
UNDERSTANDING THE SCIENCE BEHIND MITIGATING THE TRANSMISSION OF COVID-19

SESSION 1: TRANSMISSION PATHS

SESSION 2: AIRBORNE MITIGATION STRATEGIES

SESSION 3: ESTIMATING EFFECTIVENESS OF RISK MITIGATION STRATEGIES

ANGELA HARRISON KULI MSIE, PEM, CEA | AHK CONSULTING, INC.

TRANSMISSION PATHS

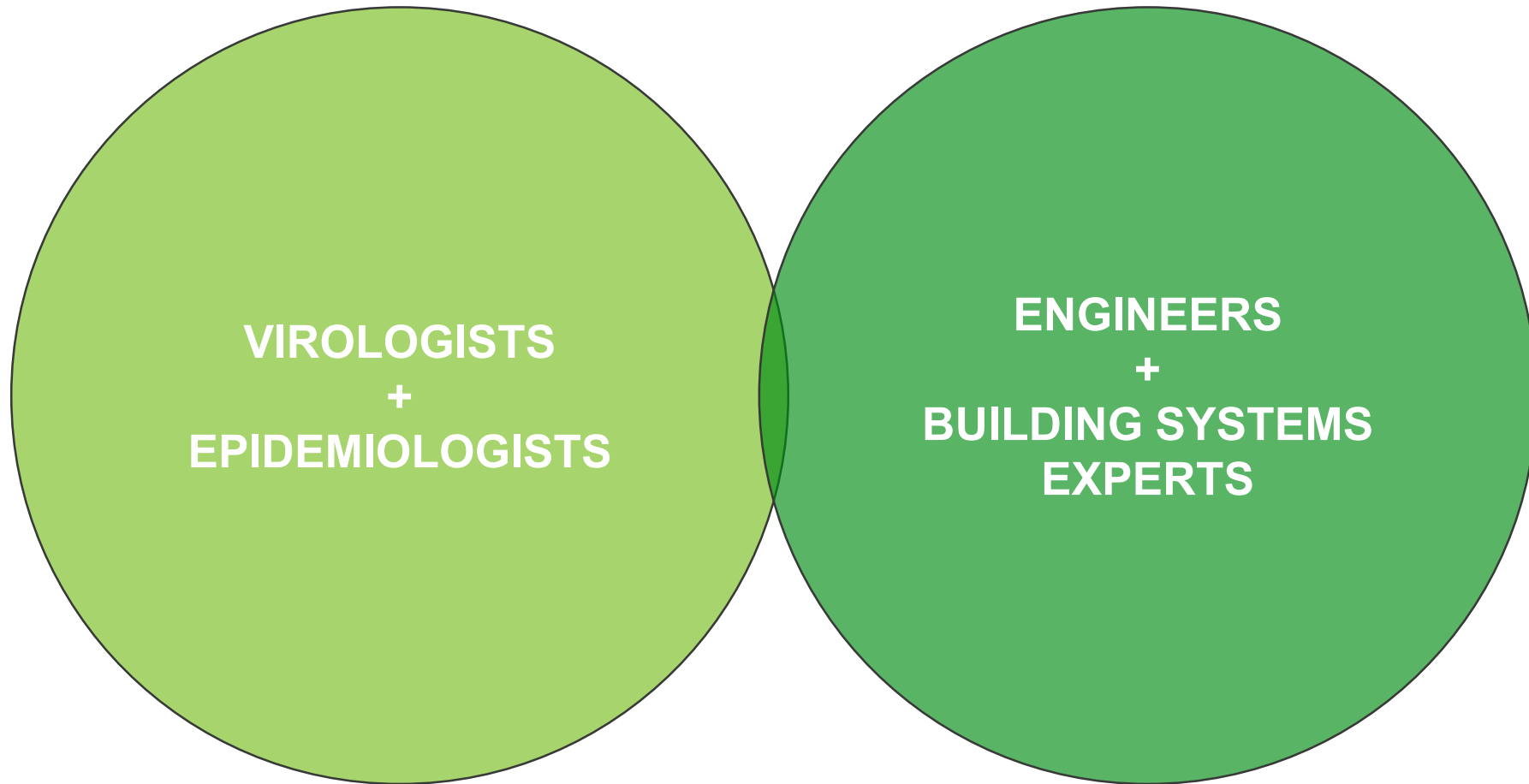
DUSTIN SCHAFER, PE | DIRECTOR OF ENGINEERING



November 5, 2020

THANK YOU TO OUR SPONSORS FOR THIS SERIES





THE WHY BEHIND THIS CONVERSATION

WHAT WE'RE GOING TO COVER



SESSION 1
Transmission Paths



SESSION 2
Airborne Mitigation



SESSION 3
Estimating Risk

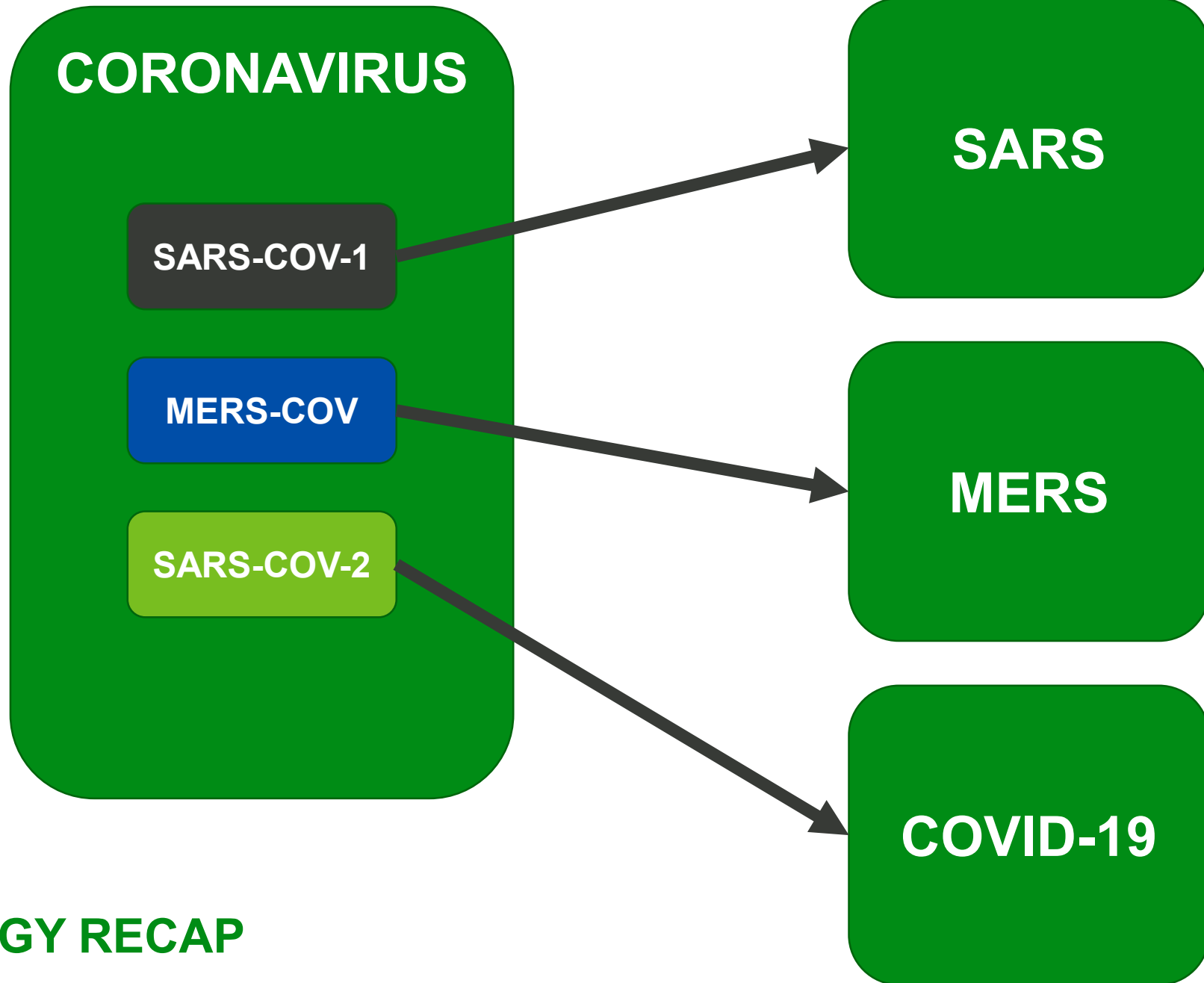


SESSION 1: UNDERSTANDING TRANSMISSION PATHS

There are 3 main transmission paths for the spread of SARS-CoV-2 within a building; fomite, large droplet, and aerosol transmission. This presentation will review and interpret several key scientific studies from 2020 on each of the 3 paths.

At the end of this presentation you will be able to:

1. Define the 3 main transmission paths of SARS-CoV-2 within a building.
2. Explain the difference between a logarithmic scale and a traditional scale on a graph.
3. Interpret the recent published science behind the survivability of the SARS-CoV-2 virus on surfaces and in the air.
4. Interpret the recent published science related to the effectiveness of several common mitigation measures to break the transmission paths.



TERMINOLOGY RECAP

THE ILLUSION OF EXPLANATORY DEPTH

“We often overestimate our ability to explain things. It’s called the illusion of explanatory depth.”

- [In one set of studies](#), people rated how well they understood devices and natural phenomena, like rainbows and zippers.
- Then they tried to explain them.
- Ratings dropped precipitously once people had confronted their own ignorance.

SOURCE: MIT Technology Review | Hutson, Matthew. “Why you don’t really know what you know.” Oct 21, 2020

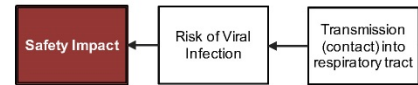


HOW THIS IS GOING TO WORK



HOW TO REDUCE THE RISK OF COVID-19 INFECTION THROUGH BUILDING DESIGN.

Transmission of COVID-19 in buildings requires two things — the active virus being present in sufficient quantity to cause infection and the transmission of that active virus into the respiratory tract of the person being infected. In public buildings, it's often difficult to control for the presence of the virus, but good design practices can work together to reduce the overall risk of infection.



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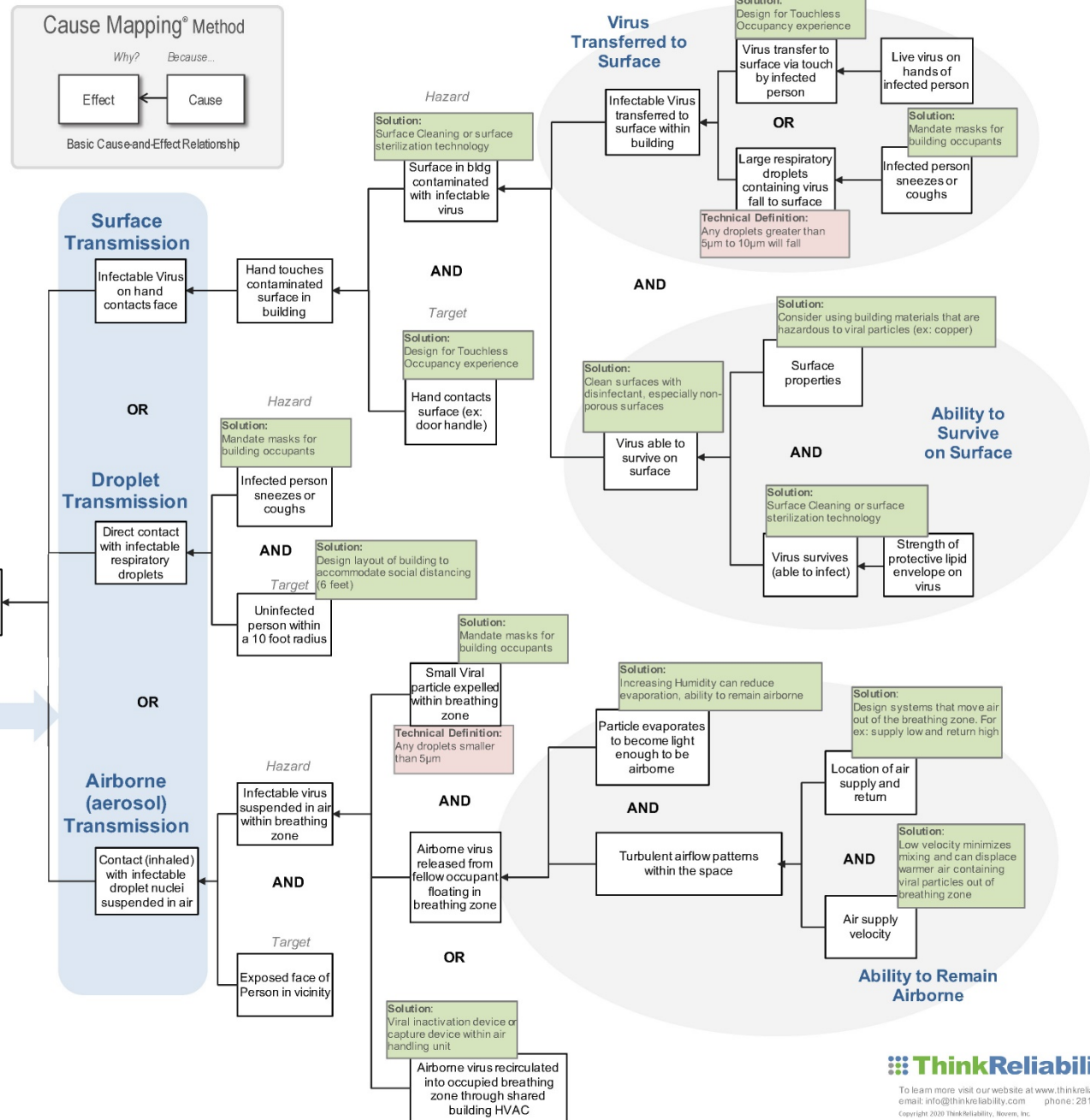
A person touches a contaminated surface and then inadvertently touches their face introducing the virus.

Droplet Transmission

An infected person is talking, coughing, or sneezing within close contact of others. Large Respiratory droplets (greater than 5µm to 10µm) makes direct contact to infect.

Airborne (aerosol) Transmission

An infected person is talking, coughing, or sneezing. The small respiratory droplets (less than 5µm to 10µm) remain suspended in air for a period of time and over greater distance.



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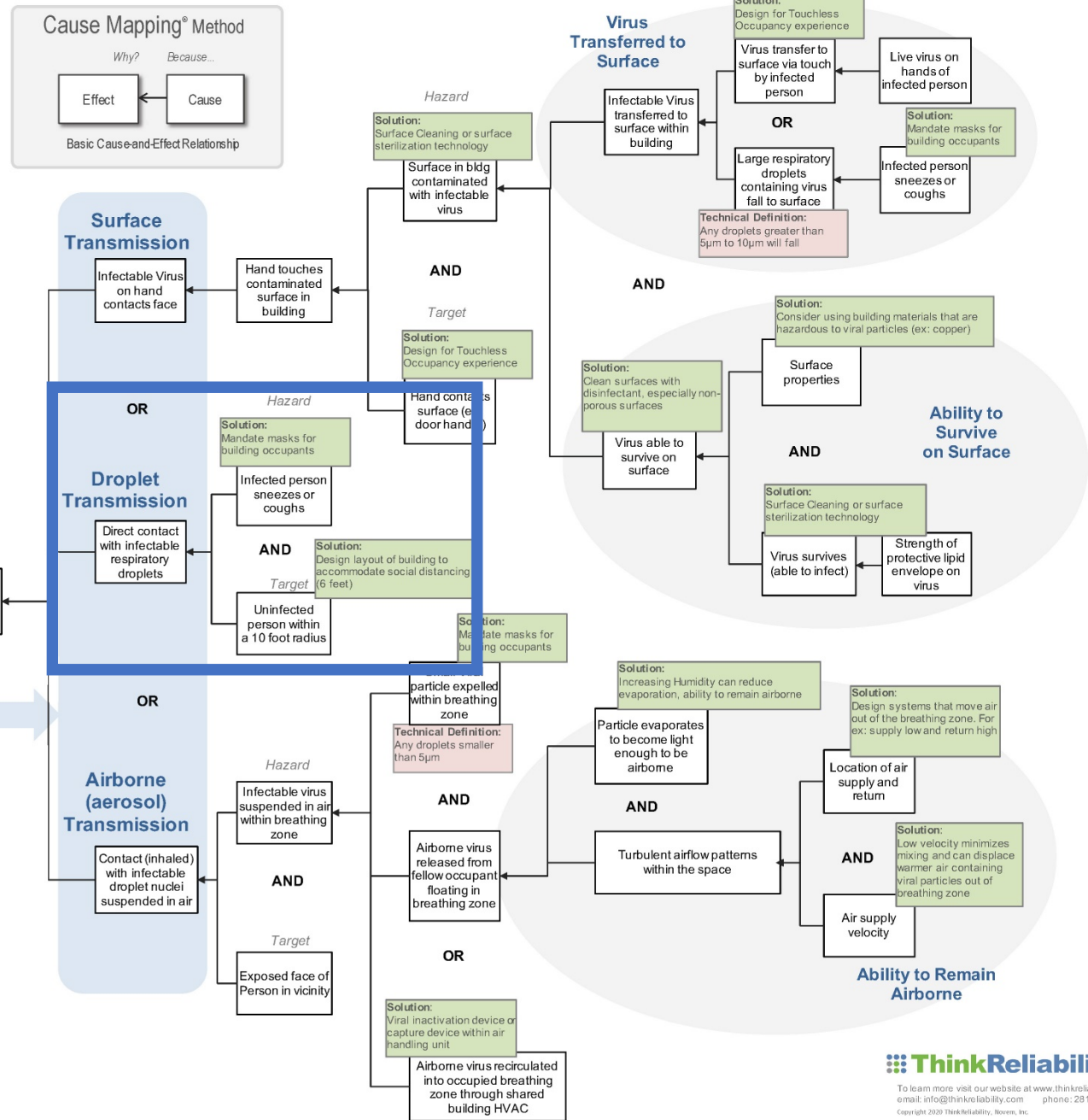
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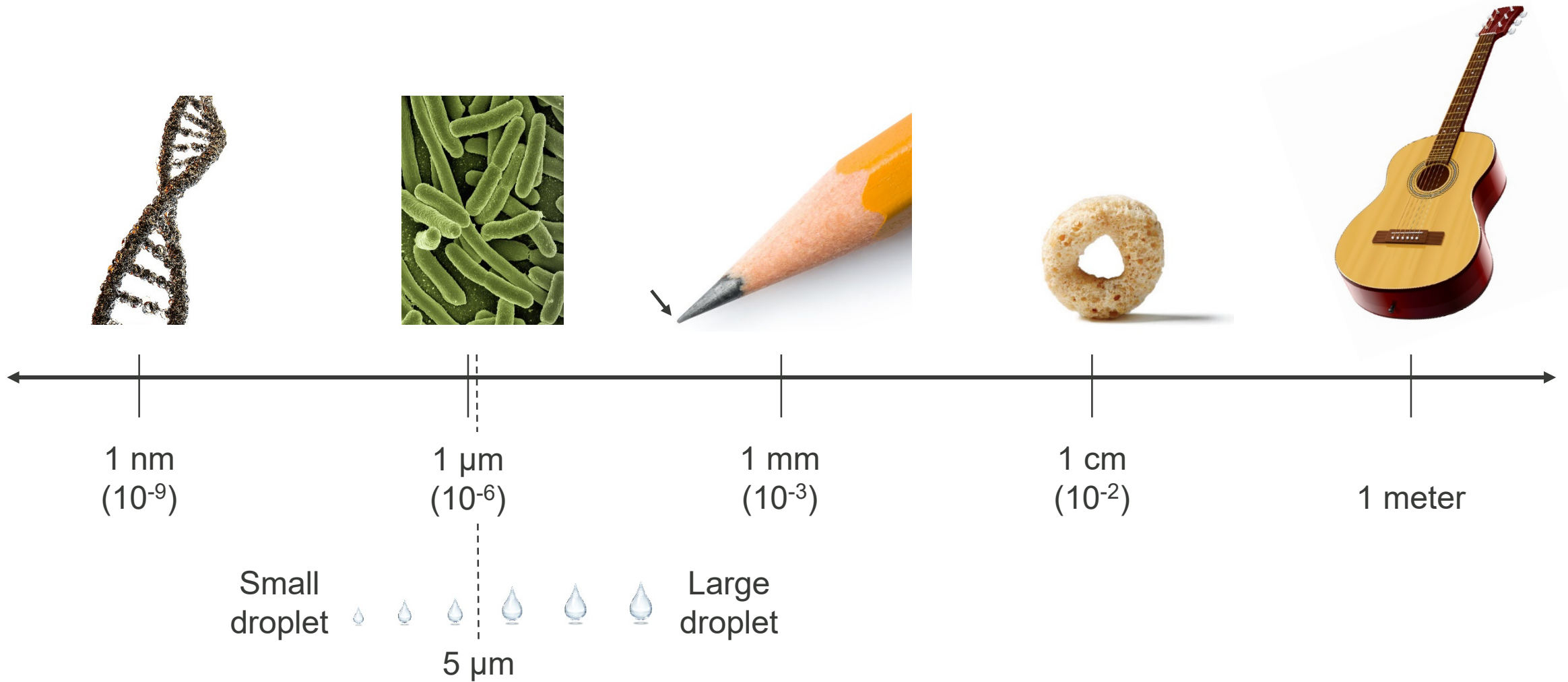
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TRANSMISSION PATHS: LARGE DROPLET

WHAT IS A LARGE DROPLET?



