- WHY INDOOR AIR QUALITY (IAQ) MATTERS

Higher particulate matter (PM) levels means lower productivity

HARVARD
UNIVERSITY



THE STUDY


Poor indoor air quality doesn't just make us unhealthy. It makes us less productive



A major new study from Harvard University shows that there is a **direct relationship between the amount of fine particulate matter in the air and how people perform in mental tests.** The more polluted the air, the worse people perform.

Each interquartile increase in fine particulate matter of just **8.8 micrograms per cubic metre** was associated with a:


0.82%
increase in Stroop
response time


6.18%
increase in Stroop
interference time


0.7%
decrease in
Stroop throughput


1.51%
decrease in
ADD throughput

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More on the Harvard study can be [found here](#)

- INDOOR AIR QUALITY: THE ROAD TO REGULATION



WHO: has defined ventilation and purification standards to prevent airborne disease transmission: **10 litres per person per second** for non-residential (offices, schools etc) and residential settings, 60 l/p/s for healthcare settings (but 160 l/p/s where AGPs are performed).



USA: the EPA “Clean Air in Buildings Challenge” helps fulfill the commitment of the Biden-Harris Administration’s National COVID-19 Preparedness Plan, by providing information and recommendations that can help improve Indoor Air Quality (IAQ).



UK: The Clean Air (Human Rights) Bill, currently going through government, calls for tight IAQ standards that should be regulated. Furthermore, the National Engineering Policy Centre (NEPC) has called for a major reform of ventilation and purification to improve infection resilience across all buildings and public transport. Their recommendations include the establishment of IAQ standards that should be monitored and regulated.



Belgium: the government has introduced a legislative framework to govern indoor air quality in public spaces. Broad in scope, it covers monitoring and risk analysis to action plans, certification and a knowledge platform for sharing insights.

- INTERNATIONAL LESSONS

Perspectives from abroad - UK National Health Service

- Different spaces require different levels of ventilation and today's levels might be insufficient:
 - While Operating Rooms, AGP and ICU are well ventilated, areas such as hospital wards (patient rooms) and A&Es can lack sufficient ventilation
 - Example: Patient with respiratory illness enters A&E
- Convertible spaces need the ability to improve ventilation depending on use
 - Covid (pandemic wards) wards need substantial ventilation
- Older buildings often do not deliver the ventilation rates expected
 - Performance drops off over time due to e.g. leakage
 - Ventilation standards are design standards only, unclear when reviews are made
- NHS focus on upgrading ventilation in AGPs and wards
 - Dentistry and Spirometry particular focus
- New research and studies are being carried out



Air Changes per Hour Requirements

Minimum	1
Hospital Ward	6
ICU	8
Centists/AGPs	10
Operating Theatre	25

Study: Improving IAQ in a dentist treatment room

ESI & Birmingham University Hospital

WP2: Dental Treatment Room – Birmingham Hospital

Open volume is 44.7m³

3 occupants and equipment included

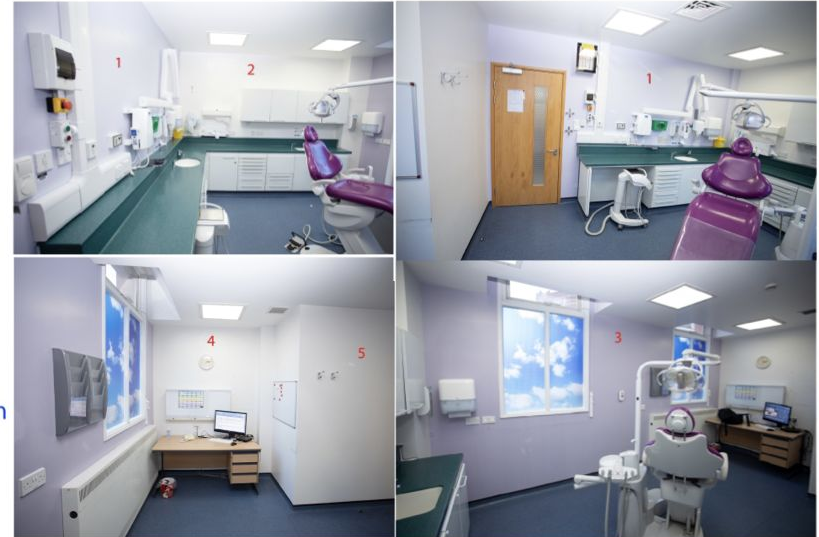
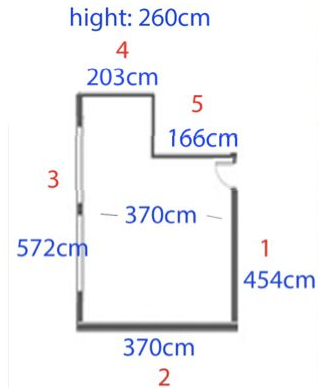
Mechanical Ventilation

