CONTAMINATED AIR:
The Invisible Threat to Patients and Healthcare Workers.
Now are you worried about the air?

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IMPROVING INDOOR ENVIRONMENTS EVERYWHERE

BIOGRAPHY

- Chief Medical Affairs and Science Officer, UV Angel
- Founding member of Stericycle
- MD Anderson Cancer Center, AVP Admin Facilities and Campus Operations
- Adjunct Faculty, UT Health School of Public Health Epidemiology
- CH2M Hill, Global Practice Director - focusing on complex environmental health, threat detection, mitigation and response and biological-chemical safety projects
- WM Healthcare Solutions, Director of Operations
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- Published author – AHA
- Certified in Infection Control by the Board of Infection Control and Epidemiology
- Public Health Practitioner

LEARNING OBJECTIVES

- **Review what we currently know about SARS-CoV2 and COVID-19**
- **Understand how air becomes contaminated in indoor environments**
- **Explain how pathogenic particles travel on air currents**
- **Describe the dangers that pathogenic air particles pose to people**
- **Learn how ultraviolet light in the C spectrum (UV-C) air purification can reduce aerosols and minimize contamination on surrounding surfaces**

Disclosure:
DNVGL Hospital Accreditation Surveyor (Physical Environment and Infection Prevention)
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Review Of SARS-CoV2

How does it spread and How long does it live[1]

Virology

- Single strand, positive sense RNA
  - Allows for quick mutation which is similar to other novel emerging viruses
  - Binds to ACE-2 receptors present in the kidneys, myocardium and lungs
  - 96% identical in whole genome of other bat coronavirus samples
  - Virus is very adaptable in the environment
  - The virus has a large genome (26-32 kb) which makes it easy to transmitted between animals and humans

Transmission

- Primarily respiratory droplets
- Close contact
- Surfaces (0-3 days, but found on the Princess cruise ship 17 days after all passengers were evacuated)
- Temperature and Humidity are very important
- Now Airborne! (What does that even mean?)

Pathogenesis of SARS-C0V2[2]

Incubation

- About 1 week, people shed virus about 1 to 2 days before symptoms in the pre-symptomatic phase

Emergence of symptoms

- Ability to invade respiratory and digestive system
- 90-95% of disease is self limiting and 25-50% are asymptomatic

Severe Symptoms (5-10%)

- Bilateral pneumonia
- 02 desaturation
- Two weeks after initial infection
  - ARDS requiring mechanical ventilation
  - Multi system organ failure
  - Death

Routes of Transmission Spread

Direct

- Respiratory Droplets exhaled by infected persons, inhaled by healthy susceptible person

Indirect

- Infected person touches a common surface or object (pens, doorknob, phone, shopping cart) leaves their respiratory droplets on the surface or object, healthy susceptible person touches the object or surface then touch their nose, mouth or eyes. Also known as touch transfer.

Countermeasures

- To break these transmission route mitigations must be instituted.
  - Direct= masks, air treatment controls, barriers, social distancing, outdoor air dilution
  - Indirect= cleaning and sanitizing fomites, hand washing, avoiding touching nose, face, eyes and mouth.

UNDERSTANDING A COMPLEX PROBLEM

Transmission happens when you don't even know it

INFECTED PEOPLE

40% of people with COVID-19 are asymptomatic carriers (according to CDC).

CLOSE QUARTERS

Interacting indoors close to each another puts people at risk of transmission.

TRANSMISSION

The air is a proven pathway for transmission.

FOMITES

High-touch surfaces become fomites for transmissions.

Asymptomatic Spread

- It is reported that 40-45% of all cases are asymptomatic spread. That is spread with by persons with high enough viral load to spread disease and no has symptoms.
- Pre-symptomatic persons will have high enough viral load to spread disease by will develop the disease.
- Both can have similar viral load and viable virus cycles (cycles between high particle load and low particle load)
- Risk of transmission when a person has symptoms is 2x higher because symptoms (coughing and sneezing) put more particle into the air.
- Viral loading is recognized as a strong determinate of transmission risk. The ID 50 of SARS-CoV2 has been reported as low as 10^7shedding viral copies. (3)
- A person infected with SARS-CoV-2 exposes more people within equivalent physical contact networks than a person infected with influenza, likely due to aerosolization of virus. (3)

Super Spreading Events

- These events are believed to share point source exposures by relatively small numbers of close contacts. (4)
- Overall secondary attack rate 35% (95%CI 27-44%; range 21-100%) from the Sturgis Motorcycle Rally in South Dakota Aug 7-16, 2020.
- There were 460,000 participants with an estimated 266,769 cases associated with the event.
- The estimate cost of care was $21.2 billion or 19% of the 1.4 million cases of COVID-19 in the US between Aug 2nd and Sept 2nd. (5)