A background graphic consisting of a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure that spans the entire page.

REVIEW OF PUBLISHED SCIENTIFIC EVIDENCE



The 6 ft distance "rule" **will reduce (but not eliminate)**
the risk of large droplet contact

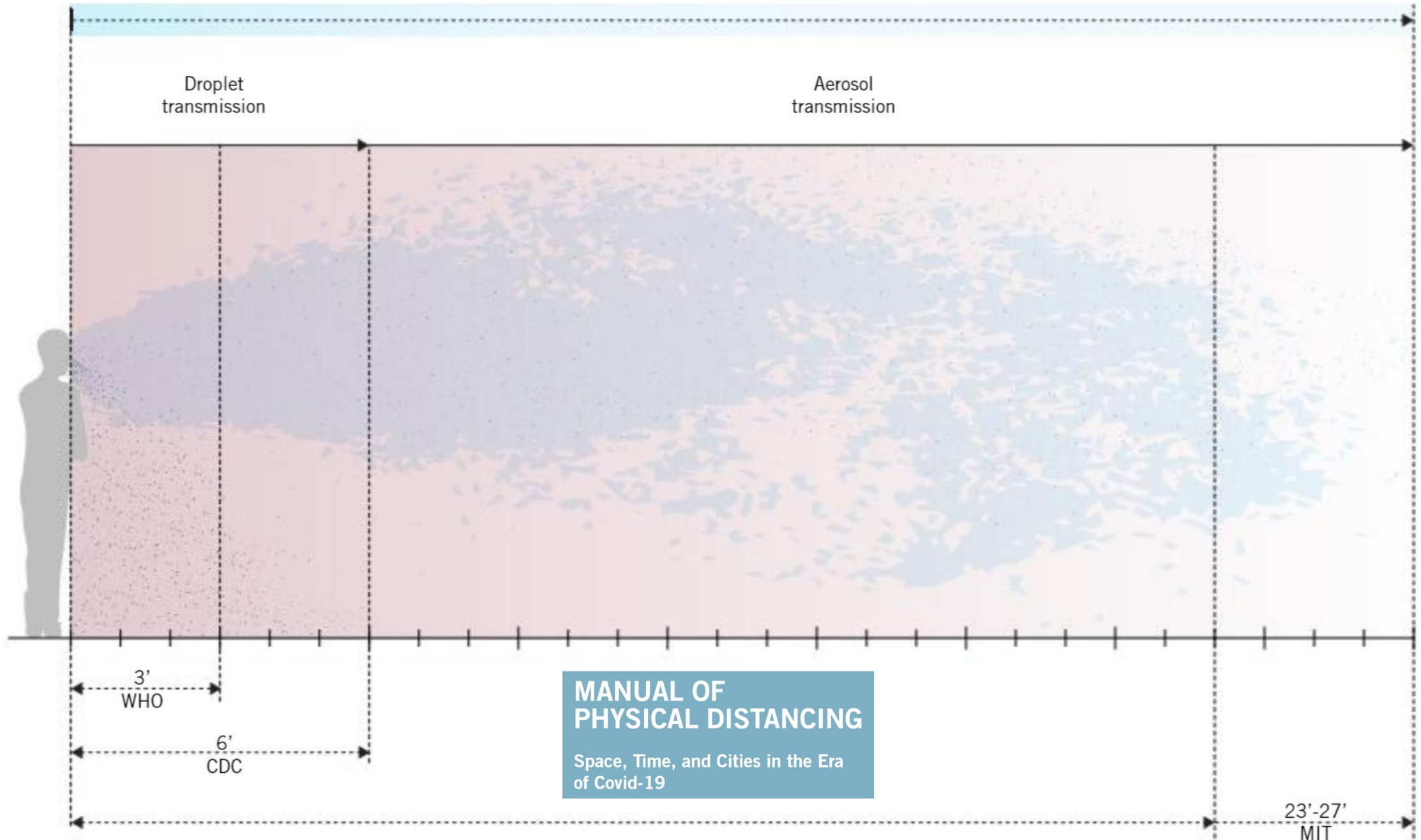




Two Metres Or One: What Is The Evidence for Physical Distancing in COVID-19?

SOURCE: British Medical Journal | BMJ 2020;370:m3223

Droplet diameter 10 to 5 μm



**MANUAL OF
PHYSICAL DISTANCING**
Space, Time, and Cities in the Era
of Covid-19

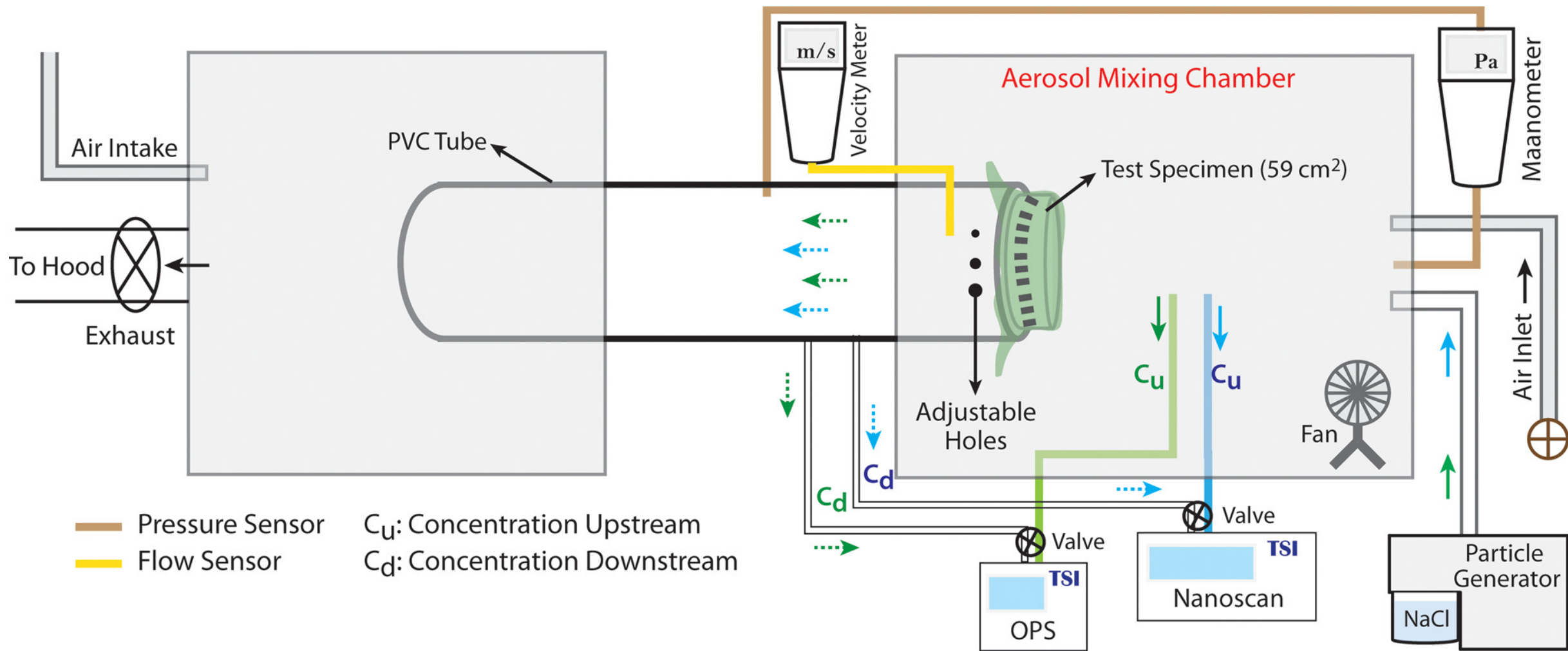
SOURCE: LTL Architects | https://issuu.com/djlewis72/docs/200622_manualphysicaldistancing_draft

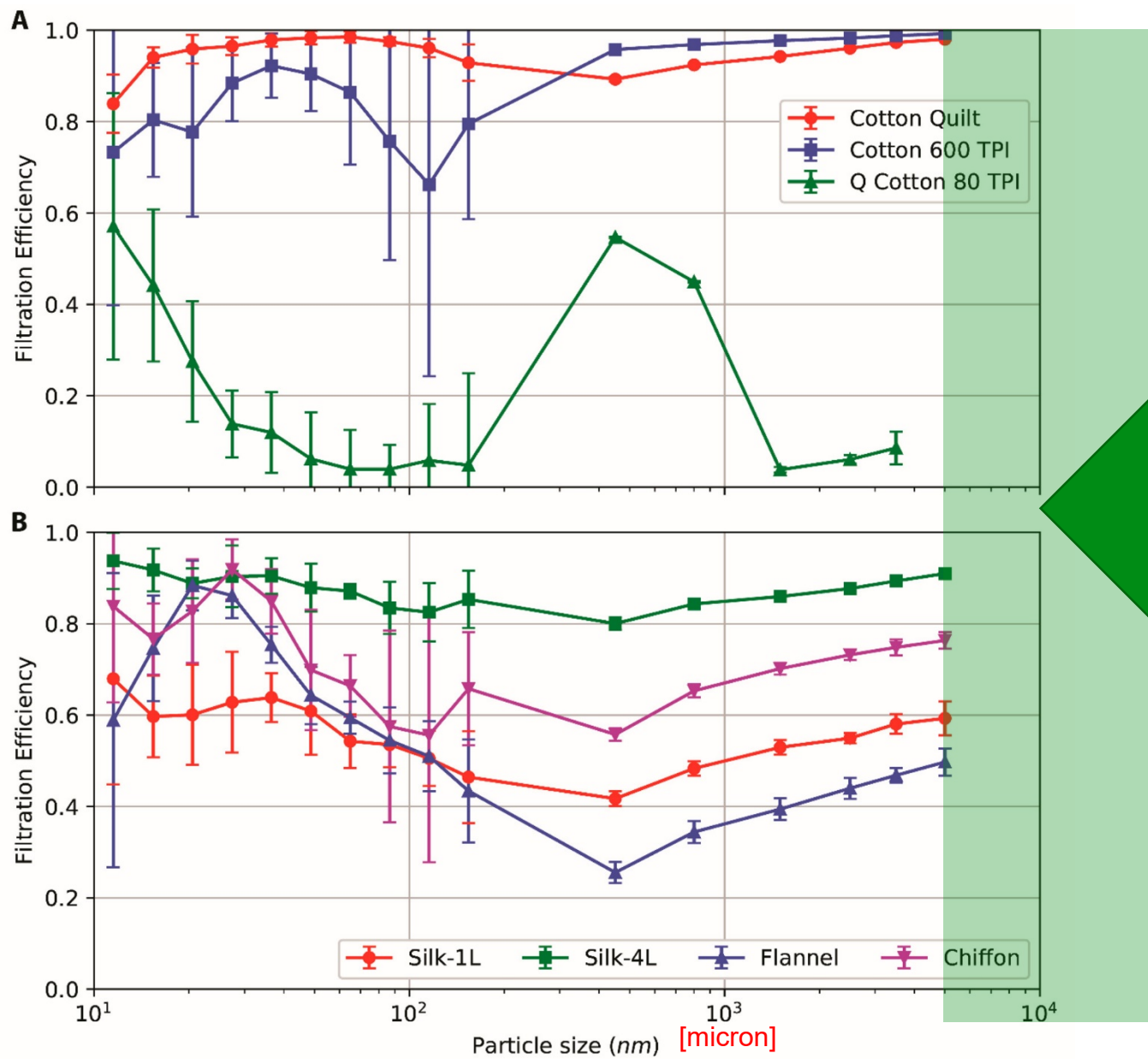


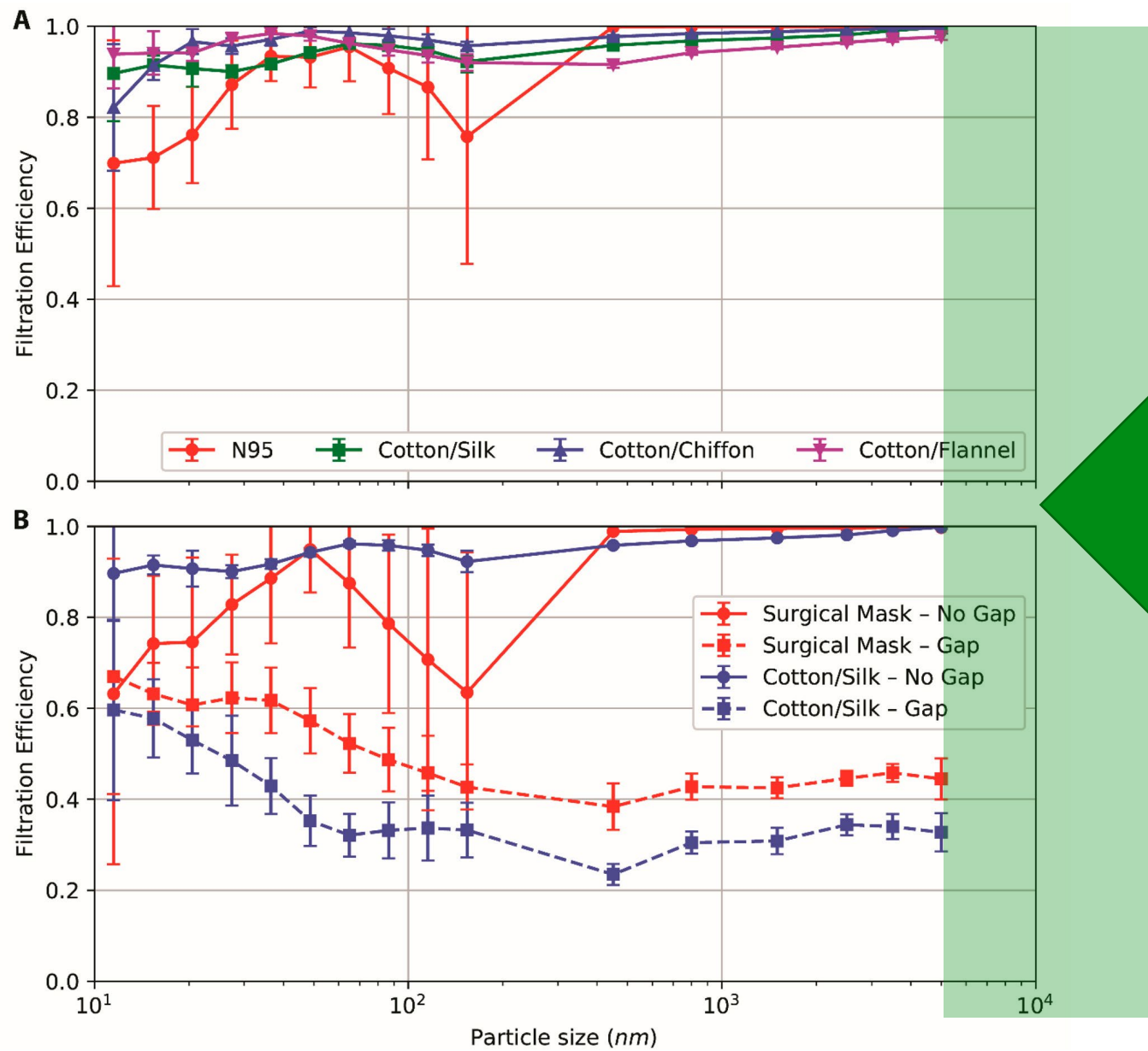
MASKS ARE HIGHLY EFFECTIVE AT CAPTURING LARGE PARTICLES

Non-medical masks are **between 20-80% effective** at capturing infectious particles depending on the size of the particles, their fit, construction, and fabric.

Masks made of double-layer tightly woven fabric that fit snugly **approach 100% effectiveness** at capturing large particles.







i Items sold on Etsy, such as masks and hand sanitizers, aren't medical-grade. Etsy sellers cannot make medical or health claims. [More info.](#)

Similar items

See more →



600 thread count cotton face ...
AmericanMaskWorks

\$14.98

FREE shipping

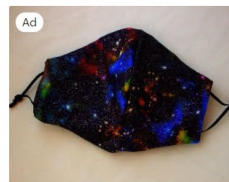


600+ Thread Count Cotton Fac...
RavenberryFibers

\$10.79

~~\$11.99~~ (10% off)

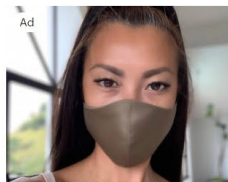
FREE shipping



4-Layer Cosmos Face Mask. 10...
LittlePalguin

\$22.99

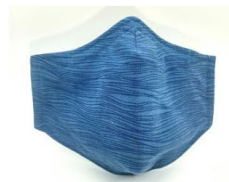
FREE shipping



PACK OF 4 - 600 Thread Count ...
ColorThreadBoutique

\$47.00

FREE shipping



Blue waves 4 Layer Cotton/Chi...
SynapseedStudio

\$19.95

Free shipping eligible



4-Layer Silk/Cotton Face Mask. ...
LittlePalguin

\$25.99

FREE shipping



AmericanMaskWorks
3,367 sales | ★★★★★

600 thread count & Chiffon Face Mask (Light Blue KONA Cotton), Premium, Washable, 100% Cotton 3-Layer, 4-Layer, US Made custom fit reusable

Bestseller

\$14.98+

✓ In stock

Style-Size

Select an option ▼

Upgrades

Select an option ▼

Add your personalization (optional) ▼

Quantity

1 ▼

Add to cart



Other people want this. Over 20 people have this in their carts right now.