- Vent air supply @ 5ACH
- Extract exactly balanced

Windows/door closed

Air supply diffuser

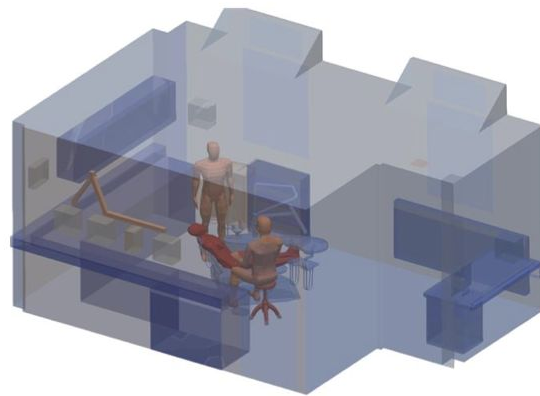
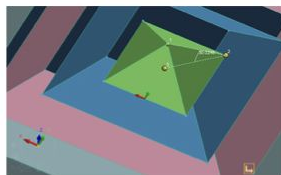
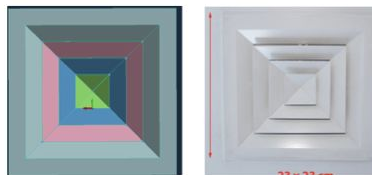
- Louver angle 30° from horizontal



WP2: Dental Treatment Room – Birmingham Hospital

CFD MODEL

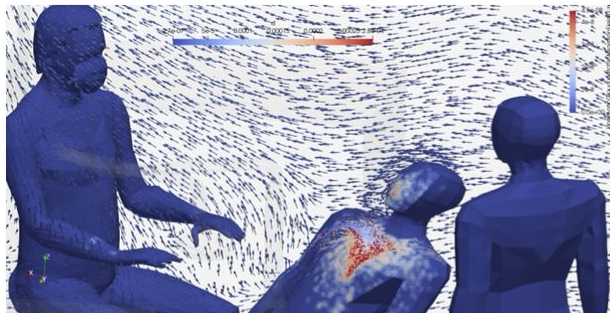
- Vent air supply @ 5ACpH
- Extract exactly balanced
- Windows/door closed
- Open volume is 44.7m³
- 3 occupants and equipment included
- Air supply diffuser
 - Louver angle 30° from horizontal
- Rensair device in positions
 - **P1:** Max (560m³/h) setting with ventilation ON and OFF
Min (300m³/h) setting with ventilation ON
 - **P2:** Max (560m³/h) setting with ventilation ON and OFF



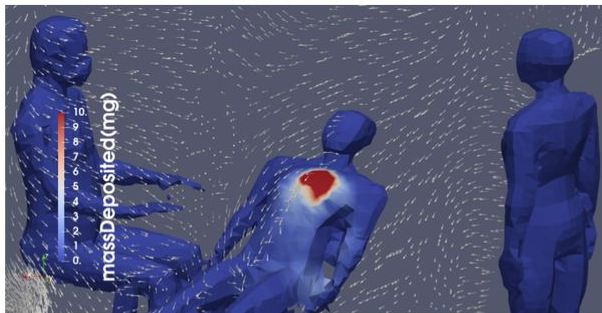
Dental AGP – Deposition and near-patient flow field