Source Control

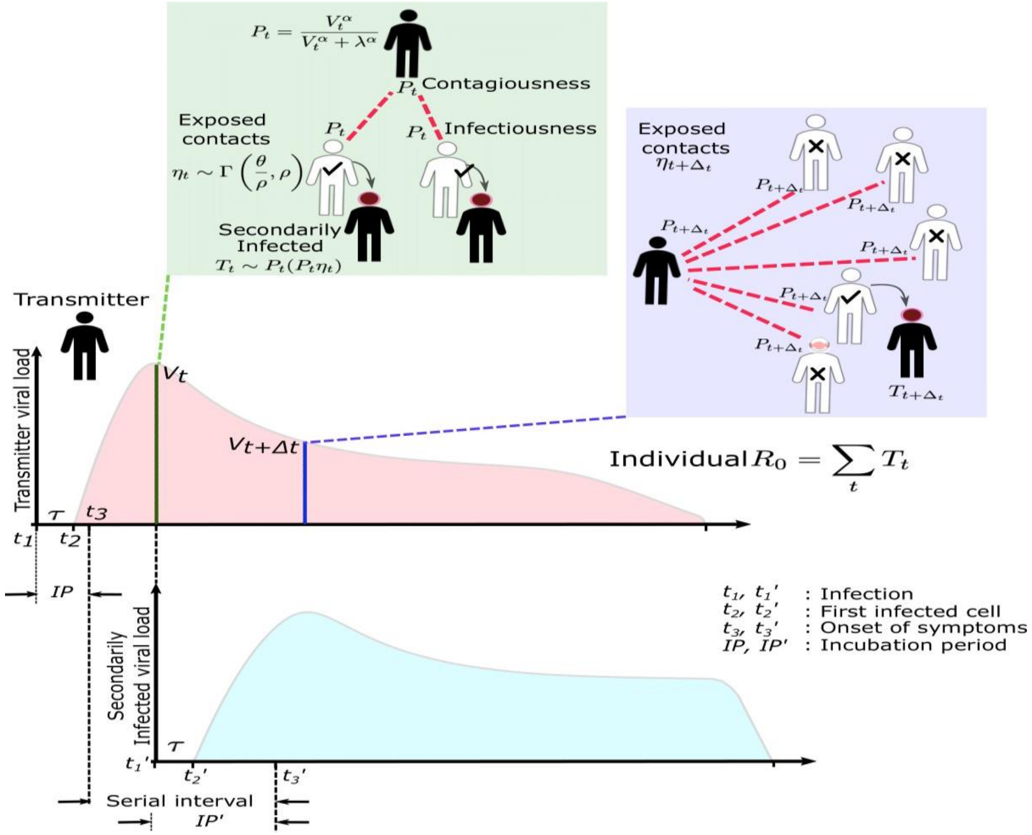


Fig 1. SARS-CoV-2 and influenza transmission model schematic. In the above cartoon, the transmitter has 2 exposure events at discrete timepoints resulting in 7 total exposure contacts and 3 secondary infections. Transmission is more likely at the first exposure event due to higher exposure viral load. (3)

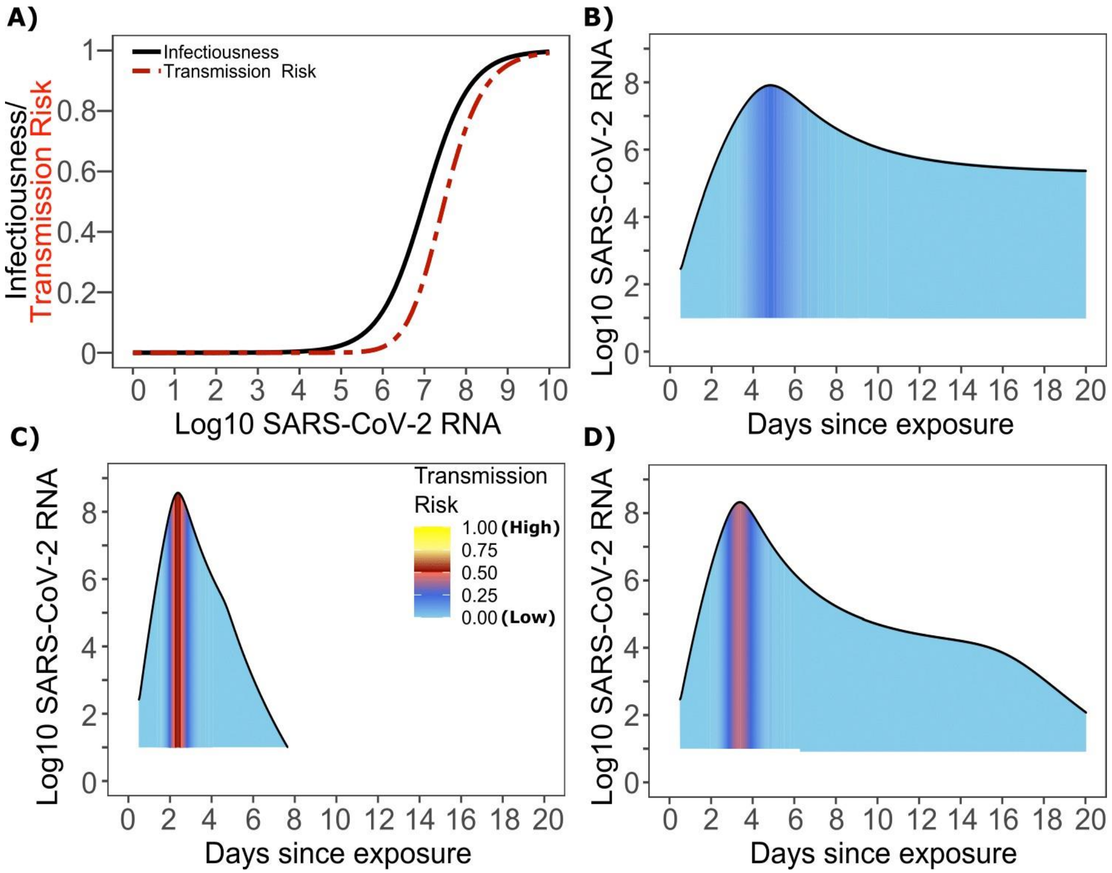
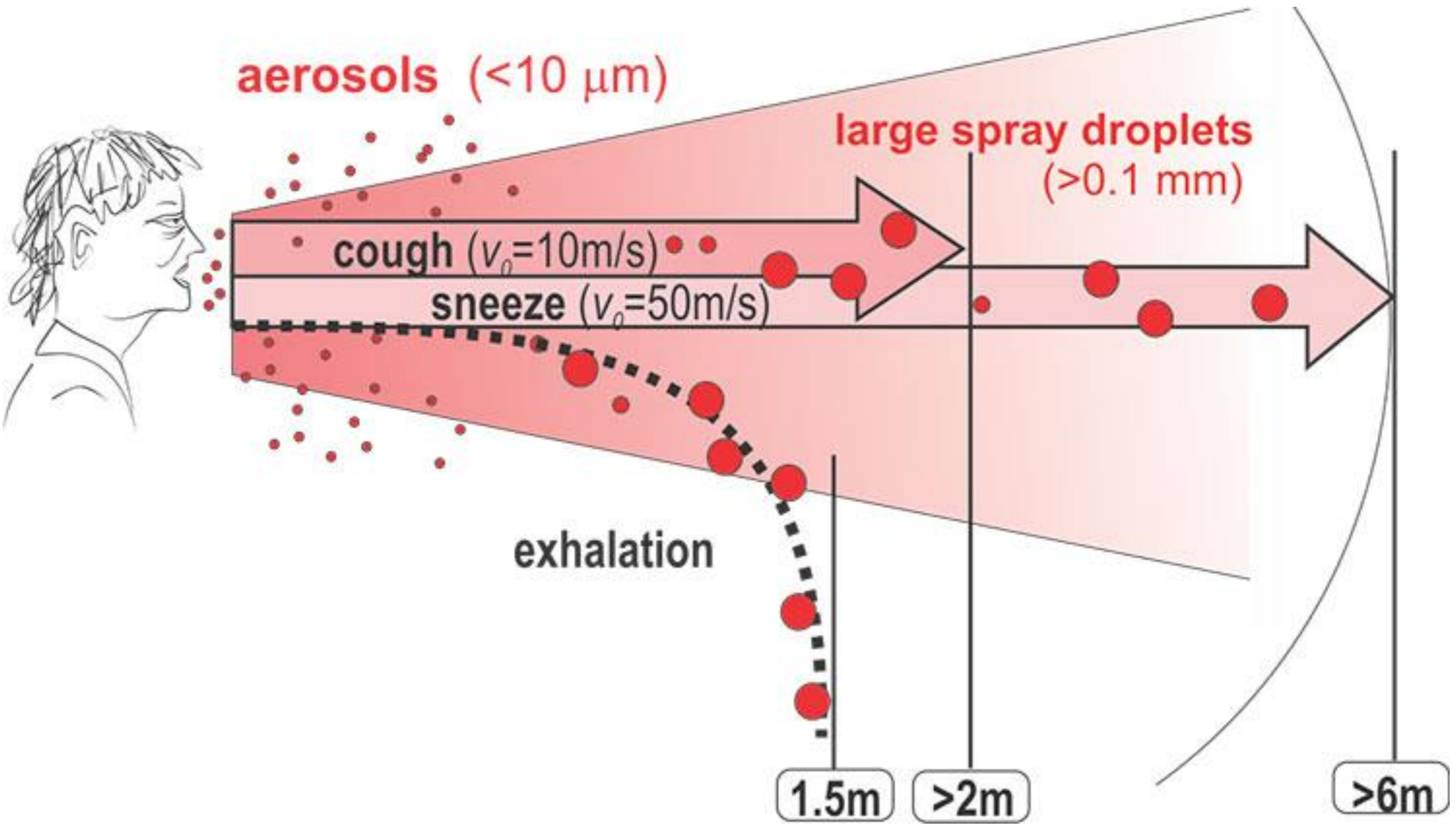