Related searches





Two Metres Or One: What Is The Evidence for Physical Distancing in COVID-19?

SOURCE: British Medical Journal | BMJ 2020;370:m3223

Type and level of group activity	Low occupancy			High occupancy		
	Outdoors and well ventilated	Indoors and well ventilated	Poorly ventilated	Outdoors and well ventilated	Indoors and well ventilated	Poorly ventilated
Wearing face coverings, contact for short time						
Silent	Low	Low	Low	Low	Low	Medium
Speaking	Low	Low	Low	Low	Low	Medium
Shouting, singing	Low	Low	Medium	Medium	Medium	High
Wearing face coverings, contact for prolonged time						
Silent	Low	Low	Medium	Low	Medium	High
Speaking	Low	Low*	Medium	Medium*	Medium	High
Shouting, singing	Low	Medium	High	Medium	High	High
No face coverings, contact for short time						
Silent	Low	Low	Medium	Medium	Medium	High
Speaking	Low	Medium	Medium	Medium	High	High
Shouting, singing	Medium	Medium	High	High	High	High
No face coverings, contact for prolonged time						
Silent	Low	Medium	High	Medium	High	High
Speaking	Medium	Medium	High	High	High	High
Shouting, singing	Medium	High	High	High	High	High

Risk of transmission
 Low ■ Medium ■ High ■

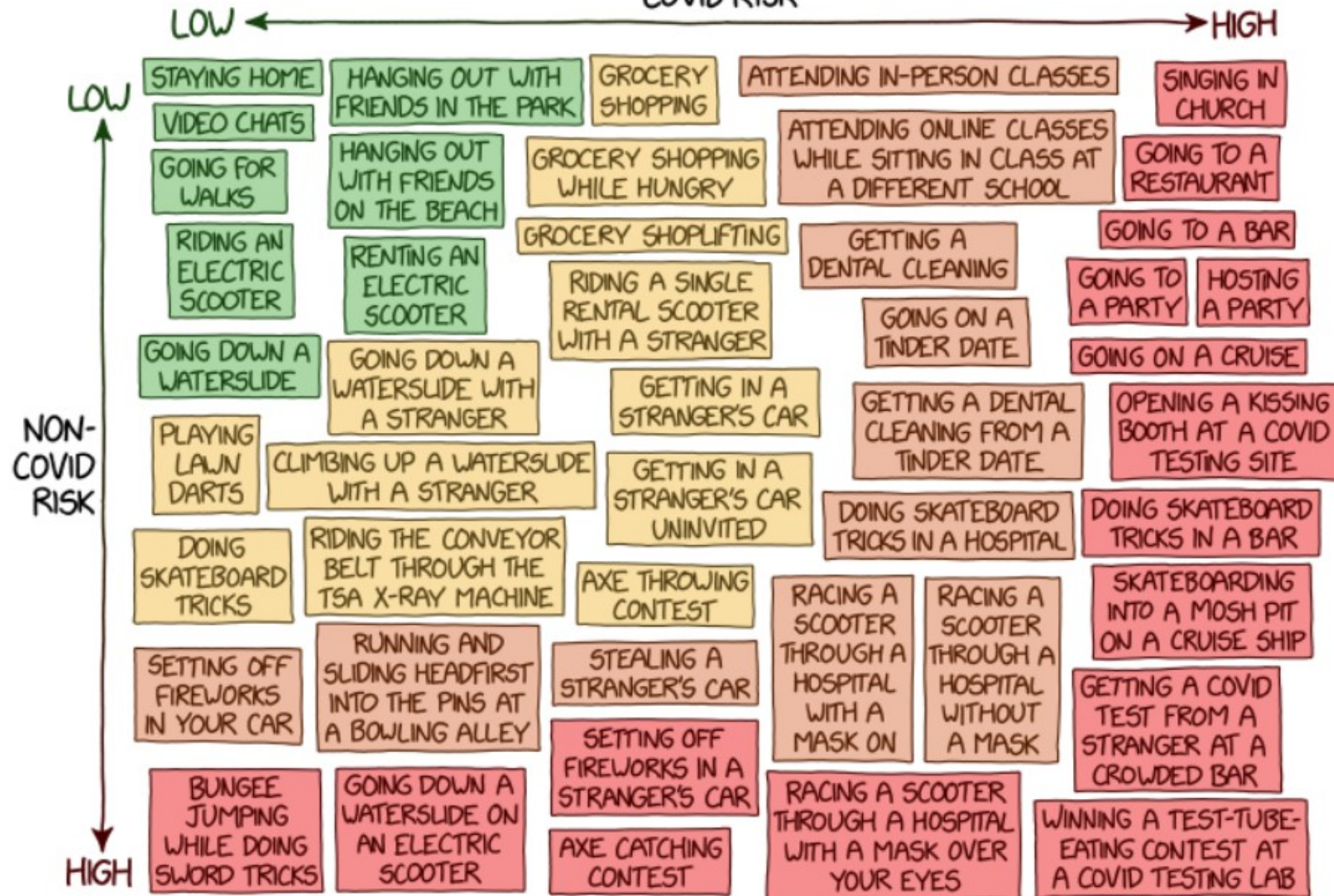
* Borderline case that is highly dependent on quantitative definitions of distancing, number of individuals, and time of exposure

Two Metres or One: What Is The Evidence for Physical Distancing in COVID-19?

SOURCE: British Medical Journal
 BMJ 2020;370:m3223

→ The importance of physical distancing is dependent on the risk of each specific situation.

COVID RISK



A background graphic featuring a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure. The overall aesthetic is modern and technical.

EXAMPLES IN THE BUILT ENVIRONMENT



SECURED ENTRY



VENUE SEATING



CLASSROOMS



PUBLIC TRANSPORTATION



SHARED OFFICES

QUIZ TIME

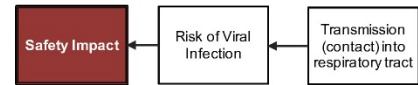
+

5 MINUTE BREAK

TRANSMISSION PATHS: FOMITE (SURFACE)

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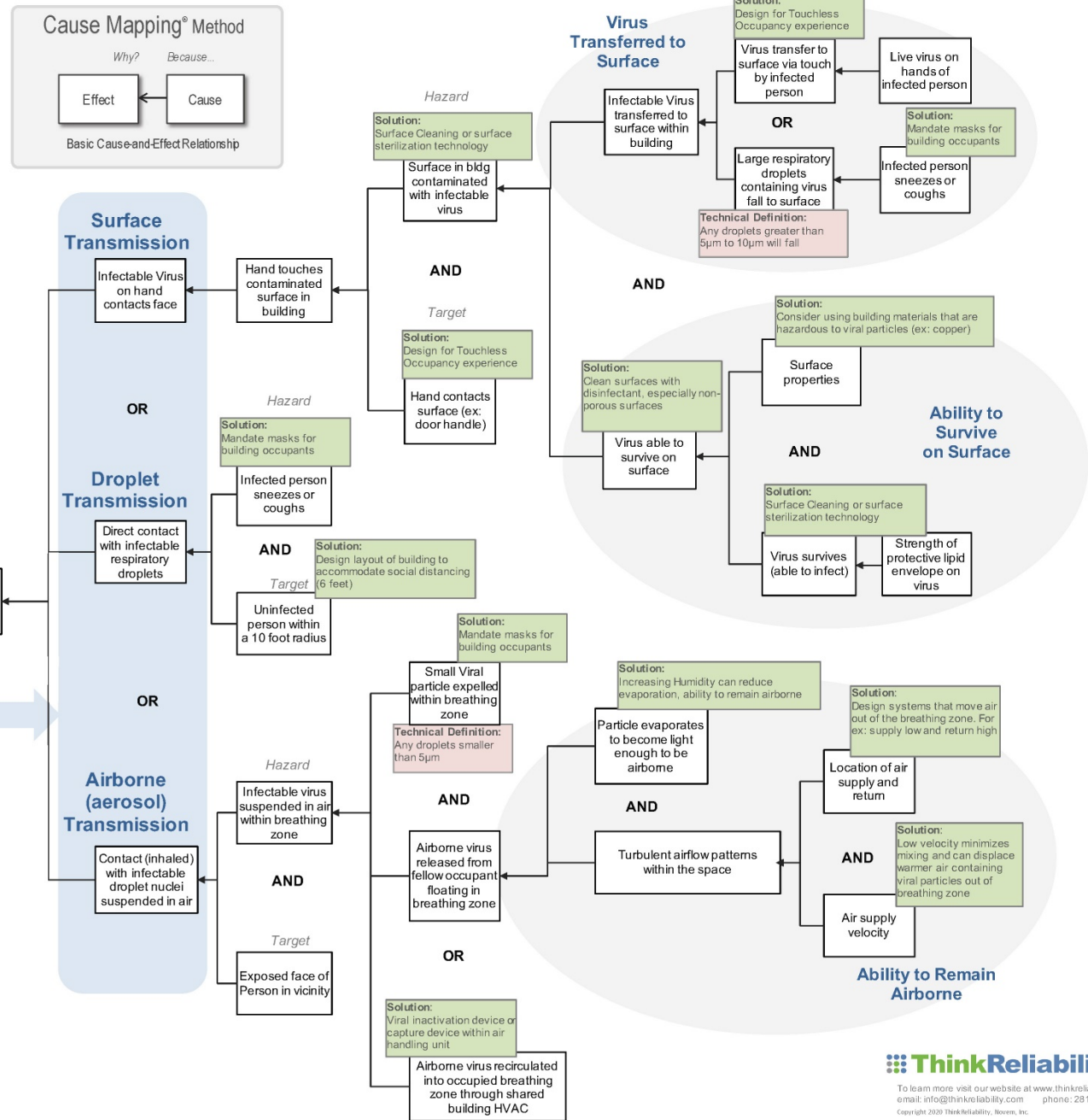
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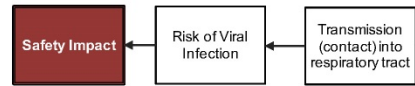
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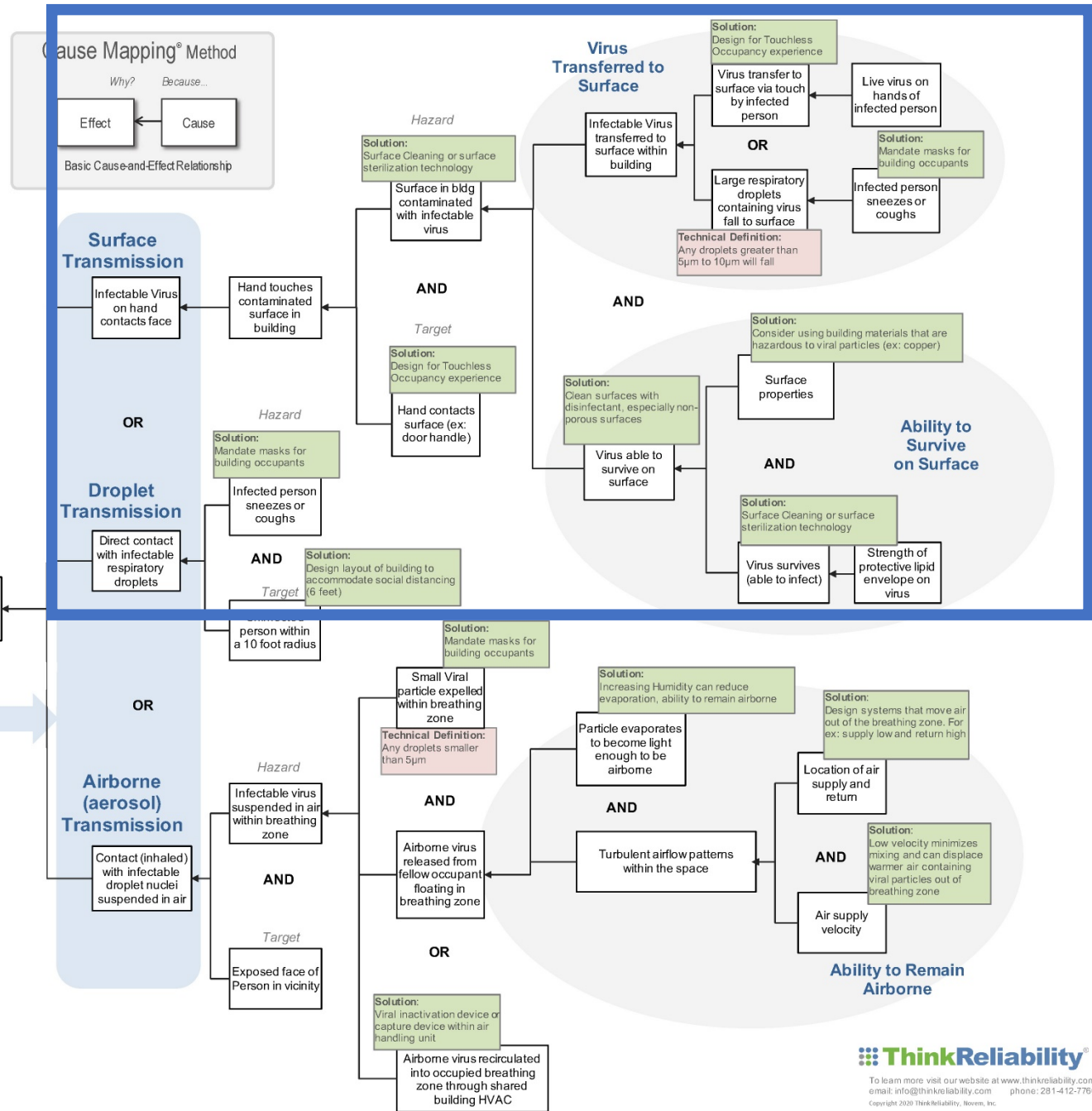
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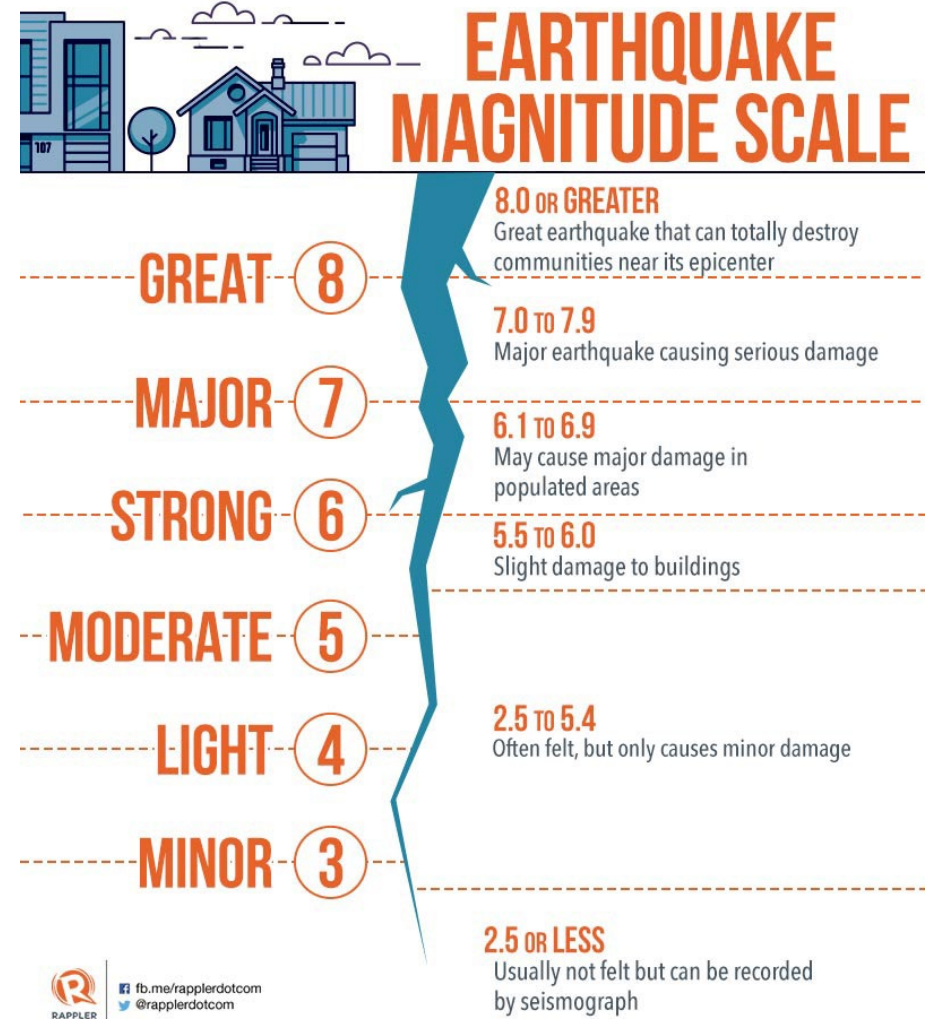
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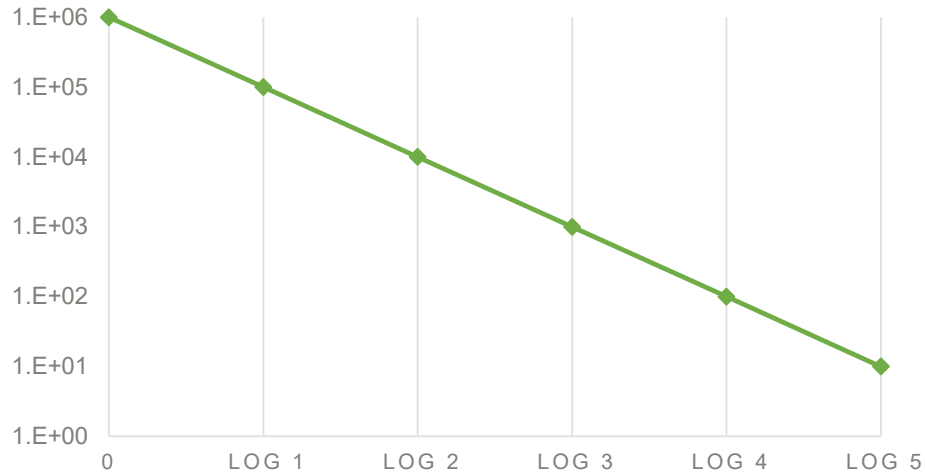
AN ASIDE ABOUT SCALES...