All cases, P1/P2 with mechanical ventilation ON/OFF

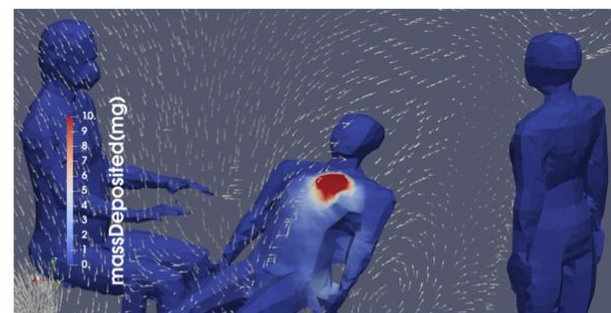
DATUM: no Rensair + M_{ON}



P₁ : 560 + M_{ON}



P₁ : 560 + M_{OFF}



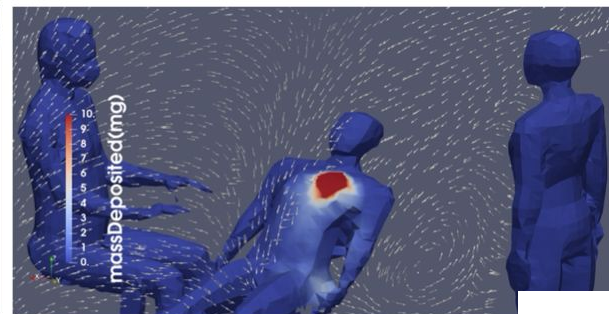
P₁ : 300 + M_{ON}



P₂ : 560 + M_{ON}

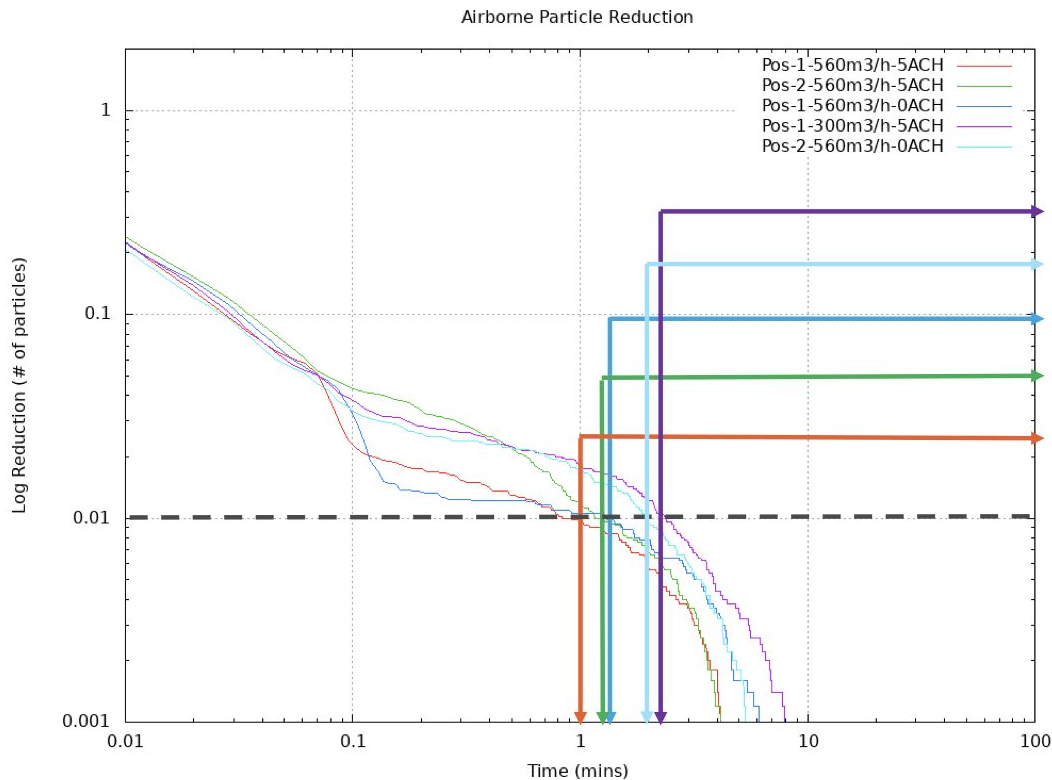


P₂ : 560 + M_{OFF}

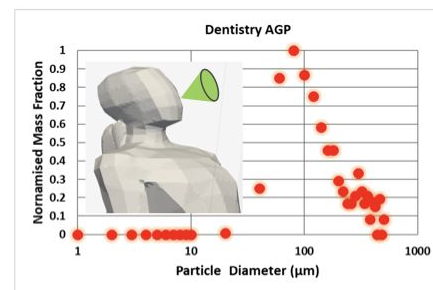


In-situ modelling – Dental AGP Log-2 (99%) clearance

Combinations of 220m³/h mechanical and 300/560m³/h enhanced



	Average Age Of Air (s)	eACH	Log-2 Clearance time (min)
Pos-1-300m ³ -5ACH	234	11.8	2.37
Pos-2-560m ³ -0ACH	234	12.6	1.95
Pos-1-560m ³ -0ACH	221	12.6	1.30
Pos-2-560m ³ -5ACH	170	17.6	1.23
Pos-1-560m ³ -5ACH	158	17.6	0.84



How do we translate IAQ regulation/best practices into action?

- Actionable measures can be taken now
 - Review existing ventilation
 - Develop a plan for addressing shortcomings
 - Educate stakeholders
- Let IAQ be a differentiator
 - IAQ can easily be monitored and displayed
 - Upgrade ventilation in patient and staff areas
- Further research and testing
 - Impact of good IAQ in different health settings
 - IAQ technology and innovation

RENSAIR

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