Fig 3. SARS-CoV-2 transmission probability as a function of shedding. A. Optimal infectious dose (ID) response curve (infection risk = *Pt*) and transmission dose (TD) response curve (transmission risk = *Pt* * *Pt*) curves for SARS-CoV-2. Transmission probability is a product of two probabilities, contagiousness and infectiousness (3)

Particle size and speed



FEDERAL RECOMMENDATIONS FOR ENGINEERING CONTROLS

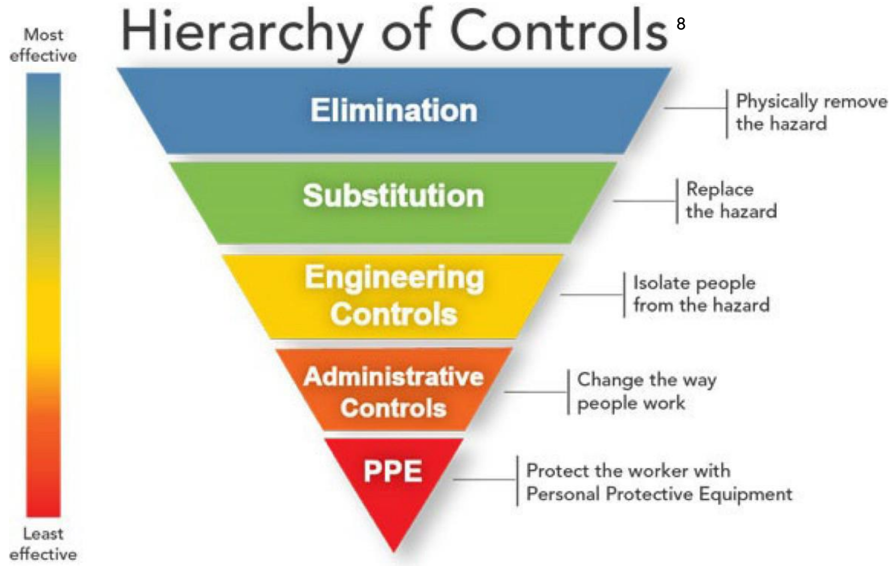
COVID-19 Response

OSHA

The **most effective** protection measures are (listed from **most effective** to **least effective**) In most cases, **a combination of control measures will be necessary to protect workers from exposure to SARS-CoV-2.** These types of controls reduce exposure to hazards **without relying on worker behavior** and can be the **most cost-effective** solution to implement.[6]

ASHRAE

Strongly recommend; good evidence - **Upper-room UVGI (with possible in-room fans)** as a supplement to supply airflow
Strongly recommend; good evidence - Enhanced filtration (higher minimum efficiency reporting value [MERV] filters over code minimums in occupant-dense and/or higher-risk spaces)[7]



[8]

WHAT THE SCIENCE TELLS US ABOUT HIGH-TOUCH SURFACES

Even in a clean environment, surfaces are constantly being contaminated

How Bad is It?

- Average clinician touches **115-130 times** in 24 hours
- Most common item touched in patient room besides the patient is **medical cart**, which can lead to transmission

Computer keyboards and mice are used in many work settings **and** have shown to harbor pathogens

A study on airport kiosks measured **253,857 CFUs** compared to the average **172 CFUs** found on a toilet seat

Even in a Hospital, Surfaces are Contaminated

- Of 203 samples, **95.1% were positive for bacteria**.
- 25% of samples had **HAI-related bacteria**.

UV-C can Neutralize Hearty Pathogens

- UV Angel Adapt reduces pathogens like **MRSA, E.coli, & C. diff** spores within 1 cycle

Control Spread

- AJIC study showed **>99% reduction** in keyboard bioburden treated with UV-C
- CDC - Individuals whose hands are contaminated with a live virus may contaminate up to **7 additional clean surfaces.**

HAZARDS OF SHARED MEDICAL EQUIPMENT

INCREASED RISK

- In 2017 AJIC study[9], hospitalized patients had **1.4 interactions** per hour with medication carts that traveled between patient rooms.

TRANSMISSION

- Patients frequently had direct or indirect interaction with medical equipment or other fomites that were shared with other patients.