- **Log Reduction** → 10-fold (one decimal) or 90% **reduction**
- **1-Log Reduction would reduce the number of bacteria 90%**
 - 100 bacteria reduced to 10 or 10 reduced to 1

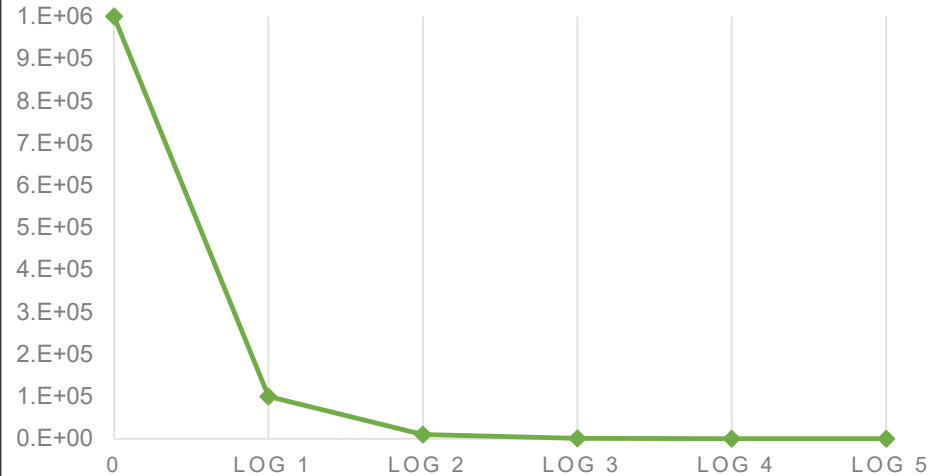


Source: UPSeis / Michigan Tech

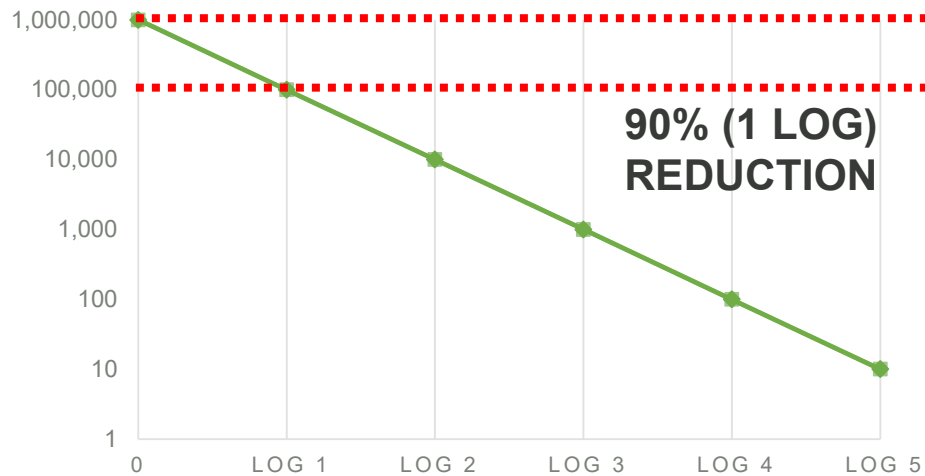
LOGARITHMIC SCALE



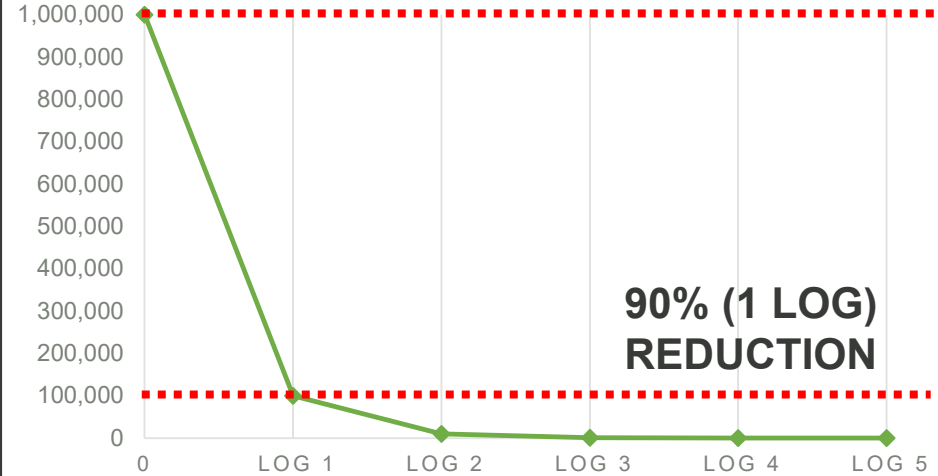
STANDARD SCALE



LOGARITHMIC SCALE



STANDARD SCALE



A background graphic consisting of a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure that spans the entire page.

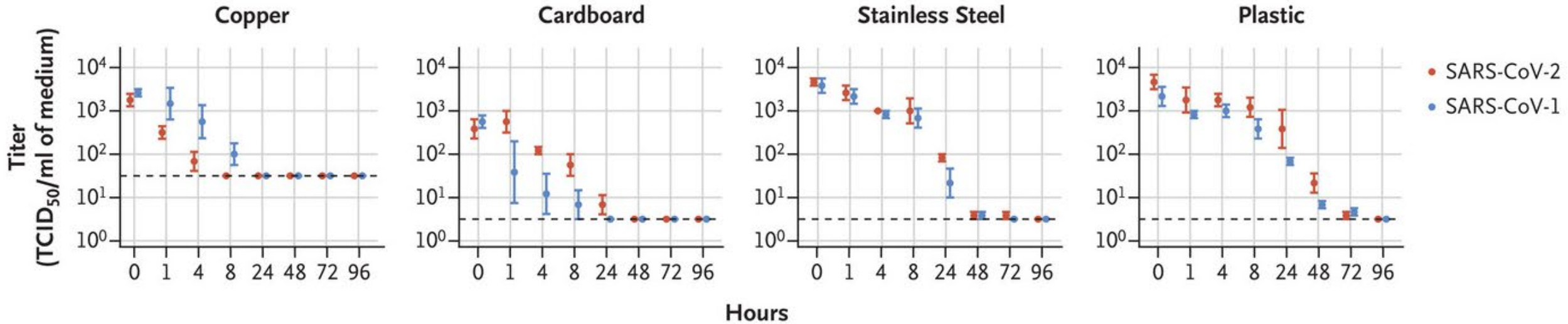
REVIEW OF PUBLISHED SCIENTIFIC EVIDENCE



SARS-CoV-2 can survive for days on non-porous surfaces if deposited in **large enough concentrations** under the **right temperature** and **humidity conditions**.



SURFACE STABILITY OF SARS-COV-2

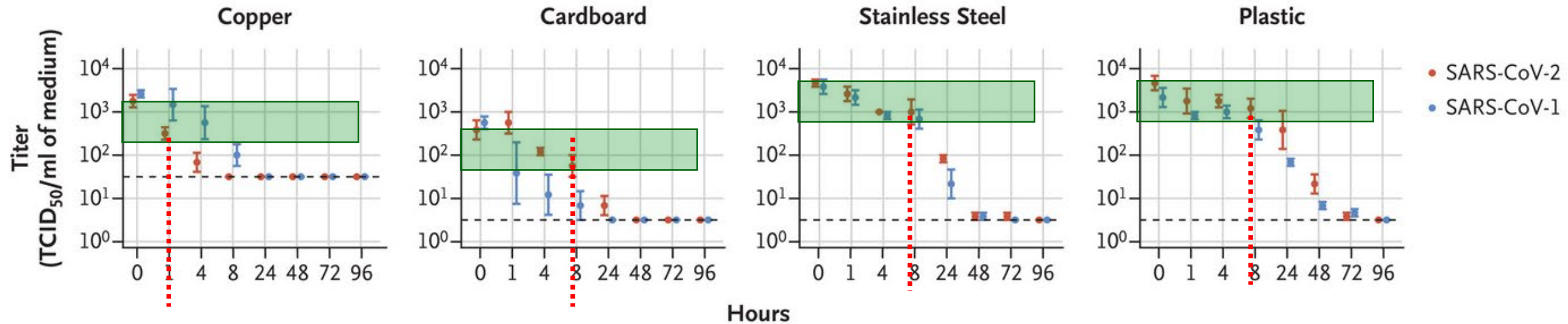


EXAGGERATED RISK OF TRANSMISSION OF COVID-19 BY FOMITES

THE LANCET | INFECTION DISEASES - JULY 03, 2020

- Assumptions are being made based on studies that aren't like real-life scenarios.
- Most studies start with a very large initial viral sample (e.g. $10^7/10^6/10^3$ infectious particles)
- In a study of influenza patients from 2010 , the actual particles expelled was found to be closer to 20-100 per cough, not 1000 to 10,000,000

TIME TO REACH 1 LOG (90%) REDUCTION IN VIABLE SARS-COV-2 VIRUS DUE TO NATURAL DECAY ON VARIOUS MATERIALS





STANDARD SURFACE CLEANING AGENTS ARE EFFECTIVE.

Alcohol, Hydrogen Peroxide, Household bleach, citric acid –
all have kill times under 1 minute when used per manufacturer directions



SOURCE: <https://www.epa.gov/pesticide-registration/list-n-disinfectants-coronavirus-covid-19>



STANDARD SURFACE CLEANING AGENTS ARE EFFECTIVE

- “Surface disinfection with 0.1% sodium hypochlorite or 62–71% ethanol significantly reduces coronavirus infectivity on surfaces within 1 min exposure time.”



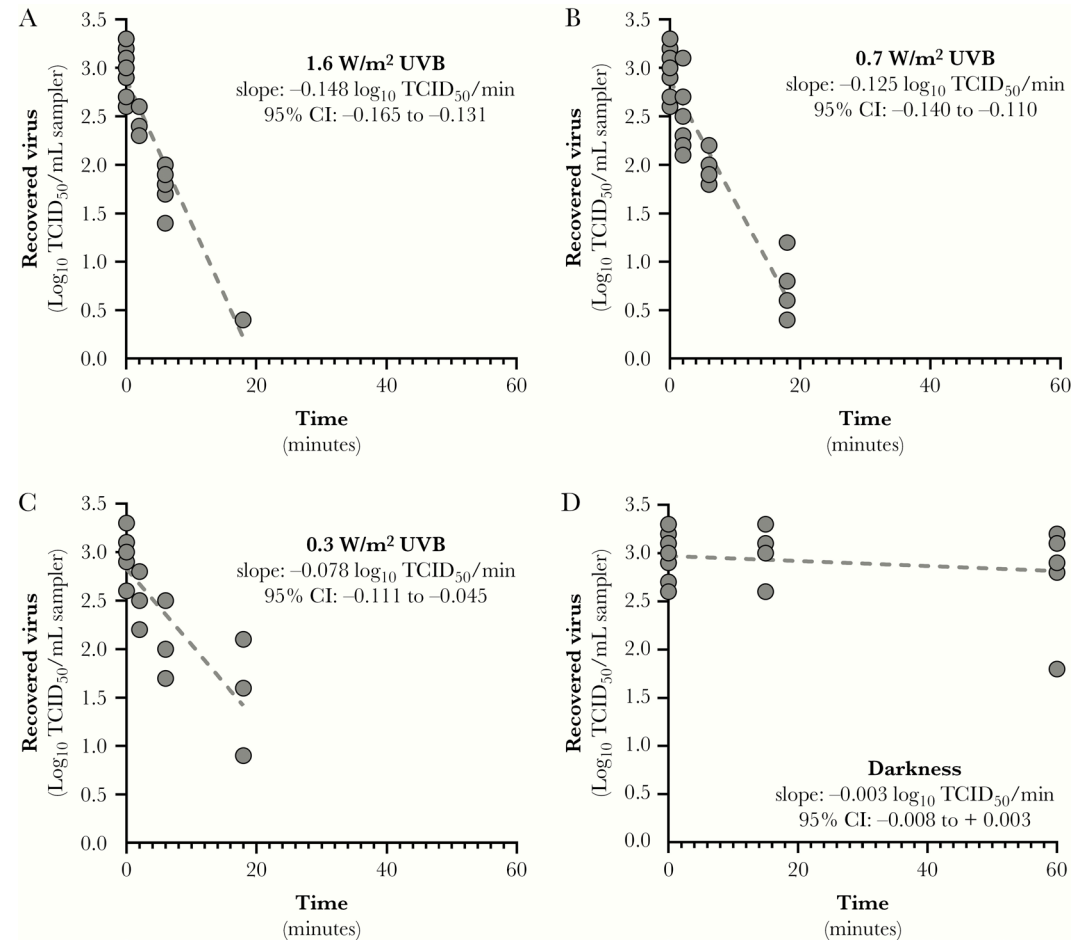
SUNLIGHT (UVB) RAPIDLY INACTIVATES THE VIRUS.

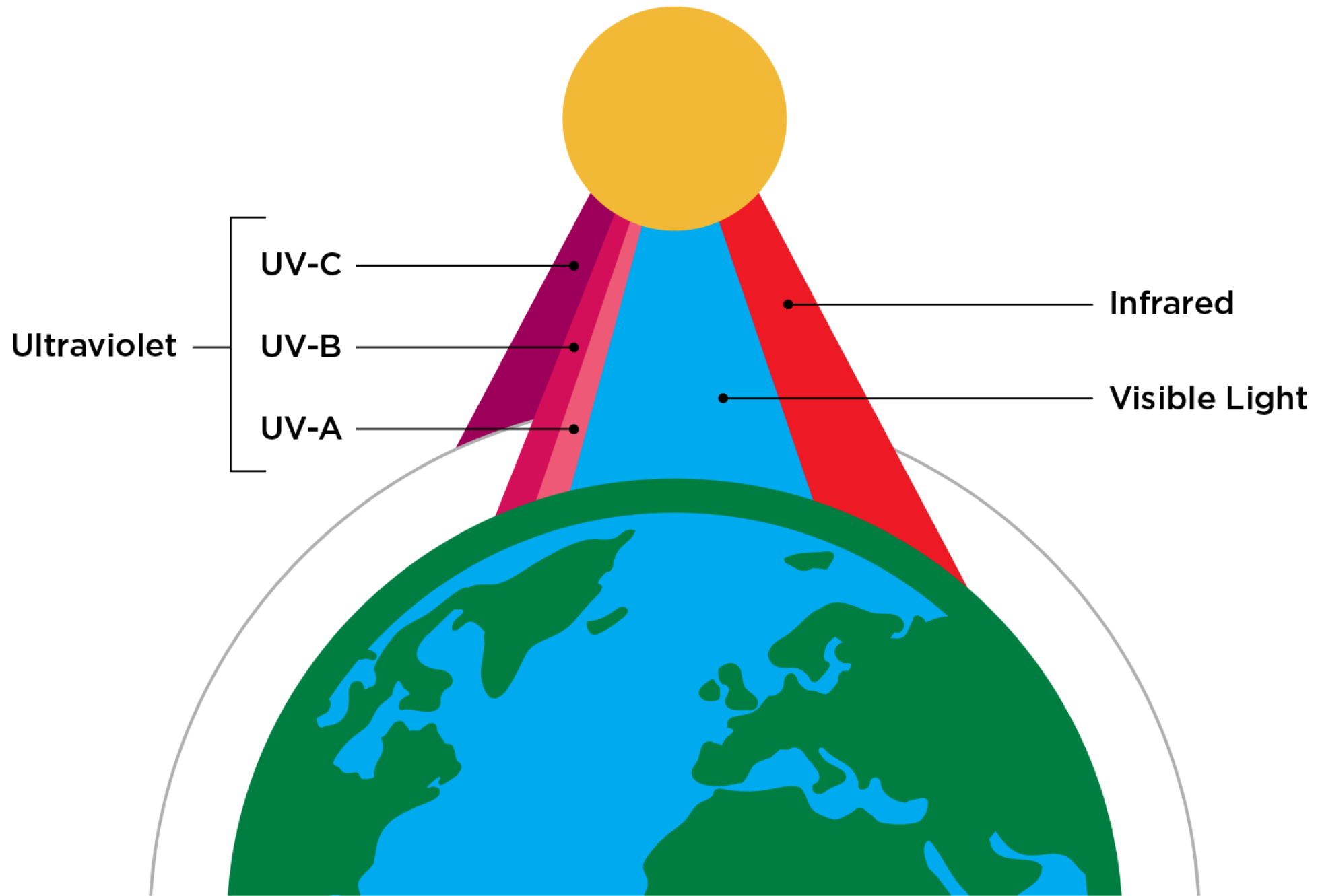
Simulated sunlight can rapidly inactivate SARS-CoV-2 on surfaces, suggesting reduced risk of surface transmission in outdoor environments.



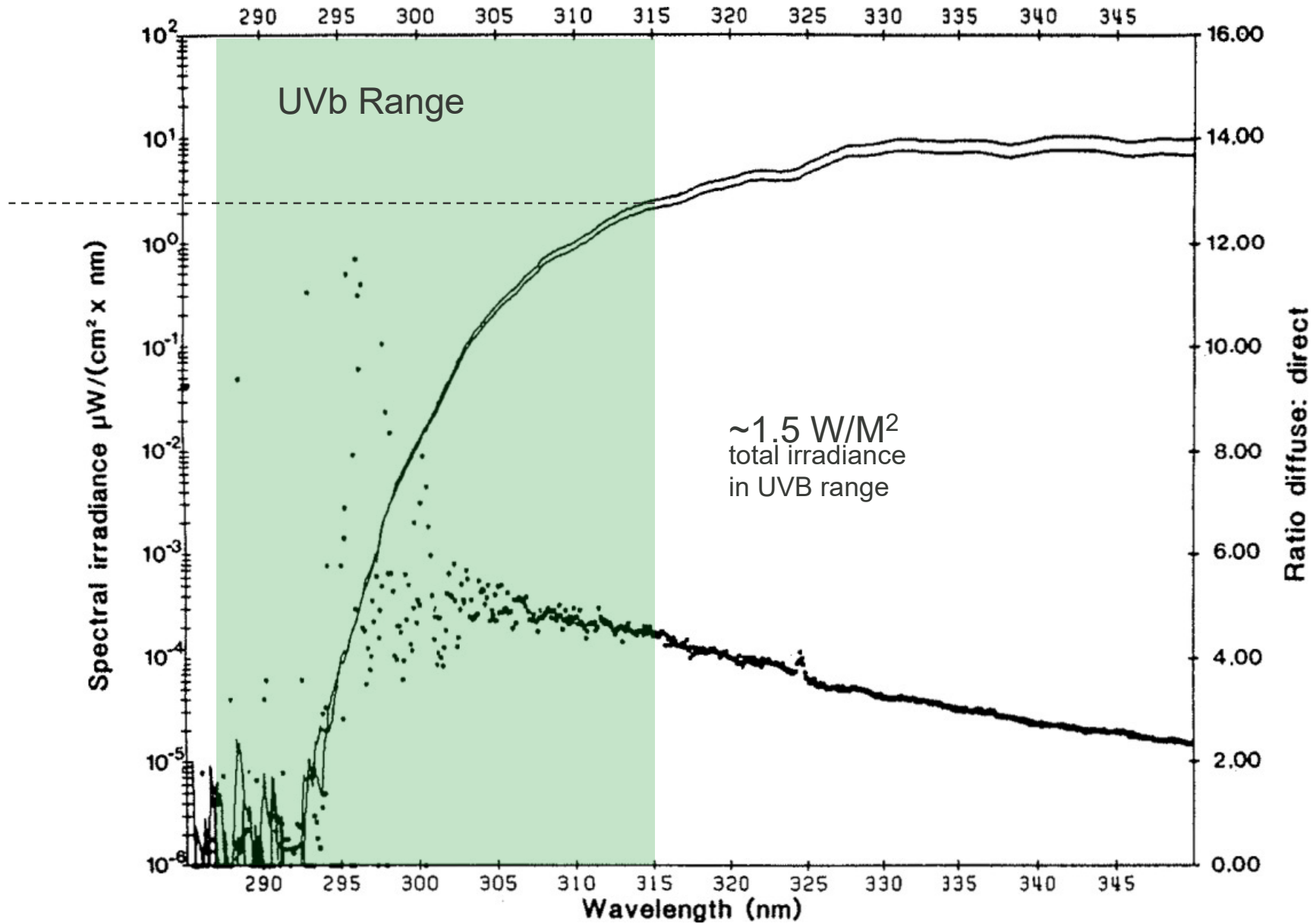
SOURCE: <https://academic.oup.com/jid/article/222/2/214/5841129>

INACTIVATION RATES FOR SARS-COV-2 SUSPENDED IN SIMULATED SALIVA AS A FUNCTION OF UVB IRRADIANCE





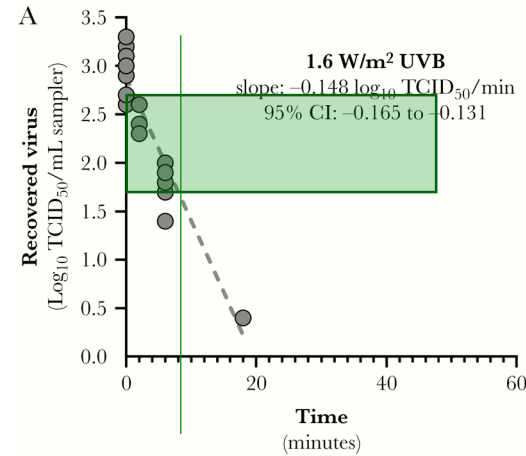
TOTAL IRRADIANCE OF DIFFUSE AND DIRECT SOLAR RADIATION



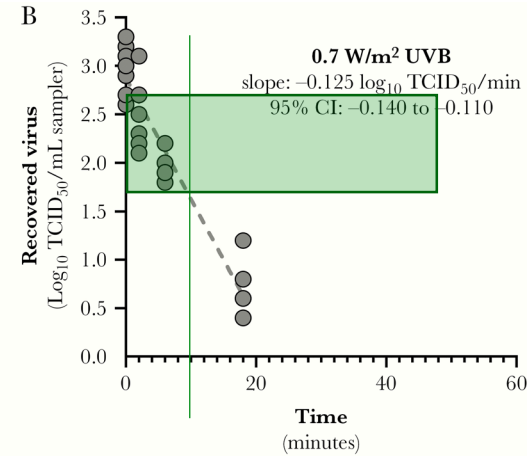
SOURCE: National Center for Biotechnology Information | <https://www.ncbi.nlm.nih.gov/books/NBK401584/>

TIME TO REACH 1 LOG (90%) REDUCTION IN VIABLE SARS-COV-2 VIRUS IN SIMULATED SALIVA DUE TO UVB EXPOSURE

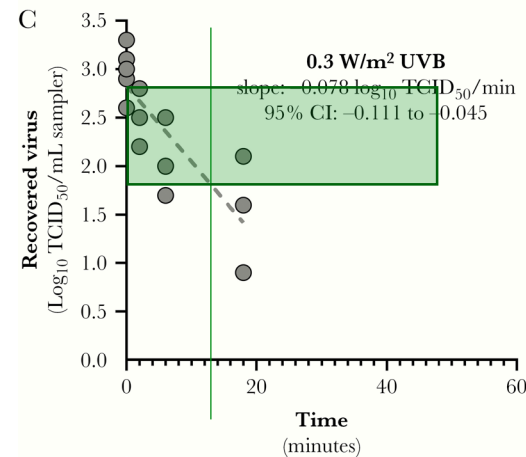
DIRECT SUNLIGHT



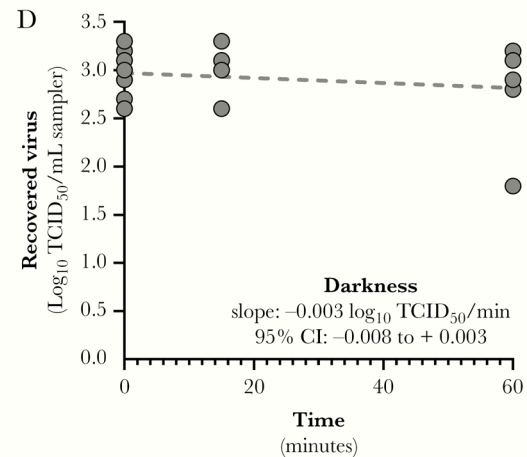
CLOUDY



TWILIGHT



DARKNESS





OUTDOOR PLAY EQUIPMENT



POROUS OUTDOOR SURFACES



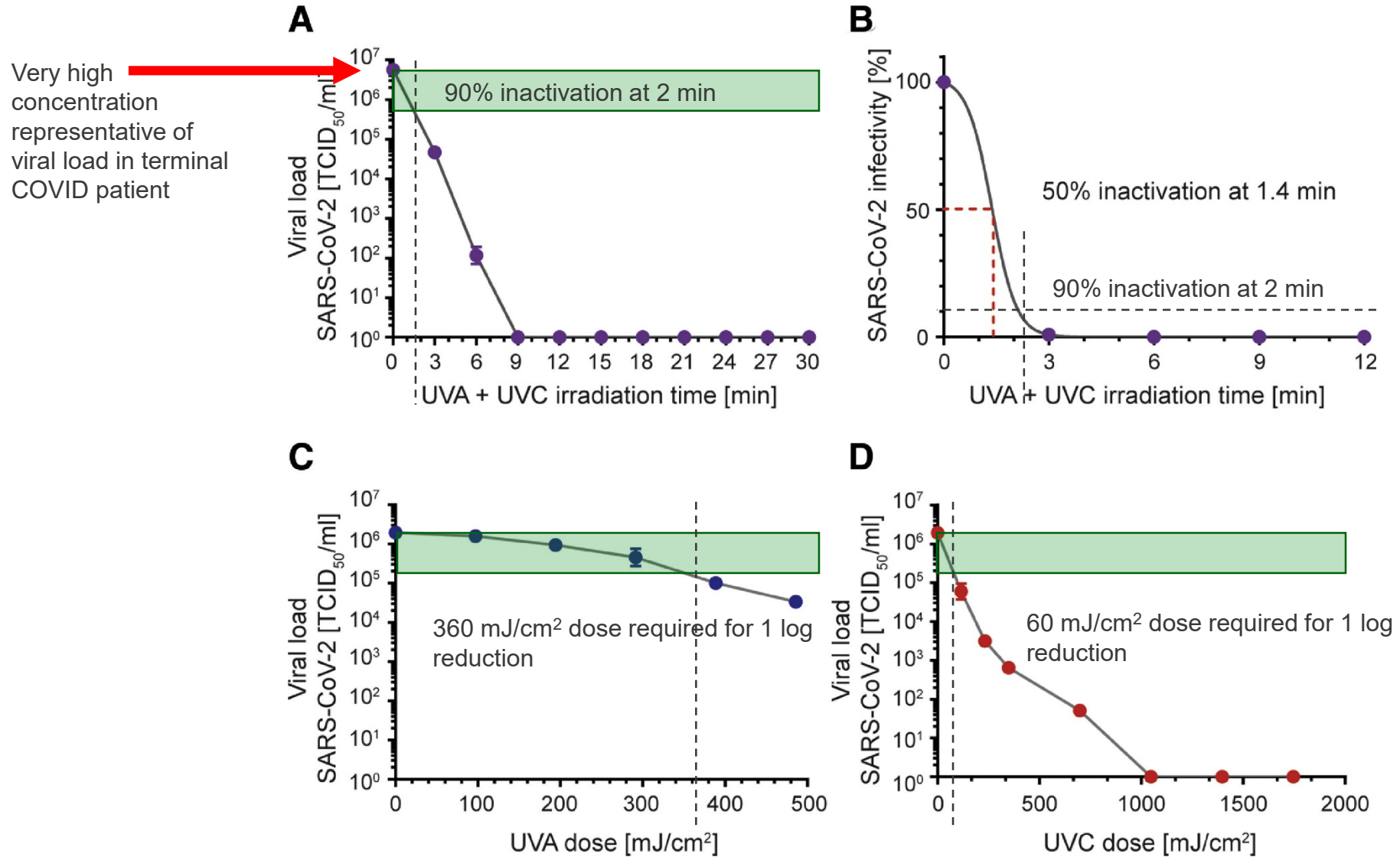
UVC LIGHT WILL ALSO RAPIDLY INACTIVATE THE VIRUS

UVC light at 254nm has been proven to rapidly inactivate SARS-CoV-2 on surfaces, even at very high viral loads.



SOURCE: [https://www.ajicjournal.org/article/S0196-6553\(20\)30756-2/fulltext](https://www.ajicjournal.org/article/S0196-6553(20)30756-2/fulltext)

VIRAL REDUCTION OF SURFACE APPLICATION OF UVA AND UVC



Disinfection with the power of light

UV-C disinfection

Home | Air | Surface | Objects | Water | UV-C lamps | UV LED | UV-C luminaires



Retail

Disinfecting shopping carts, shelves and counters



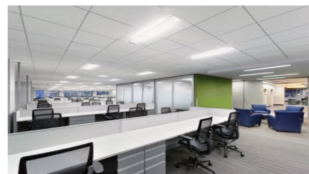
Hair and beauty salons

Disinfect client rooms, floor, mirror, chair, counter surfaces and other sensitive areas



Schools

Disinfect classroom walls, floors, desks and surfaces



Offices

Disinfect work rooms, meeting spaces and corridors



Banking

Disinfect counters, cash machines and work surfaces



Hospitality

Disinfect guest rooms, reception areas and health club facilities



Food outlets

Disinfect preparation surfaces and equipment



Washrooms

Disinfect vanity units, basins and mirrors



Transportation

Disinfect interior and exterior surfaces of different vehicles and passengers' waiting spaces

A background graphic featuring a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure. The overall aesthetic is modern and technical.

EXAMPLES IN THE BUILT ENVIRONMENT



ELEVATOR BUTTONS



RESTROOM FIXTURES



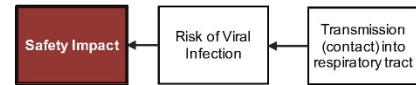
SHOPPING CARTS



SECURITY SCREENING

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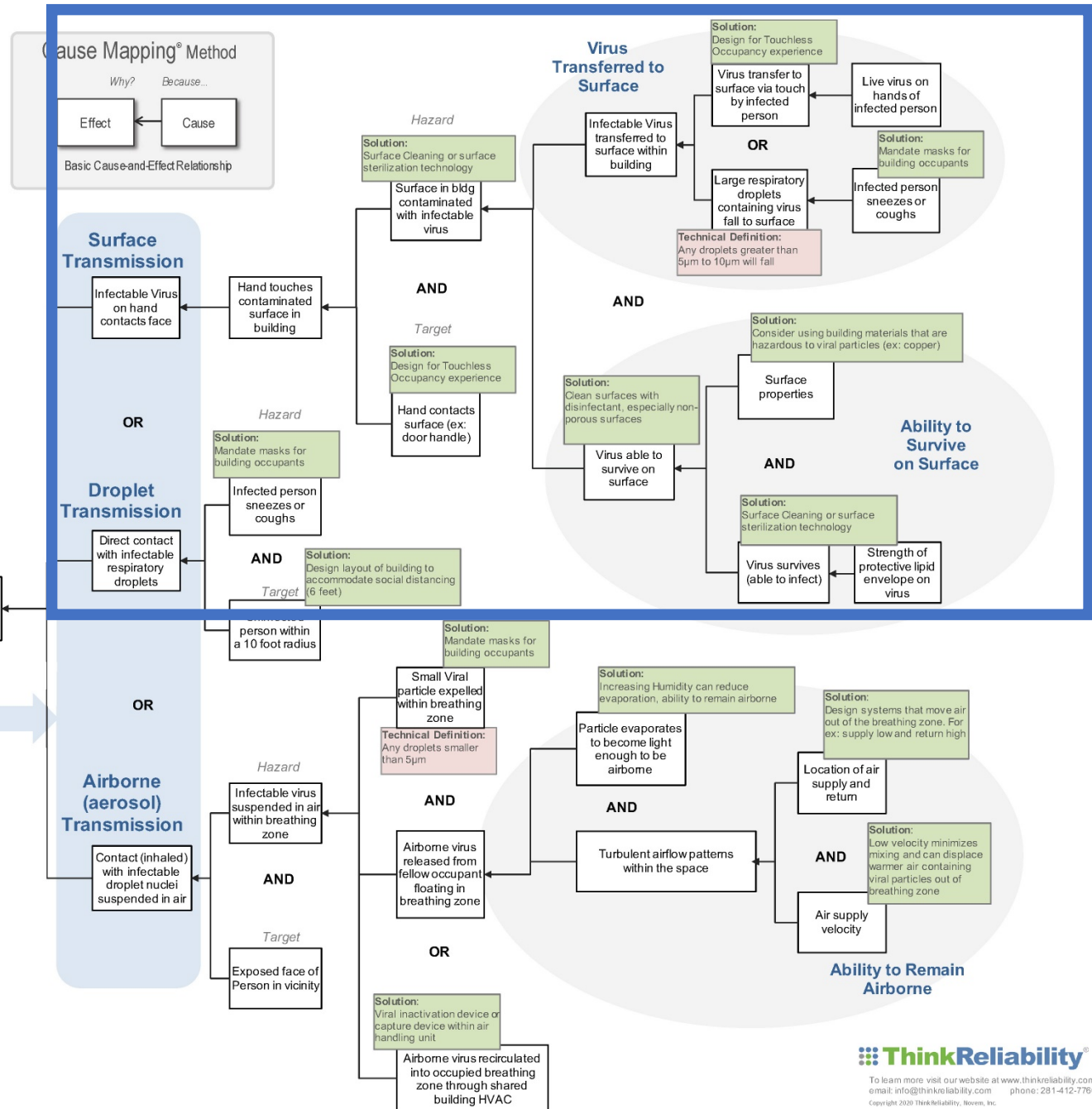
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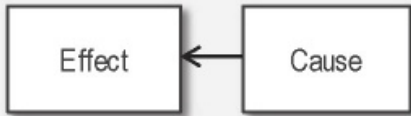
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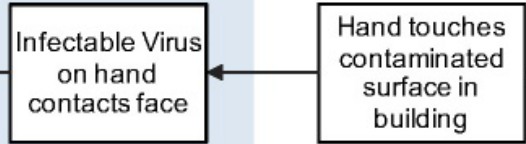
Cause Mapping® Method

Why? Because...



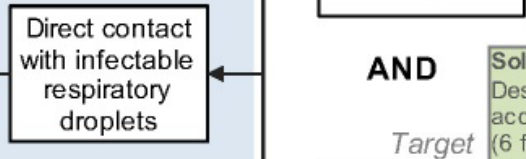
Basic Cause-and-Effect Relationship

Surface Transmission



OR

Droplet Transmission



AND

Target

Solution:
Design layout of building to accommodate social distancing (6 feet)

Hazard
Solution:
Surface Cleaning or surface sterilization technology

Surface in bldg contaminated with infectable virus

AND

Target

Solution:
Design for Touchless Occupancy experience

Hand contacts surface (ex: door handle)

Virus Transferred to Surface

Infectable Virus transferred to surface within building

Solution:
Design for Touchless Occupancy experience

Virus transfer to surface via touch by infected person

Live virus on hands of infected person

OR

Large respiratory droplets containing virus fall to surface

Infected person sneezes or coughs

Technical Definition:
Any droplets greater than 5µm to 10µm will fall

Reduce touch-points

Solution:
Mandate masks for building occupants

Masks – 90%

Time 1-24 hours

AND

Solution:
Clean surfaces with disinfectant, especially non-porous surfaces

Virus able to survive on surface

Solution:
Consider using building materials that are hazardous to viral particles (ex: copper)

Surface properties

Ability to Survive on Surface

AND

Solution:
Surface Cleaning or surface sterilization technology

Virus survives (able to infect)

Stability of virus

**Sunlight (Uvb) 5-10 min
Uvc 1-2 min
Cleaning solution (i.e. bleach) – 1 min**

QUIZ TIME

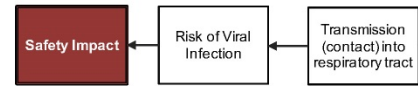
+

5 MINUTE BREAK

TRANSMISSION PATHS: AIRBORNE (BIOAEROSOLS)

HOW TO REDUCE THE RISK OF COVID-19 INFECTION THROUGH BUILDING DESIGN.

Transmission of COVID-19 in buildings requires two things — the active virus being present in sufficient quantity to cause infection and the transmission of that active virus into the respiratory tract of the person being infected. In public buildings, it's often difficult to control for the presence of the virus, but good design practices can work together to reduce the overall risk of infection.



3 Transmission Paths

Using the Cause Map diagram we are able to highlight the 3 potential transmission paths of a viral infection. Each path has different control opportunities (Solutions) that can reduce the risk of transmission. The 3 paths include:

Surface Transmission

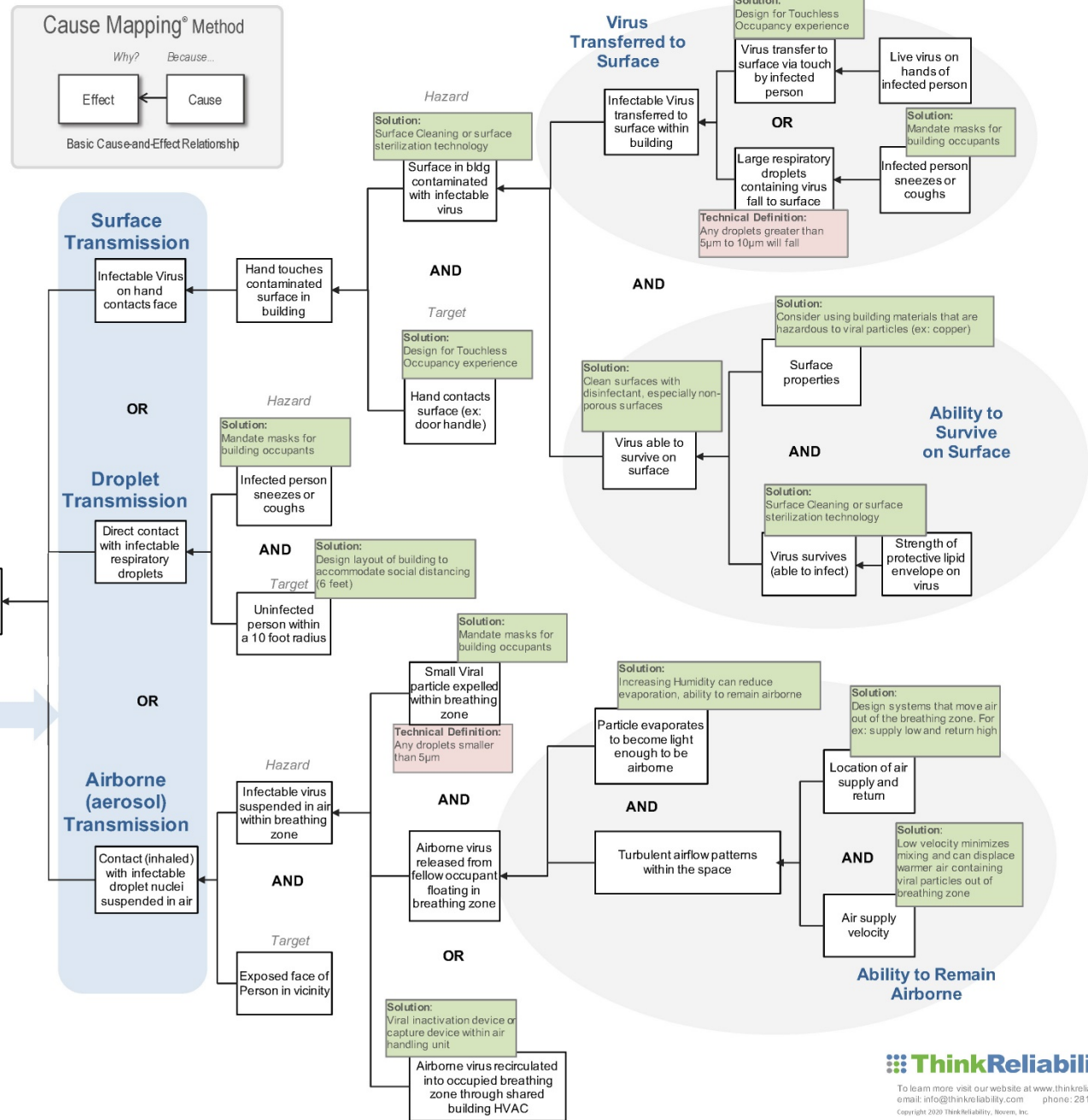
A person touches a contaminated surface and then inadvertently touches their face introducing the virus.