PROOF

- Equipment was often found to be contaminated with healthcare-associated pathogens.
- **12%** of the cultures found MRSA, VRE or *C. difficile*.

"Our findings suggest that there is a need for protocols to ensure effective cleaning of shared portable equipment"

Suwantarat, et. al

*Nuntra Suwantarat, Laura A. Supple, Jennifer L. Cadnum, Thriveen Sankar, Curtis J. Donskey, Quantitative assessment of interactions between hospitalized patients and portable medical equipment and other fomites, *AJIC*, Volume 45, Issue 11, Pages 1276–1278

CURRENT CLEANING PROCEDURES… We still have problems

HANDWASHING

DAILY CLEANING

DEEP CLEANING

HIGH-TOUCH SURFACES

10 HOSPITAL SITE ANALYSIS, N=2,079

Of the 2,079 samples 1,464 samples were positive for clinically relevant organisms (70%) Below are the average CFU for the organisms tested. (hospital group no-pass policy greater than 10 CFU)

Organism	Average CFU
Total aerobes	111*
Staphylococcus aureus	34
Methicillin-resistant Staphylococcus aureus	35
Enterococcus	137
Vancomycin-resistant enterococcus	54
Gram-negative bacilli	196
Candida spp.	60
Clostridioides difficile	N/A
Too Numerous To Count (limit is 250 CFU) Gram Negative Enterococcus	38% (549) 199 42

- All surfaces sampled; WOW Work Surfaces, WOW Keyboard, Wall Arm Keyboard, Nurse Station Keyboard, Patient Vitals Monitor, Pyxis Machines, IV Pumps
- Surface with the highest number of samples positive for HAI Bacteria: Nurse Keyboard (26%), WOW Work Surface (25%), Wow Keyboard (23%)
- Most contaminated surface by avg CFU'S: Pyxis Machine (171 CFU), WOW Work Surface (114 CFU), WOW Keyboard
- Most clinically relevant surface contamination by percent: Wall arm keyboard (86%), WOW Work Surfaces (79%)

WHAT GOES UP MUST COME DOWN.

Pathogens travel on air

and can lead to infection.

Surface contamination is directly affected by the air.

THE INVISIBLE THREAT




WHAT THE SCIENCE TELLS US ABOUT AIR

Air transports the pathogens that contaminate people and surfaces

How bad is it?

- Air is up to **8 times more contaminated** than surfaces
- The air is most contaminated in a room **1 hour** after cleaning

All pathogens can become airborne

- NIH reports Coronavirus remains airborne up to **3 hours**
- MRSA counts remain elevated up to **15 minutes** after bedmaking

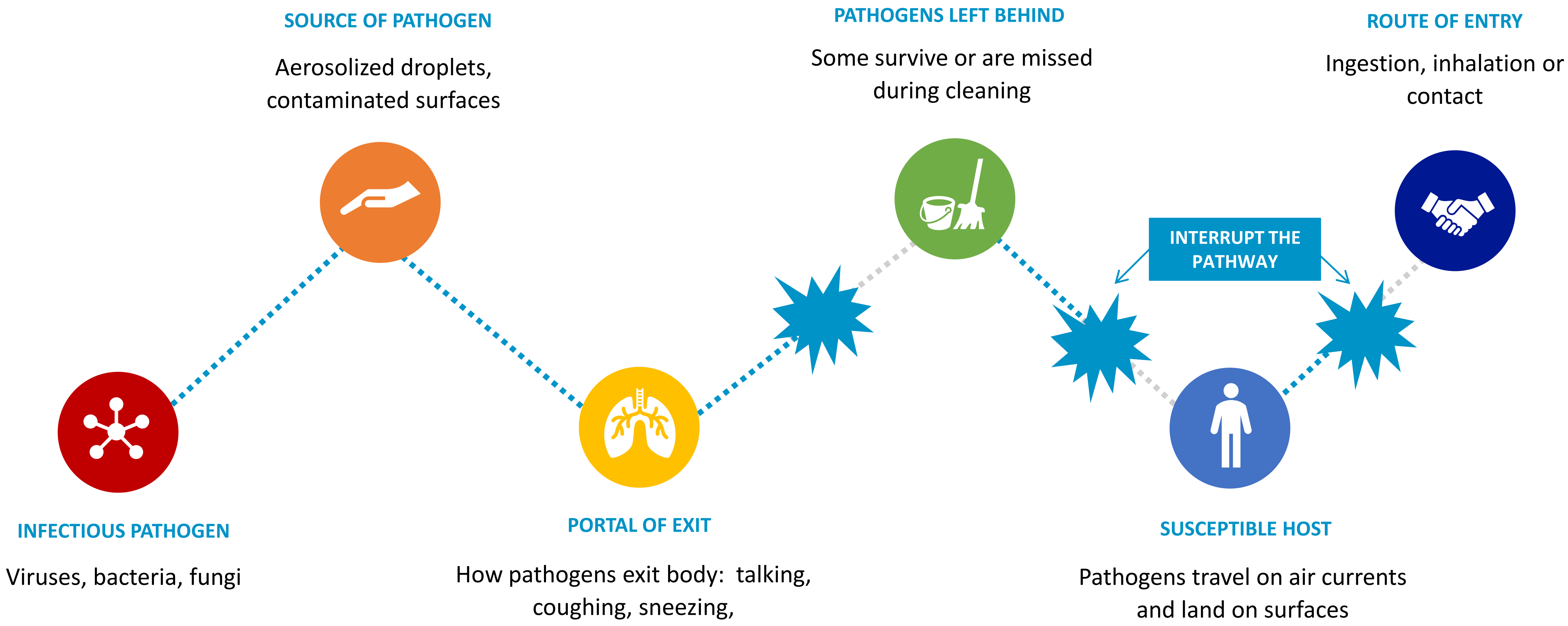
Even breathing can spread infection

- Influenza patients breathe the virus out in tiny particles that can stay suspended in the air for minutes or hours

Treating the air, cleans the surfaces

- Reducing pathogens from the air can **lower surface contamination** by as much as **66%**