Droplet Transmission

An infected person is talking, coughing, or sneezing within close contact of others. Large Respiratory droplets (greater than 5µm to 10µm) makes direct contact to infect.

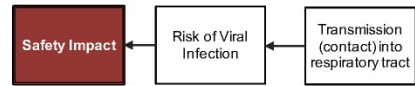
Airborne (aerosol) Transmission

An infected person is talking, coughing, or sneezing. The small respiratory droplets (less than 5µm to 10µm) remain suspended in air for a period of time and over greater distance.



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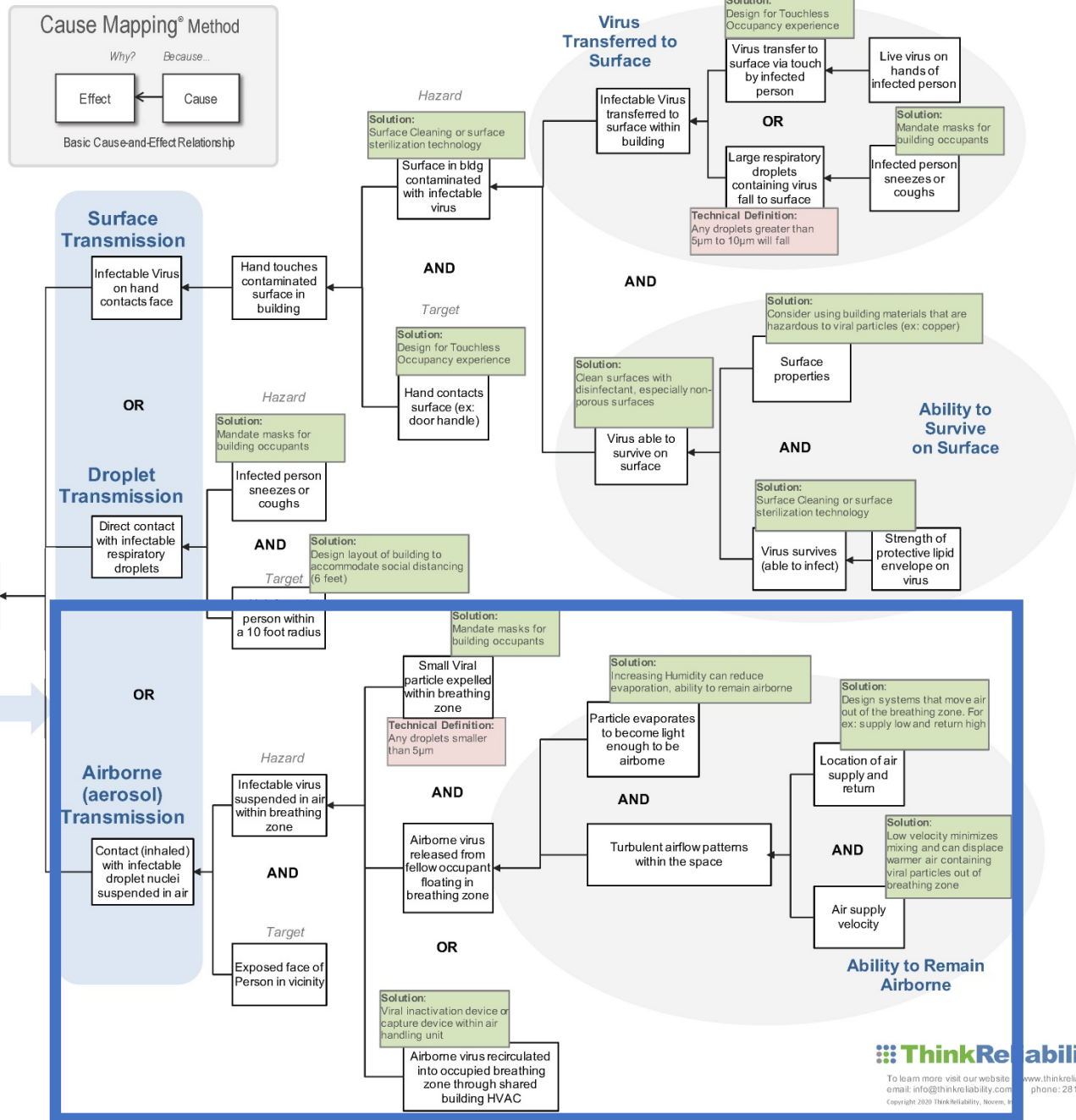
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A background graphic consisting of a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure that spans the entire page.

REVIEW OF PUBLISHED SCIENTIFIC EVIDENCE

IS AIRBORNE (AEROSOL) TRANSMISSION EVEN POSSIBLE?

“To evaluate evidence of aerosol transmission of SARS-CoV-2, we apply the criteria of Jones and Brosseau ([Jones and Brosseau, 2015](#)), which are that aerosol transmission is plausible when (1) virus-containing aerosols are generated by or from an infectious person, (2) virus remains viable and infective in the aerosols for some period of time, and (3) the target tissues where virus initiates infection are accessible to the aerosol with enough load.”

Aerosol transmission of SARS-CoV-2? Evidence, prevention and control

[Song Tang](#),^{a,b,1} [Yixin Mao](#),^{a,1} [Rachael M. Jones](#),^{c,1} [Qiyue Tan](#),^a [John S. Ji](#),^{d,e} [Na Li](#),^a [Jin Shen](#),^a [Yuebin Lv](#),^a [Lijun Pan](#),^a [Pei Ding](#),^a [Xiaochen Wang](#),^a [Youbin Wang](#),^a [C. Raina MacIntyre](#),^{f,g} and [Xiaoming Shi](#)^{a,b,*}



LOGIC TEST FOR AEROSOL TRANSMISSION

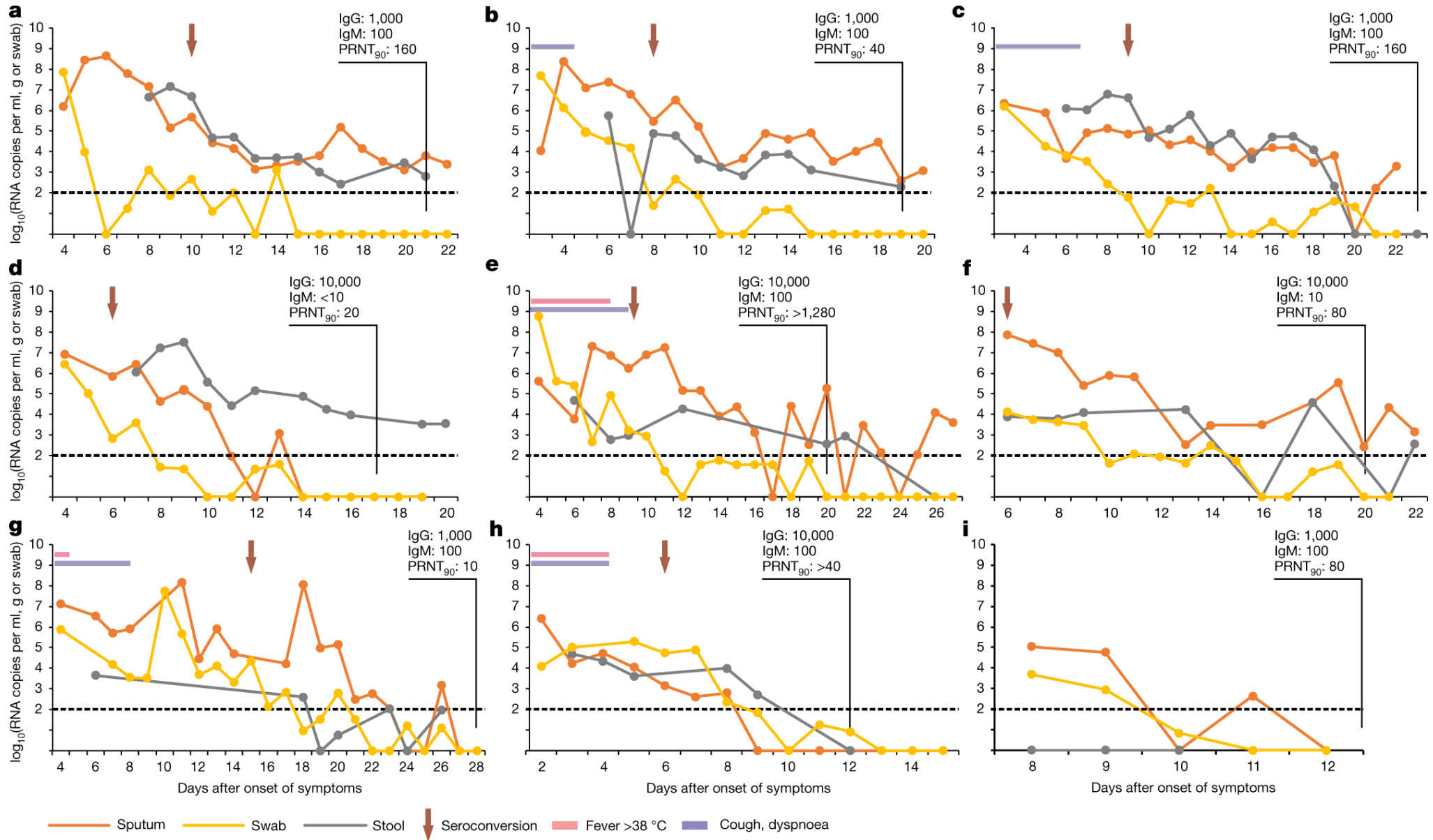
1. Saliva and/or respiratory fluids contain viable virus.
2. Breathing/talking/singing/coughing generate airborne particles of sufficiently small size to aerosolize.
3. Virus remains viable in airborne particle.
4. Breathing in airborne particles can cause infection.
 - The evidence for infection is always circumstantial.



Saliva and/or respiratory fluids **contain viable virus.**



CONCENTRATION OF ACTIVE VIRUS IN LUNGS, SINUSES, & STOOL OF COVID-19 PATIENTS





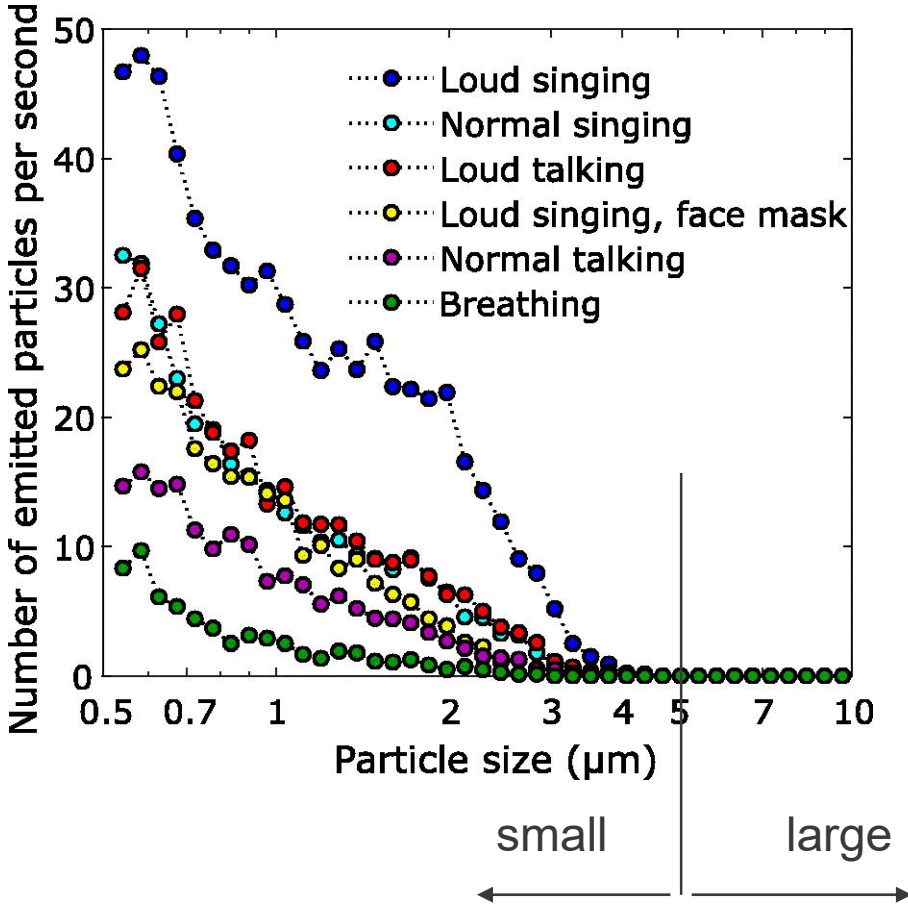
Breathing/talking/singing/coughing generate airborne particles of sufficiently small size to aerosolize.





SOURCE: Hamilton

PARTICLE SIZE DISTRIBUTION FOR VARIOUS ACTIVITIES



HOW DOES A PARTICLE BECOME AIRBORNE?

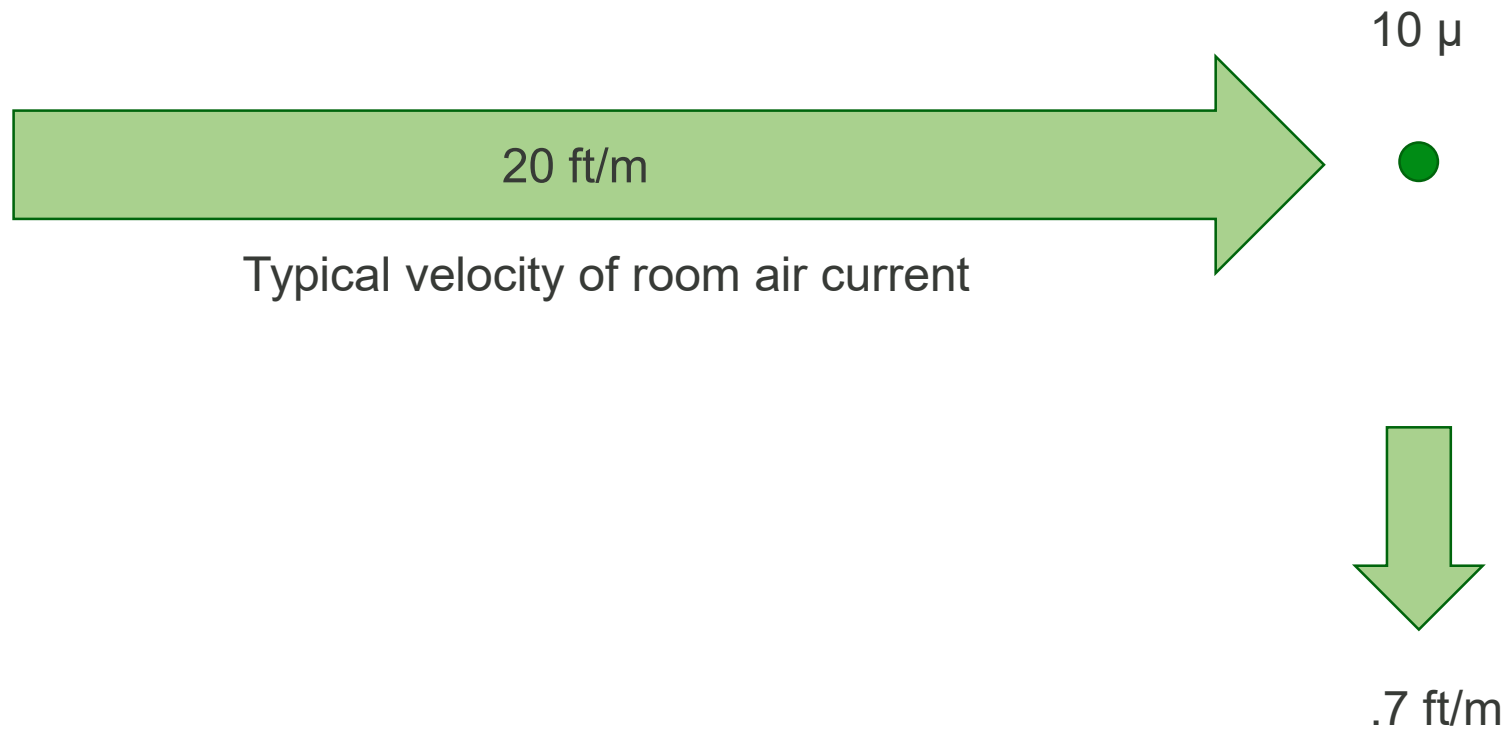


“According to Stokes’ law, the terminal velocity of a falling droplet scales as the square of its diameter. Once airborne, speech-generated droplets rapidly dehydrate due to evaporation, thereby decreasing in size and slowing their fall.”

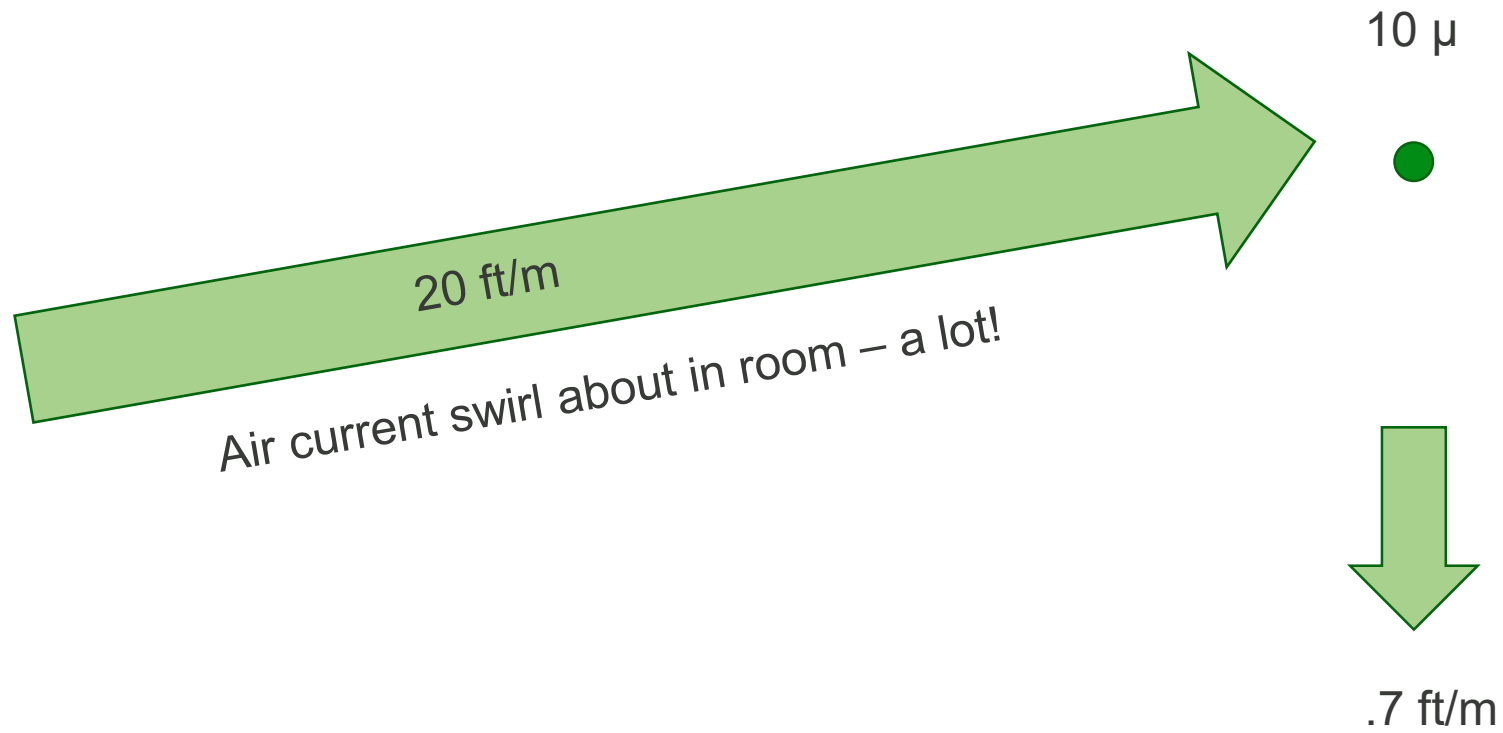
SOURCE: Proceedings of the National Academy of Sciences

The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission, <https://doi.org/10.1073/pnas.2006874117>

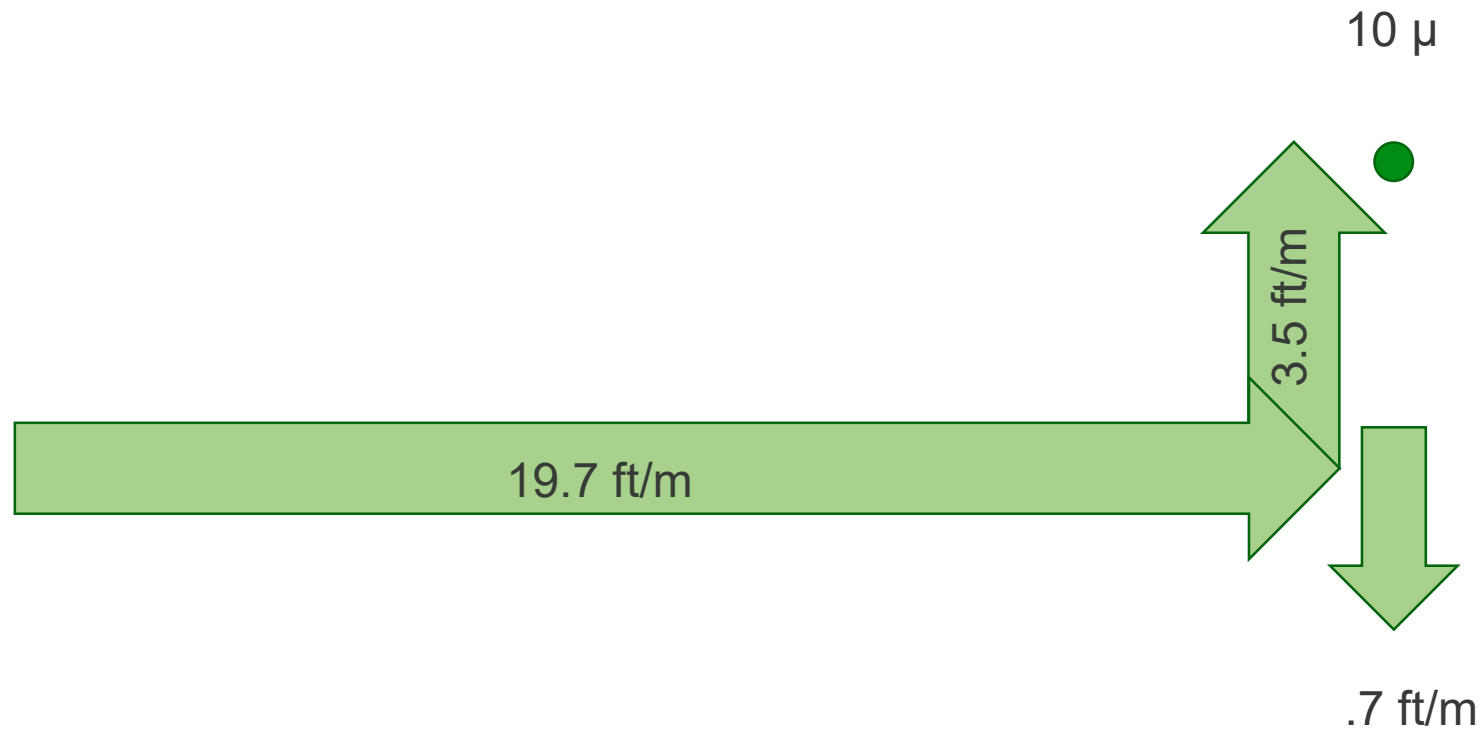
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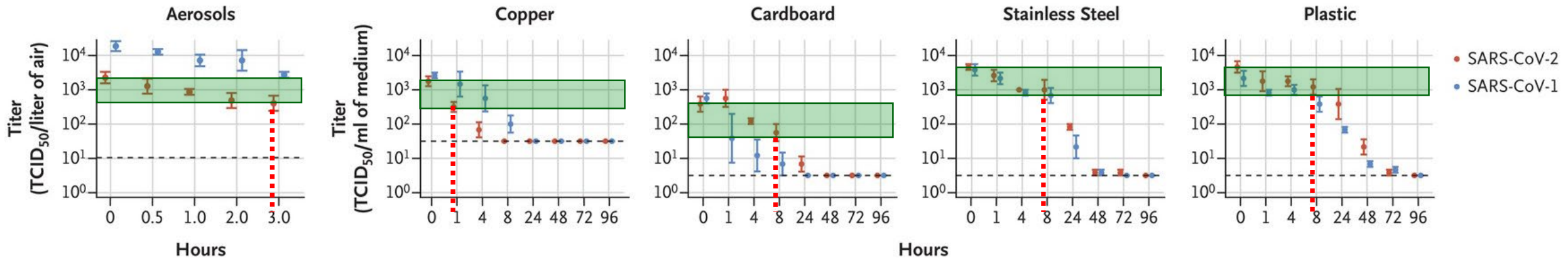


Virus remains **viable** in an airborne particle.



TIME TO REACH 1 LOG (90%) REDUCTION IN VIABLE SARS-COV-2 VIRUS DUE TO NATURAL DECAY ON VARIOUS MATERIALS

A Titers of Viable Virus



SARS-CoV-2 can survive for more than 3 hr in the air, with a half-life of 1.1 hr in aerosols (21–23 °C; relative humidity 65%)



There is a risk of “shared space” or “recirculated air” aerosol transmission of COVID-19.

The 6 ft distance "rule" should be treated as a guideline not a rule, droplets fall in a gradient based on their size.

Keeping 6ft away from an infected person will reduce (but not eliminate) the risk of large droplet contact, but will **do very little to minimize aerosol particle contact.**



Two Metres Or One: What Is The Evidence for Physical Distancing in COVID-19?