INTERRUPT DISEASE TRANSMISSION



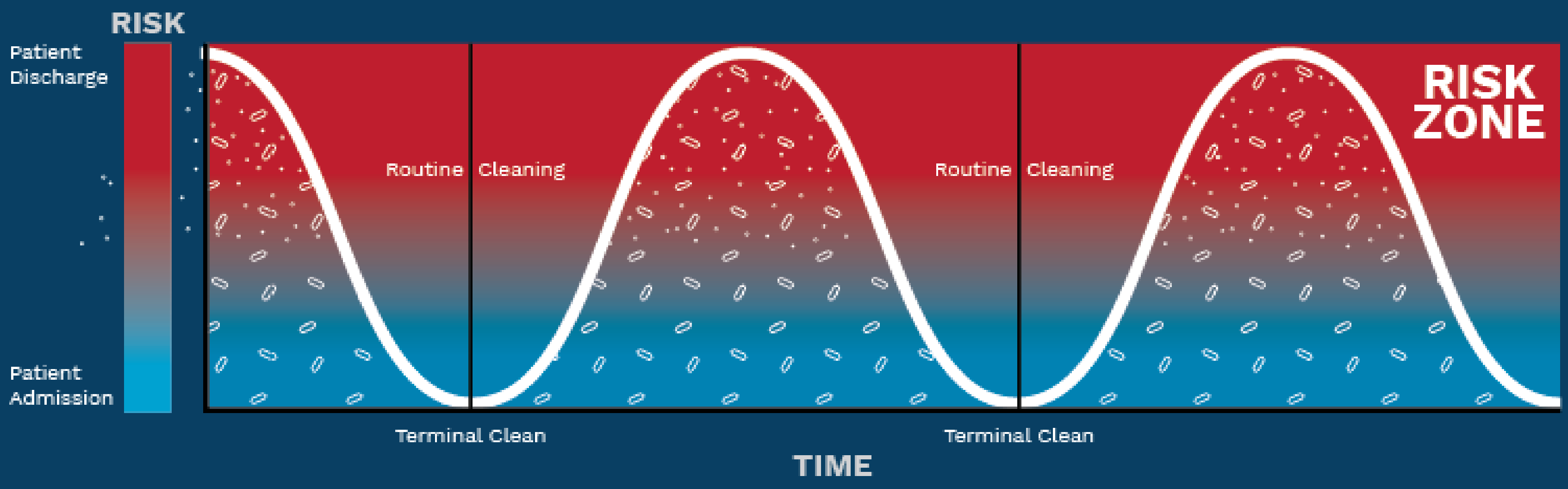
PRIOR ROOM OCCUPANCY INCREASES RISK

WHERE DID THE PATHOGENS COME FROM IN TERMINALLY CLEAN ROOM?

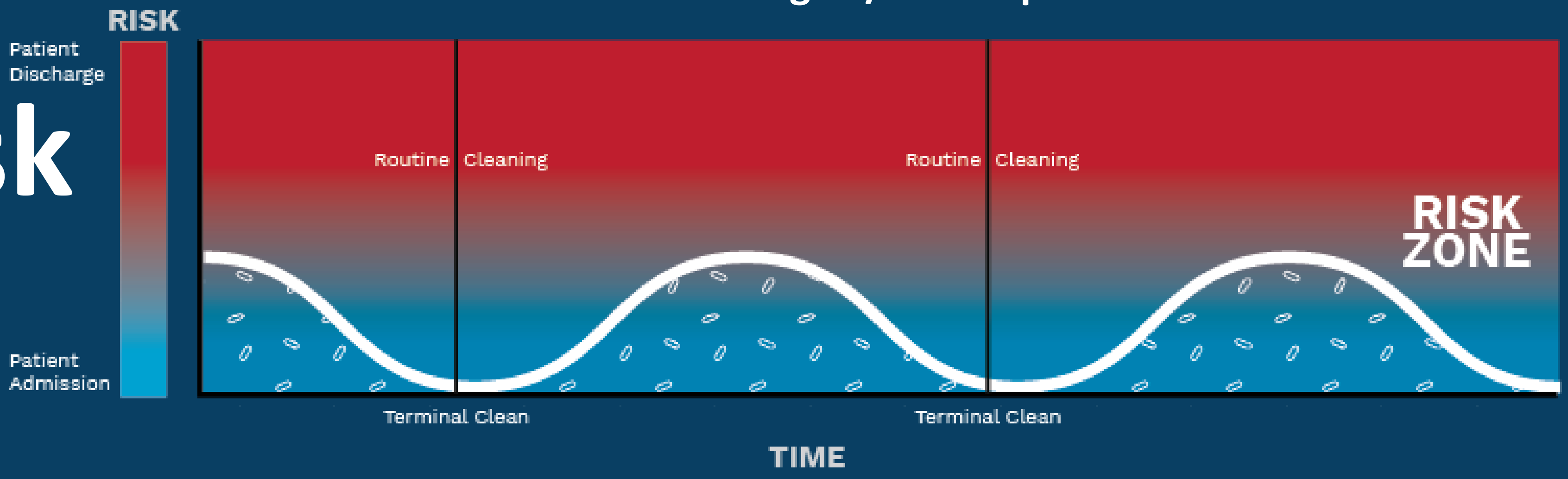
Study	Healthcare-associated pathogen	Likelihood of patient acquiring HAI based on prior room occupancy (comparing previously 'positive' room with a previously 'negative' room)
Martinez 2003	VRE – cultured within room	2.6x
Huang 2006	VRE – prior room occupant	1.6x
	MRSA – prior room occupant	1.3x
Drees 2008	VRE – cultured within room	1.9x
	VRE – prior room occupant	2.2x
	VRE – prior room occupant in previous 2 weeks	2.0x
Shaughnessy 2008	*C. difficile* – prior room occupant	2.4x
Nseir 2010	A. baumannii – prior room occupant	3.8x
	P. aeruginosa – prior room occupant	2.1x

Episodic Cleaning Protocols Have Inherent Risk

Before using 24/7 UV-C protocols



After using 24/7 UV-C protocols



The Glass Container

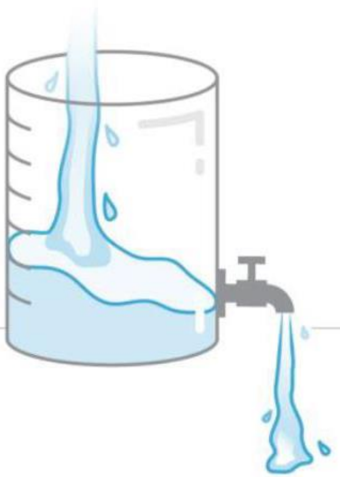
Laboratory Versus Real-Word Settings

"A person typically sheds some **37 million bacteria** into the surrounding air or onto surfaces touched."

Designing a Hospital to Better Fight Infection
April 27, 2015 – By Robert Lee Hotz
The Wall Street Journal

UV System in a lab setting

Hospital without **UV System**



Hospital with **UV System**

The Problem

Understanding Air Technology Controls

Besides your mask!

WHY IS THE AIR IMPORTANT?

SURFACE CLEANING EFFORTS ARE NOT ENOUGH

Well-child visits account for 700,000+ new influenza cases costing $500m annually

2011 study of 150,000 people, 82% visited doctor or dentist prior to diagnosis, without visiting hospital

69% of infrequently touched (high-dust) surfaces positive for *C. difficile* in elderly ward

Is Alzheimer’s caused by fungus?

380,000 die in LTCF annually (CDC)

MRSA and C. difficile survive for months on surfaces

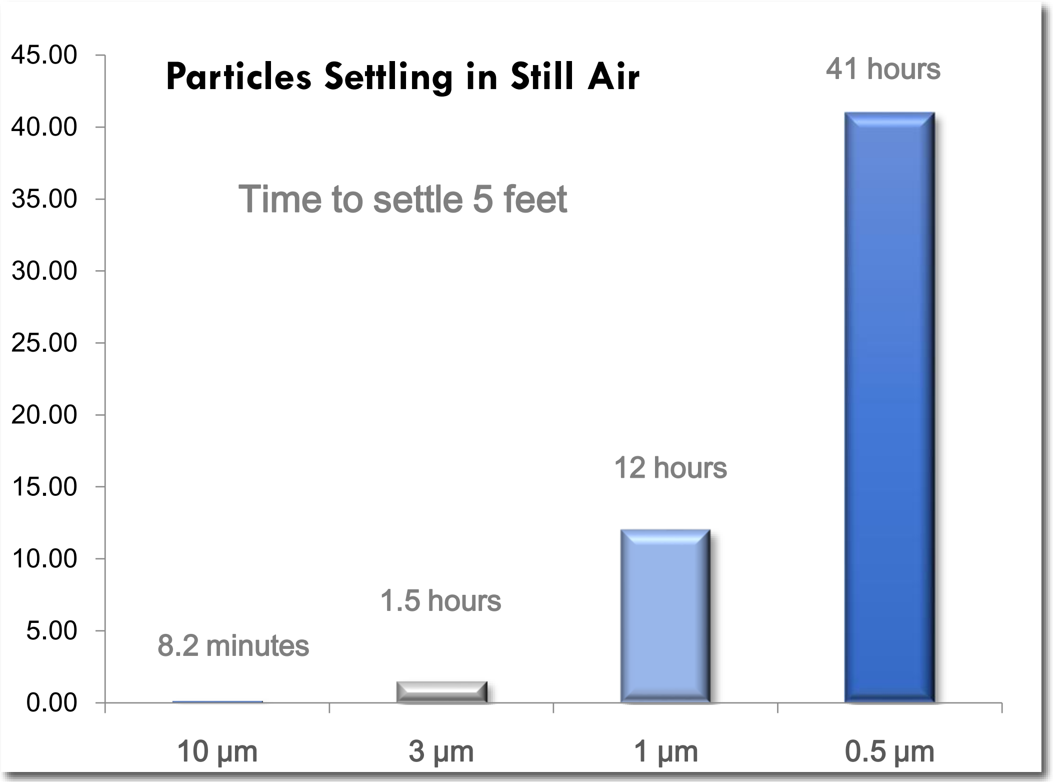
Airborne dispersion plays role in non-respiratory infections

CURRENT HVAC UV-C AND FILTRATION –

Pathogen Resistance to Disinfectant Chemistries

	Microorganism	Example
More Resistant ↑	Mycobacteria	*Mycobacterium tuberculosis (TB), M. terrae, M. chelonae*
	Small, Non-Enveloped Viruses	Poliovirus, Parvoviruses, Papilloma viruses
	Fungal Spores	*Aspergillus, Penicillium*
	Gram Negative Bacteria	*Pseudomonas, Providencia, Escherichia*
	Large, Non-Enveloped Viruses	Adenoviruses, Rotaviruses
	Gram Positive Bacteria	*Staphylococcus, Streptococcus, Enterococcus*
Less Resistant	Enveloped Viruses	HIV, Hepatitis B virus, Herpes Simplex Virus

Particles Float on Air



Microbe	Type	Size - µm
Paravovirus B19	Virus	0.022
Rhinovirus	Virus	0.023
Coxsakievirus	Virus	0.027
Norwalk virus	Virus	0.029
Rubella virus	Virus	0.061
Rotavirus	Virus	0.073
Reovirus	Virus	0.075
Adenovirus	Virus	0.079
Influenza A virus	Virus	0.098
Coronavirus (SARS)	Virus	0.110
Measles virus	Virus	0.158
Mumps virus	Virus	0.164
VZV	Virus	0.173
Mycoplasma pneumoniae	Bacteria	0.177
RSV	Virus	0.190
Parainfluenza virus	Virus	0.194
Bordetella pertussis	Bacteria	0.245
Haemophilus influenzae	Bacteria	0.285
Proteus mirabilis	Bacteria	0.494
Pseudomonas aeruginosa	Bacteria	0.494
Legionella pneumophila	Bacteria	0.520
Serratia marcescens	Bacteria	0.632
Mycobacterium tuberculosis	Bacteria	0.637
Klebsiella pneumoniae	Bacteria	0.671
Corynebacterium diphtheriae	Bacteria	0.698
Streptococcus pneumoniae	Bacteria	0.707
Neisseria meningitidis	Bacteria	0.775
Staphylococcus aureus	Bacteria	0.866
Staphylococcus epidermis	Bacteria	0.866
Streptococcus pyogenes	Bacteria	0.894
Clostridium perfringens spores	Bacteria	1.000
Mycobacterium avium	Bacteria	1.118
Nocardia asteroides	Bacteria	1.118
Acinetobacter	Bacteria	1.225
Enterobacter cloacae	Bacteria	1.414
Enterococcus	Bacteria	1.414
Haemophilus parainfluenzae	Bacteria	1.732
Clostridium difficile spores	Bacteria	2.000
Aspergillus spores	Fungi	3.354
Cryptococcus neofrmans spores	Fungi	4.899
Rhizopus spores	Fungi	6.928
Mucor spores	Fungi	7.071
Fusarium spores	Fungi	11.225
Blastomyces dermatitidis spores	Fungi	12.649