SOURCE: British Medical Journal | BMJ 2020;370:m3223

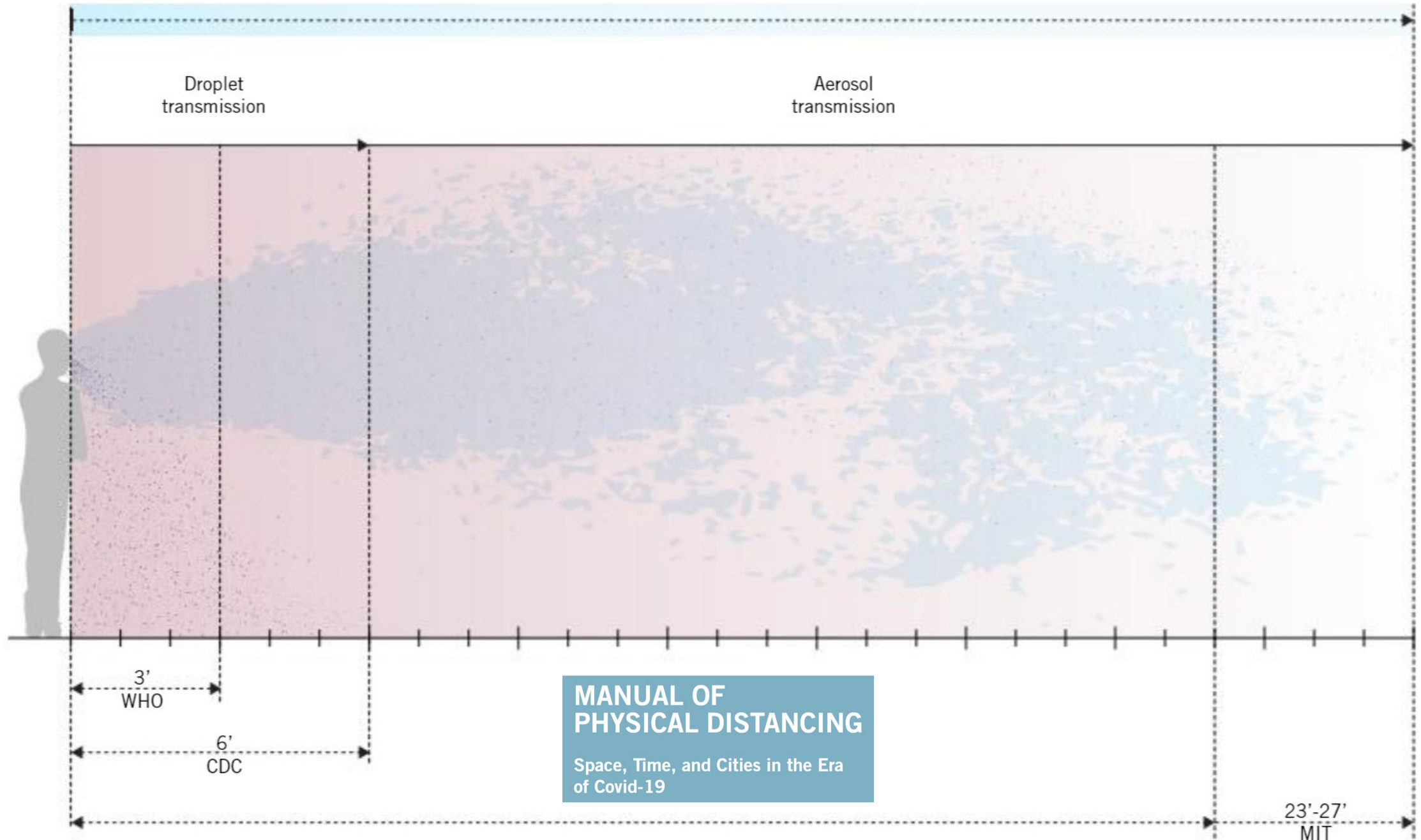


≈ 7-8 m

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Droplet diameter 10 to 5 μm



Droplet transmission

Aerosol transmission

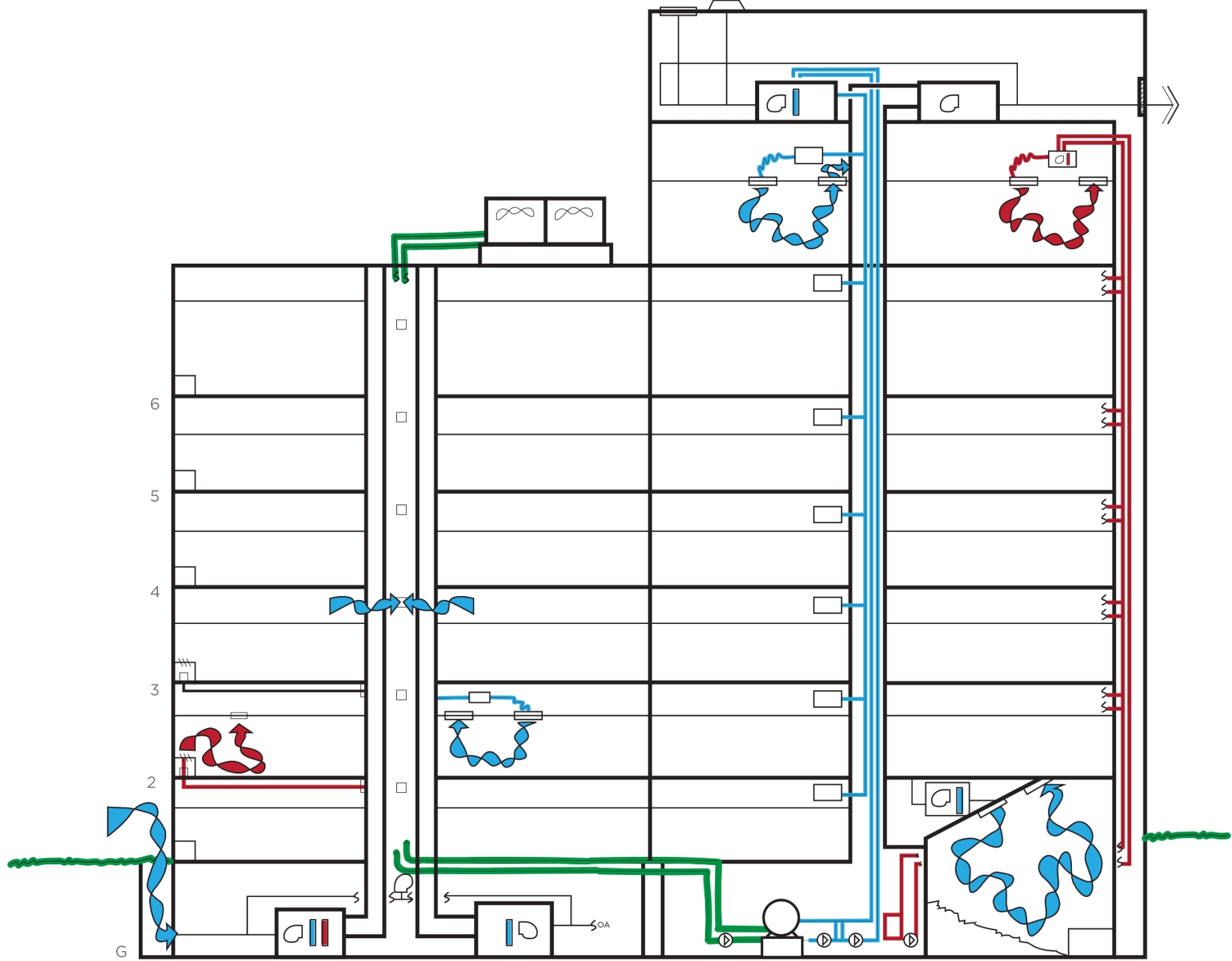
3'
WHO

6'
CDC

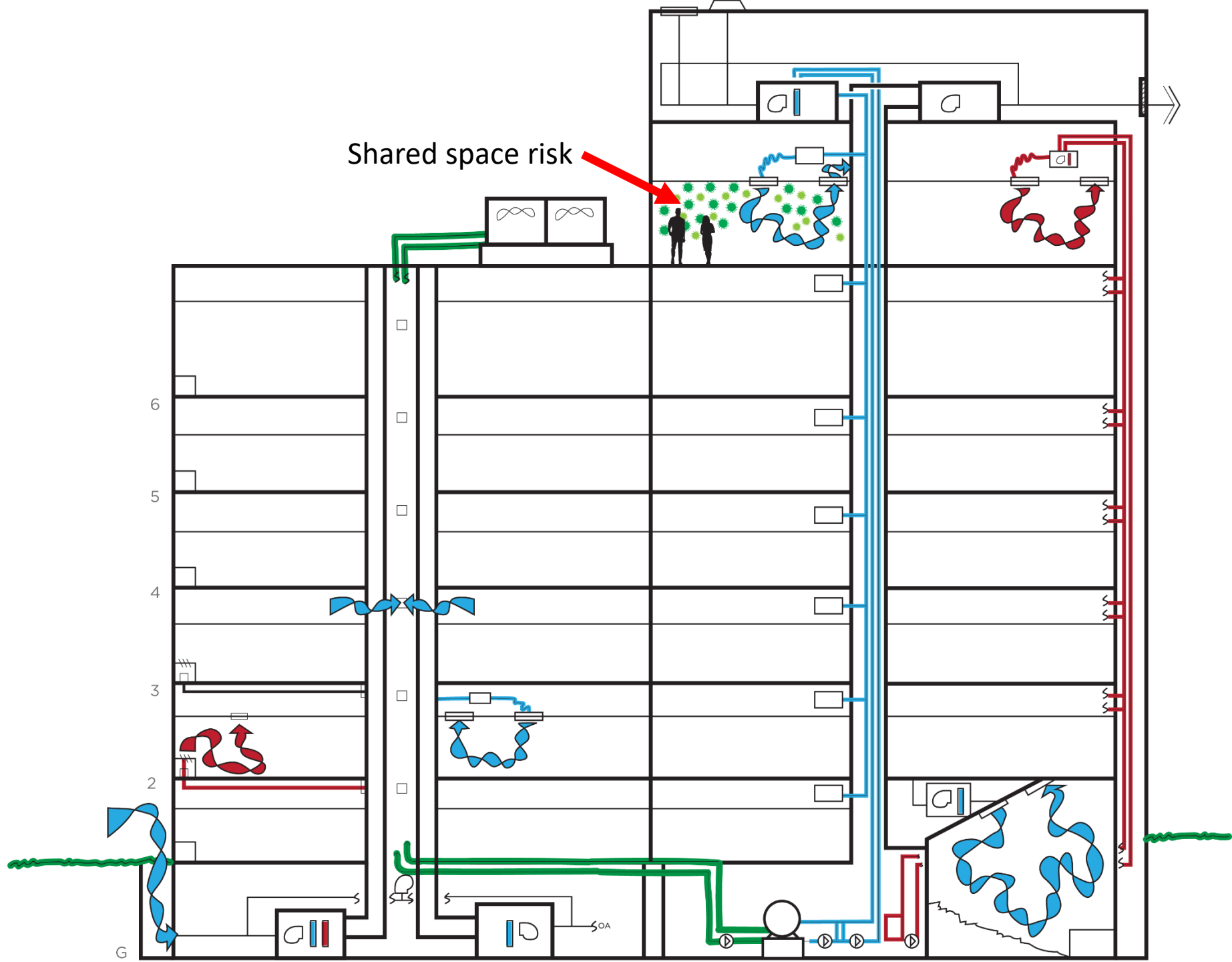
MANUAL OF PHYSICAL DISTANCING

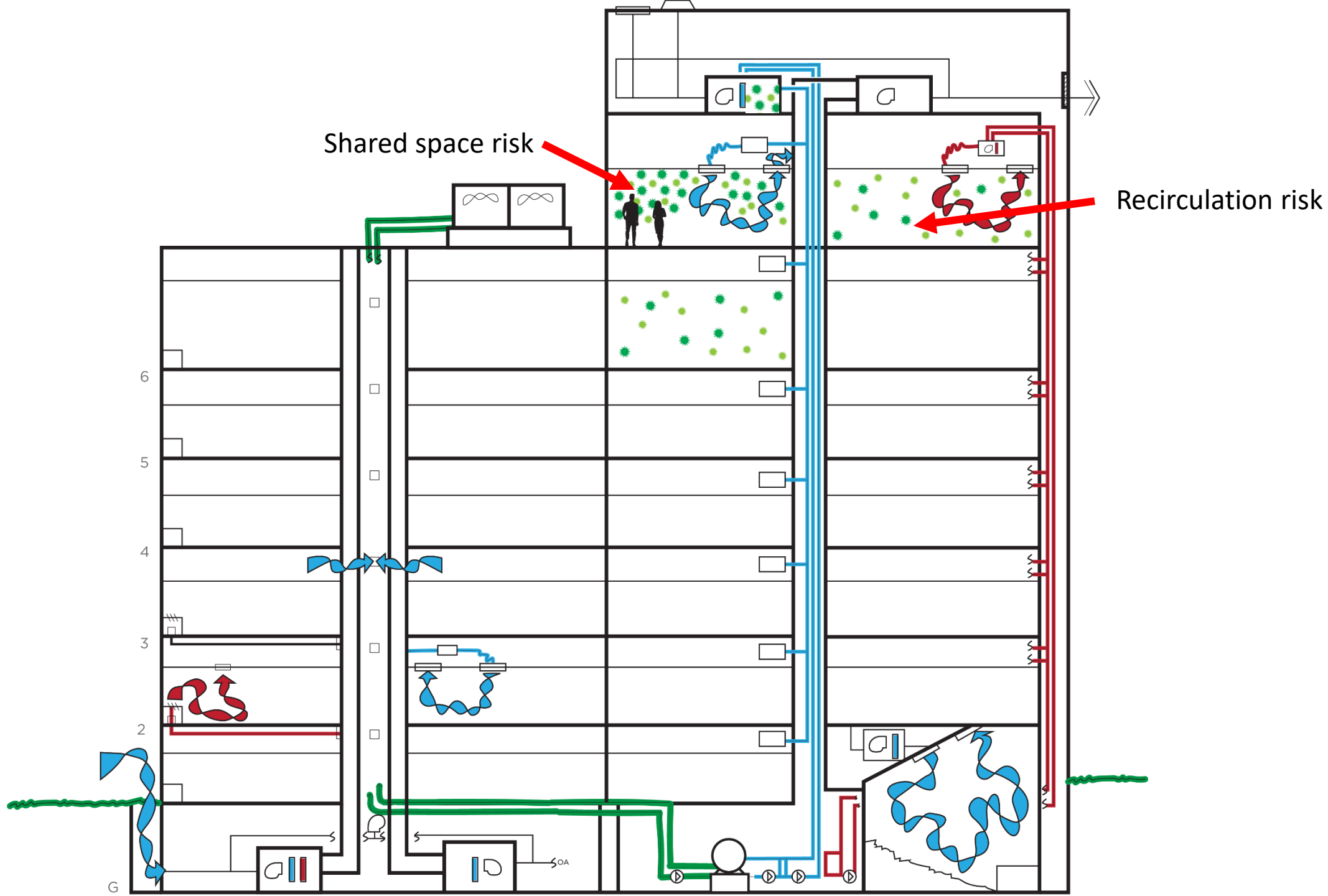
Space, Time, and Cities in the Era of Covid-19

23'-27'
MIT







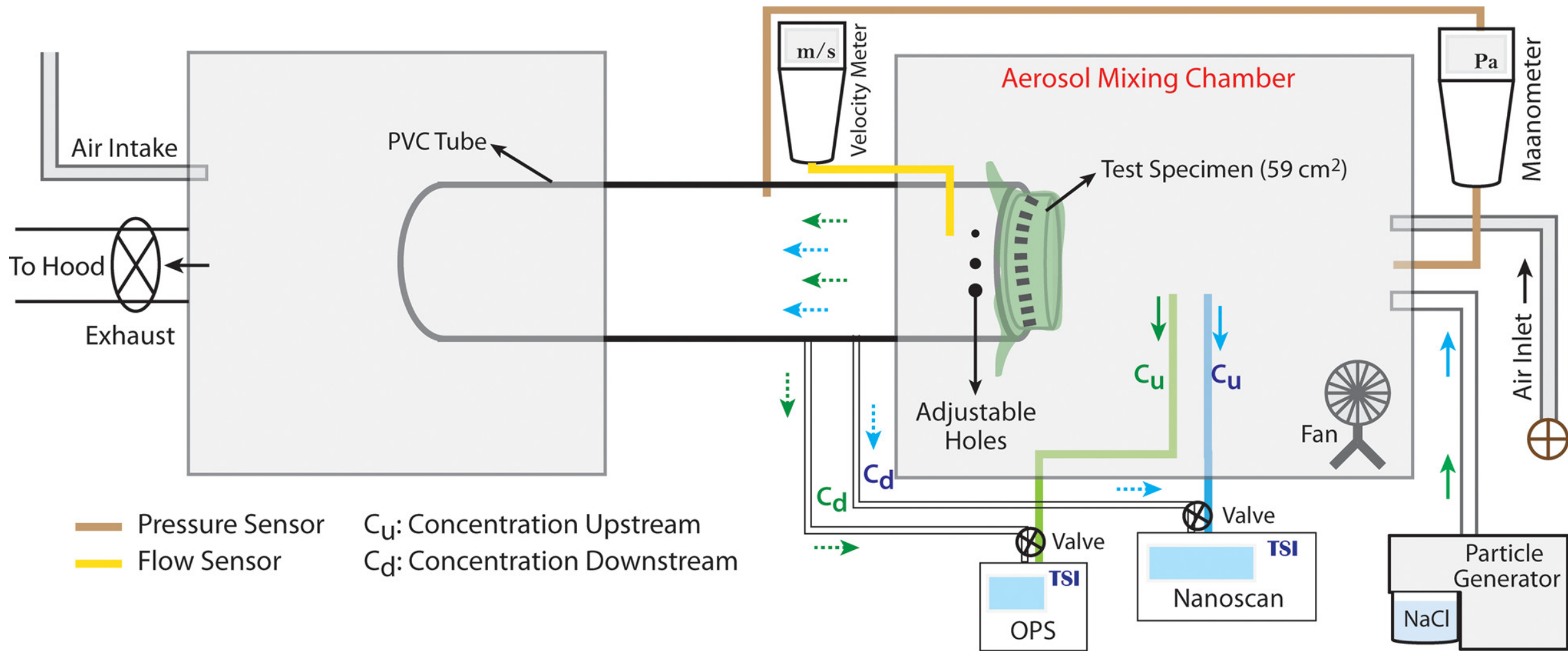


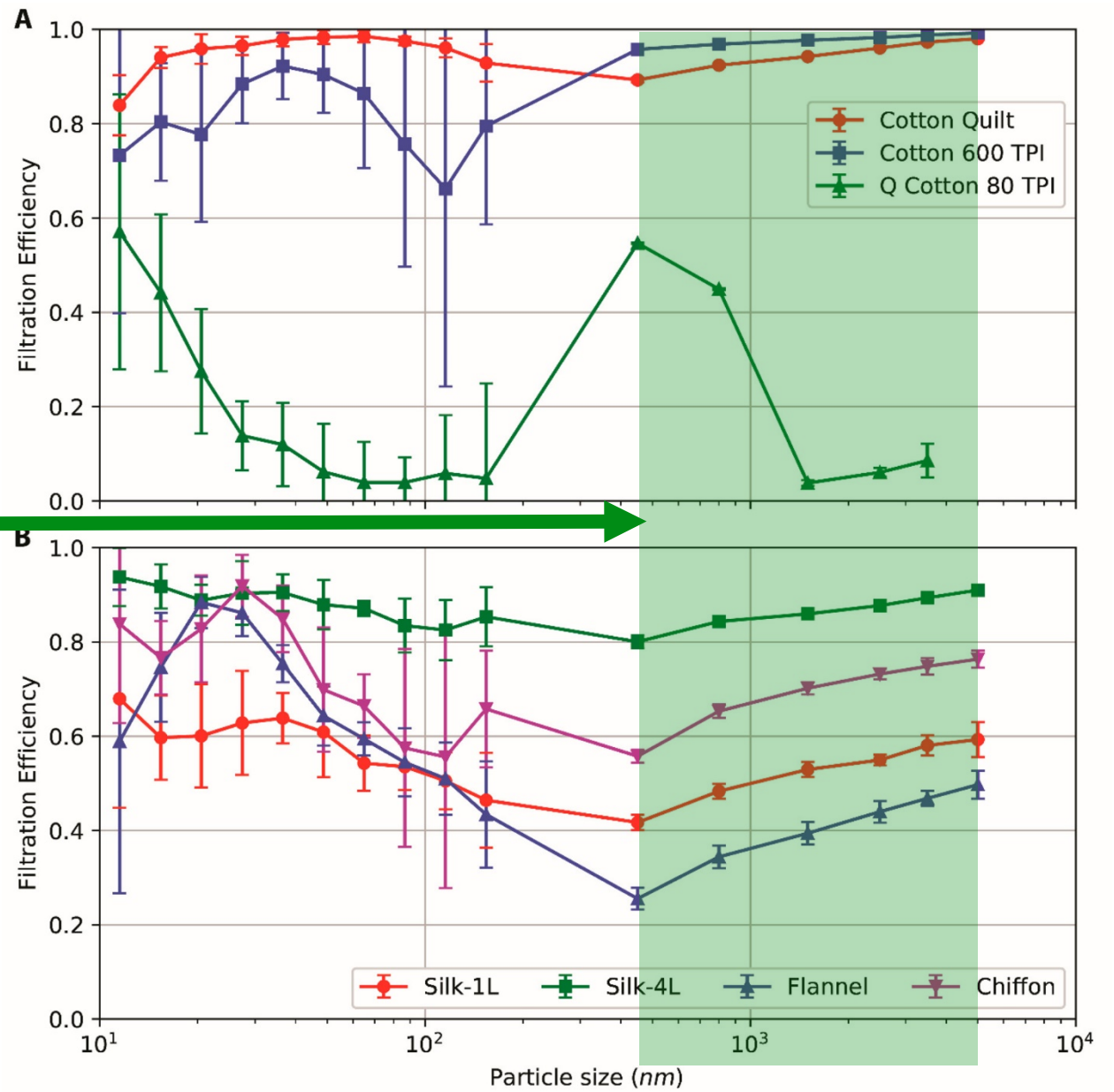
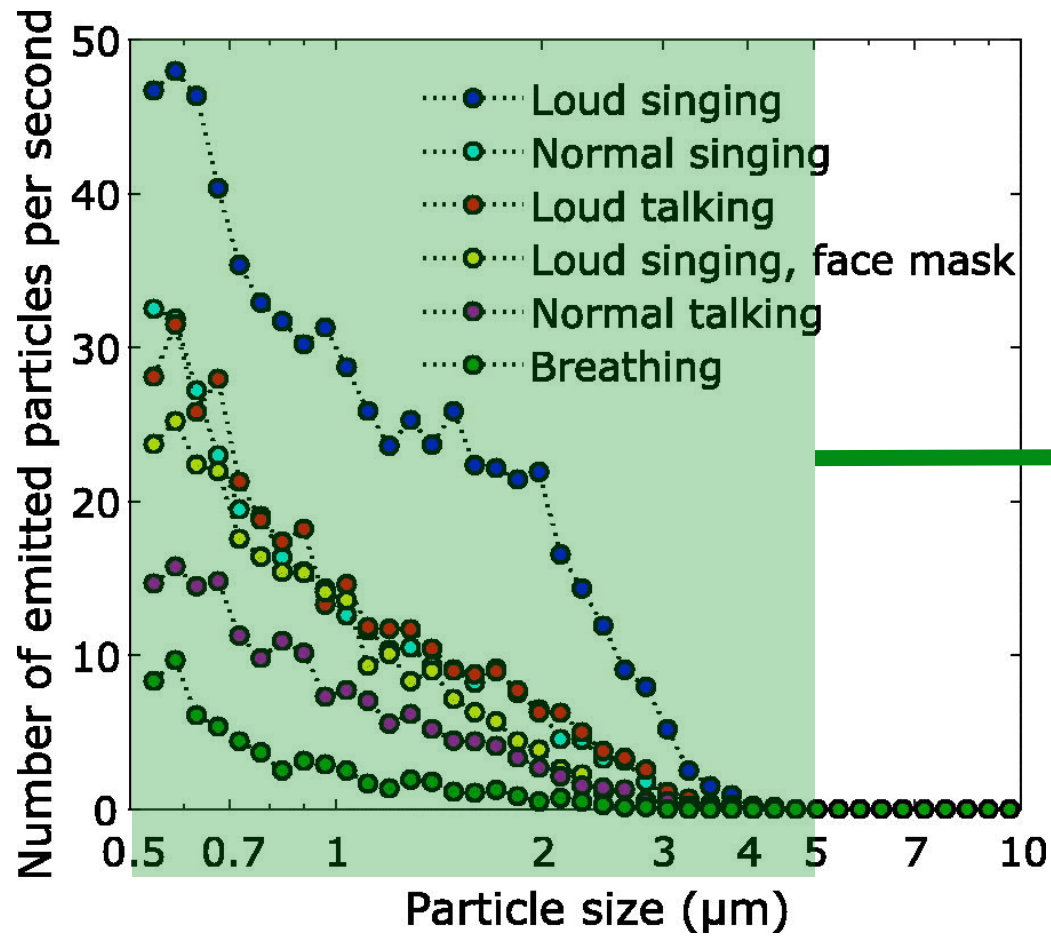


MASKS ARE FAIRLY EFFECTIVE AT CAPTURING SMALL PARTICLES

Non-medical masks are **between 20-80% effective** at capturing infectious particles depending on their fit, construction, and fabric.

Masks made of double layer, tightly woven fabric (like cotton) that fit snugly are likely **around 50-60% effective on small aerosol particles** and **approach 100% effectiveness on large droplets.**





A background graphic featuring a network of interconnected nodes and lines, rendered in a light gray color against a dark blue and green gradient. The nodes are represented by small circles, and the lines are thin, creating a complex web-like structure. The overall aesthetic is modern and technical.

EXAMPLES IN THE BUILT ENVIRONMENT



EDUCATION



WORKPLACE MEETING AREAS



DINING AREAS

QUIZ TIME

The background of the slide features a complex network diagram. It consists of numerous nodes, represented by small circles of varying sizes and colors (some are solid grey, some are hollow white), interconnected by thin, light-colored lines. The nodes are distributed across the top and bottom sections of the slide, with a higher density in the top-left and bottom-right corners. The overall aesthetic is technical and digital.

RECAP

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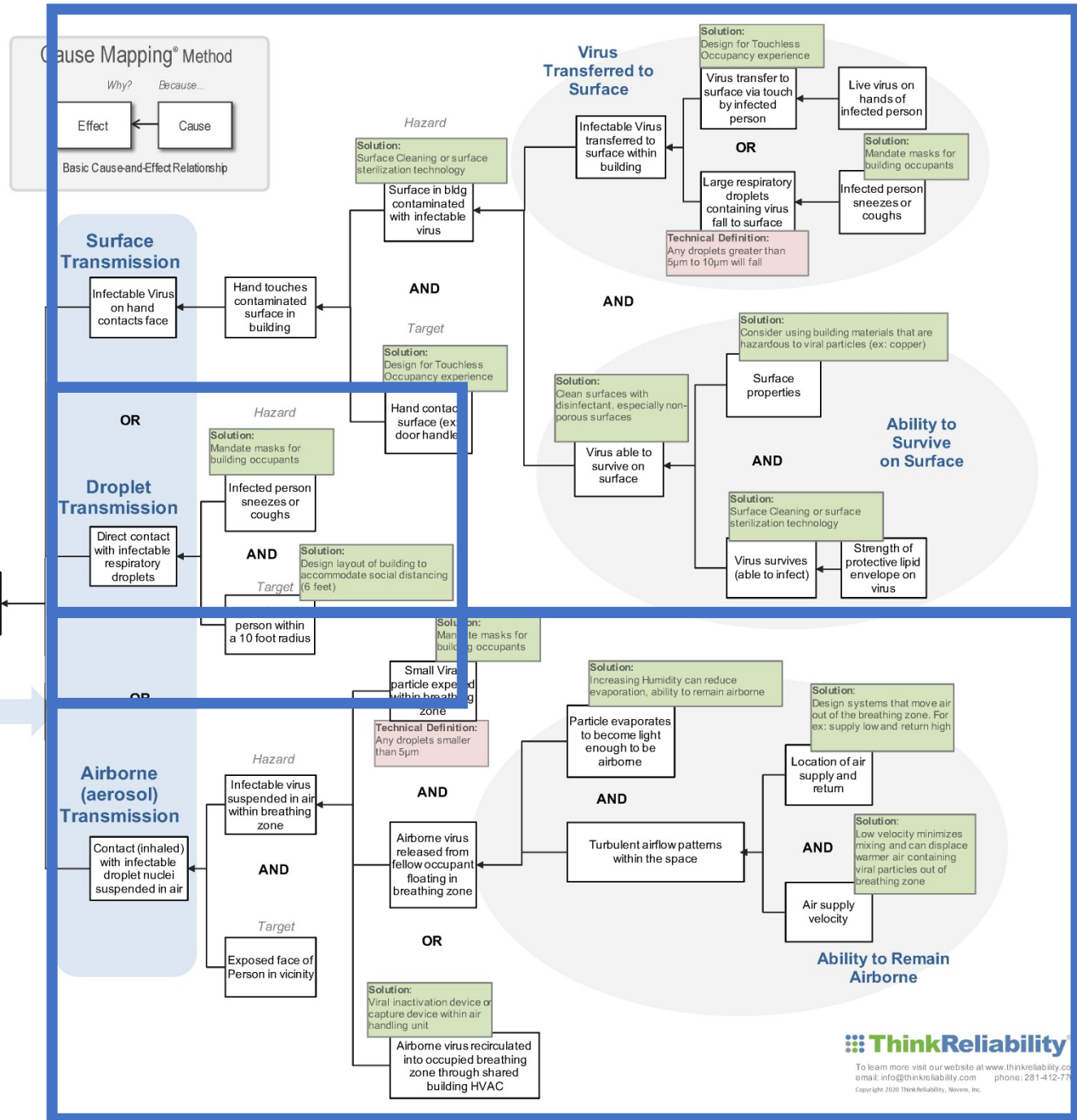
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REVIEW OF SESSION 1

- There are **3 main transmission paths**: Fomite, Large droplet, and Aerosol
- Masks are very effective at large droplet capture & ~50% effective at capturing small ones
- Sunlight rapidly inactivates coronavirus
- UVC light also rapidly inactivates coronavirus
- Aerosol transmission is possible
- The virus that causes COVID-19 stays viable in the air for roughly 3 hours



THANK YOU

Dustin Schafer PE | Director of Engineering
dustin.schafer@hendersonengineers.com



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