National Institute for Occupational Safety and Health
NIOSH

TESTING

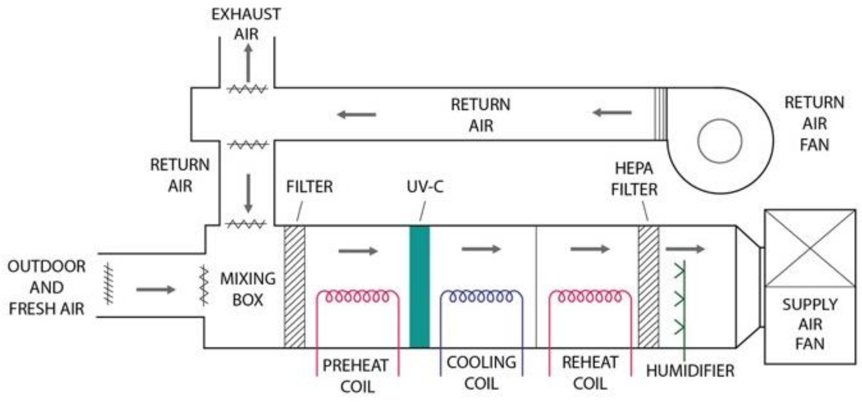
Table 4: Combined UV + Filter Removal Rates

Microbe	Type	Size µm	Filter %	UV Rate %	Total %
Acinetobacter	Bacteria	1.225	21	100	100.00
Adenovirus	Virus	0.079	9	100	100.00
Aeromonas	Bacteria	2.098	35	100	100.00
Aspergillus	Fungi	3.354	45	93	96.30
Bacillus anthracis	Bacteria	1.118	19	61	68.20
Bacteroides fragilis	Bacteria	3.162	44	100	100.00
Blastomyces dermatitidis	Fungi	12.649	50	99	99.65
Bordetella pertussis	Bacteria	0.245	4	100	100.00
Burkholderia cenocepacia	Bacteria	0.707	11	100	100.00
Burkholderia mallei	Bacteria	0.674	10	100	100.00
Burkholderia pseudomallei	Bacteria	0.494	7	100	100.00
Candida albicans	Fungi	4.899	49	79	89.19
Candia auris	Fungi	4.899	49	75	87.31
Chlamydia pneumoniae	Bacteria	0.548	8	100	100.00
Chlamydophila psittaci	Bacteria	0.283	4	100	100.00
Cladosporium	Fungi	8.062	50	98	98.75
Clostridium botulinum	Bacteria	1.975	33	100	100.00
Clostridium difficile	Bacteria	2	34	100	100.00
Clostridium perfringens	Bacteria	5	49	100	100.00
Coronavirus (Wuhan)	Virus	0.11	6	100	100.00
Corynebacterium diphtheriae	Bacteria	0.698	10	100	100.00
Coxsackievirus	Virus	0.027	19	100	100.00
Cryptococcus neoformans	Fungi	4.899	49	99	99.67
Curvularia lunata	Fungi	11.619	50	71	85.57
Ebola virus	Virus	0.09	8	100	100.00
Echovirus	Virus	0.024	20	100	99.89
E. coli	Virus	0.5	7	100	100.00
Enterobacter cloacae	Bacteria	1.414	24	100	100.00
Enterococcus	Bacteria	1.414	24	100	100.00
Enterococcus faecalis	Bacteria	0.707	11	100	100.00
Francisella tularensis	Bacteria	0.2	4	91	91.49
Fusarium	Fungi	11.225	50	92	96.23
Haemophilus influenzae	Bacteria	0.285	4	100	100.00
Haemophilus parainfluenzae	Bacteria	1.732	30	100	99.99
Hantaan virus	Virus	0.096	7	100	100.00
Helicobacter pylori	Bacteria	2.1	35	100	100.00
Histoplasma capsulatum	Fungi	2.236	36	99	99.56
Influenza A virus	Virus	0.098	7	100	100.00
Junin virus	Virus	0.122	6	100	100.00
Klebsiella pneumoniae	Bacteria	0.671	10	100	100.00
Lassa virus	Virus	0.122	6	100	100.00
LCV	Virus	0.087	8	100	100.00
Legionella pneumophila	Bacteria	0.52	7	100	100.00
Listeria monocytogenes	Bacteria	0.707	11	99	98.98
Marburg virus	Virus	0.039	15	100	100.00
Measles virus	Virus	0.158	5	100	100.00
MERS virus	Virus	0.11	6	89	90
Mucor	Fungi	7.071	50	95	98
Mumps virus	Virus	0.164	5	100	100
Mycobacterium avium	Bacteria	1.118	19	100	100
Mycobacterium kansasii	Bacteria	1.118	19	100	100
Mycobacterium tuberculosis	Bacteria	0.637	9	100	100
Mycoplasma pneumoniae	Bacteria	0.177	5	100	100
Neisseria meningitidis	Bacteria	0.775	12	100	100
Nocardia asteroides	Bacteria	1.118	19	100	100
Norwalk virus	Virus	0.029	18	97	98
Parainfluenza virus	Virus	0.194	4	100	100
Parvovirus B19	Virus	0.022	21	100	100
Penicillium	Fungi	3.262	44	60	78
Proteus mirabilis	Bacteria	0.494	7	100	100
Pseudomonas aeruginosa	Bacteria	0.494	7	100	100
Reovirus	Virus	0.075	9	99	99
RSV	Virus	0.19	5	100	100
Rhinovirus	Virus	0.023	21	99	99
Rhizopus	Fungi	6.928	50	93	96
Rickettsia prowazeki	Bacteria	0.6	9	100	100
Rotavirus	Virus	0.073	9	100	100
Rubella virus	Virus	0.061	11	67	71
Salmonella typhi	Bacteria	0.806	13	100	100
SARS virus	Virus	0.11	6	100	100
Serratia marcescens	Bacteria	0.632	9	100	100
Stachybotrys chartarum	Fungi	5.623	49	12	55
Staphylococcus aureus	Bacteria	0.866	14	100	100
Staphylococcus epidermis	Bacteria	0.866	14	100	100
Streptococcus pneumoniae	Bacteria	0.707	11	77	80
Streptococcus pyogenes	Bacteria	0.894	14	100	100
Trichophyton	Fungi	4.899	49	71	85
Ustilago	Fungi	5.916	50	46	73
VZV	Virus	0.173	5	100	100
Yersinia pestis	Virus	0.707	11	100	100

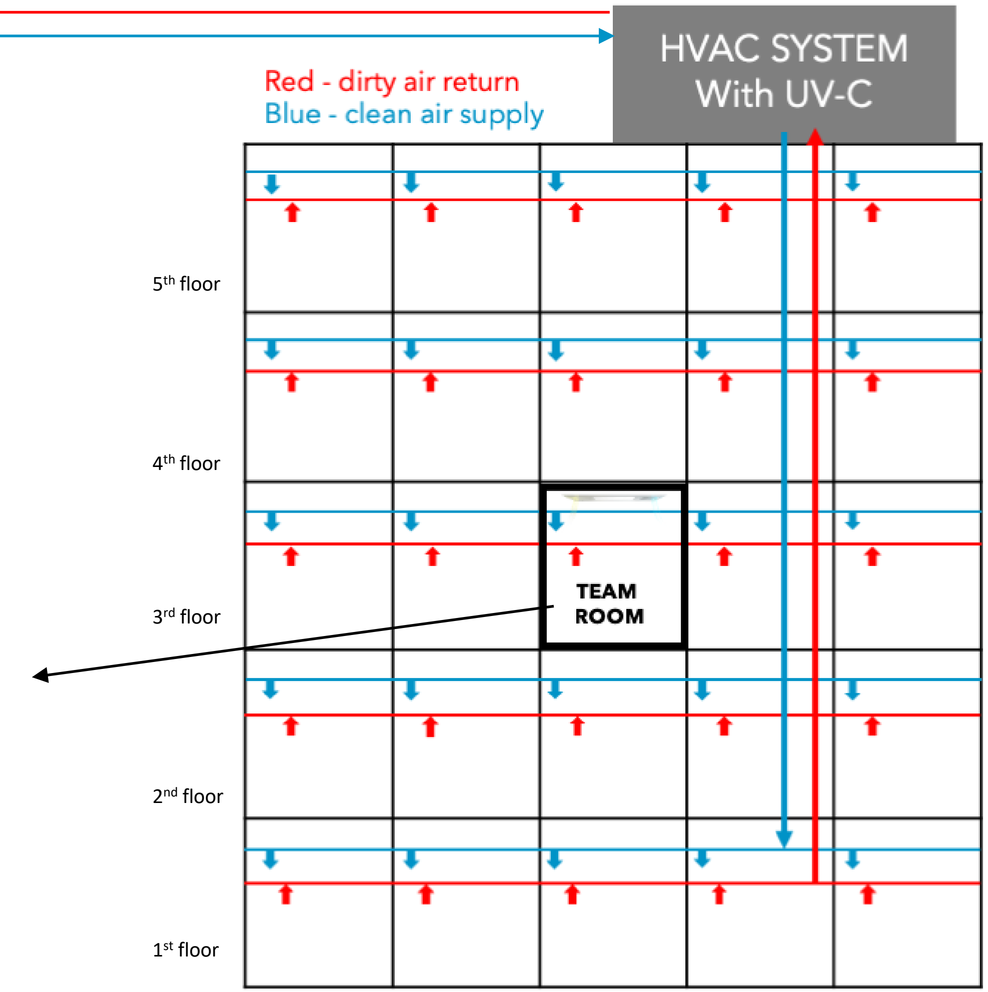
HVAC SYSTEM ADDITIONS

Air Handling Technologies

UV-C
Ion
HEPA
H_2O_2
Ozone



HVAC system supplies air for entire building.
Air travels from one source to reach all areas.



HVAC systems don't effect room level contamination which is directly correlated with the presence of people.

TEAM ROOM

CURRENT HVAC UV-C AND FILTRATION –

Products	Other Air Solutions Can't Compete at Room-Level
UV in HVAC System	• Keeps coils clean and system working efficiently • Treats air coming from outside building • Air treated in HVAC system then travels long distances to get to room-level • Speed of air through HVAC is much faster so pathogen elimination rate is much lower • Doesn't improve room-level air quality
Portable Air Purifiers	• Requires someone to operate • Takes up floor space • Doesn't cover sq. footage required for effectiveness needed • Most don't improve room-level air quality at hospital grade level
Bi-Polar Ionization	• Creates positive and negative ions in air handler and emits them into room • People breathe in negative or positive ions which may effect serotonin levels • Air handler must run 24/7 to provide benefit of system • Single-emitters may produce ozone • Require frequent maintenance and calibration • Doesn't improve room-level air quality
Upper Room UV-C at 254nm	• Safety precautions must be in place • Light may need to be turned off when rooms are occupied • Works passively, treating air that passes over the lamps • May not circulate the entire room because of limited ability to draw in air
Far UVC, 222 nm	• 222nm is not as effective wavelength as 254nm for pathogen elimination • Long term usage us unknown
Shielded room-level UV-C air purification system	• Room-level air treatment where contamination is brought in • Improves the air at the room-level where it is needed most • Engineering control operates 24/7 • Peer-reviewed and proven effective • Unobtrusive, works as light in ceiling • Doesn't create ozone or any chemicals • Nothing but treated air emitted at room-level • Actively draws air through UV chamber with fans • Shielded UV allows unit to operate 24/7 safely in occupied spaces • Proven in lab tests to eliminate up to 99.99%

Summary

- ✓The virus that causes COVID-19 is very similar to SARS-CoV1 therefore we know a lot about more about this virus then we did.
- ✓Disease outcomes range from asymptomatic, Presymptomatic, symptomatic flu like symptoms to severe illness and death.
- ✓Presymptomatic and asymptomatic transmission is possible.
- ✓Routes of transmission include direct (droplets and airborne) and indirect (fomites and contact). Source control pick the right technology!
- ✓Envelop viruses are fragile and environmentally sensitive and directly disrupted by proven technologies, UV-C, surfactants, disinfection, filtration and dilution.
- ✓When does it end? Buckle up we are in for the long haul! According to Dr. Irwin Redlener[10] a minimum of 2022 to 2024.

ANY QUESTIONS?

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