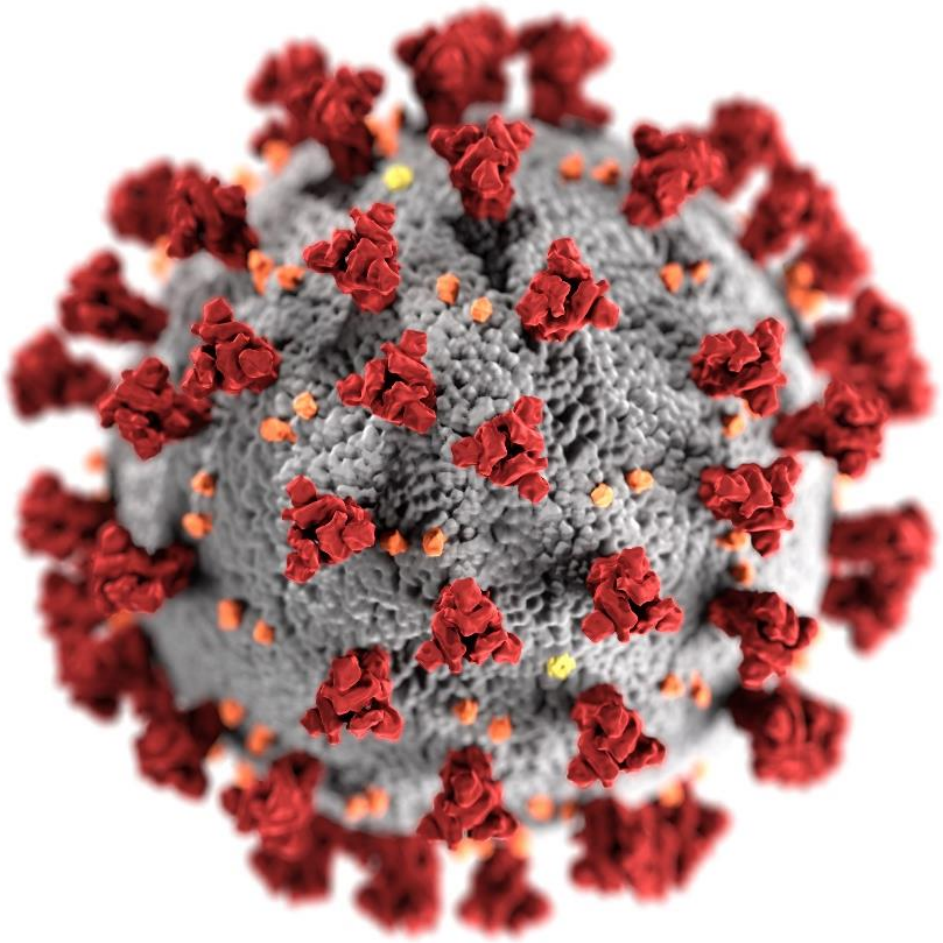
COVID-19 and Indoor Air: Considerations for Buildings



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The National Tribal Air Association
Indoor Air Quality Work Group
Webinar Series

November 24, 2020

cdc.gov/coronavirus

Outline of talk

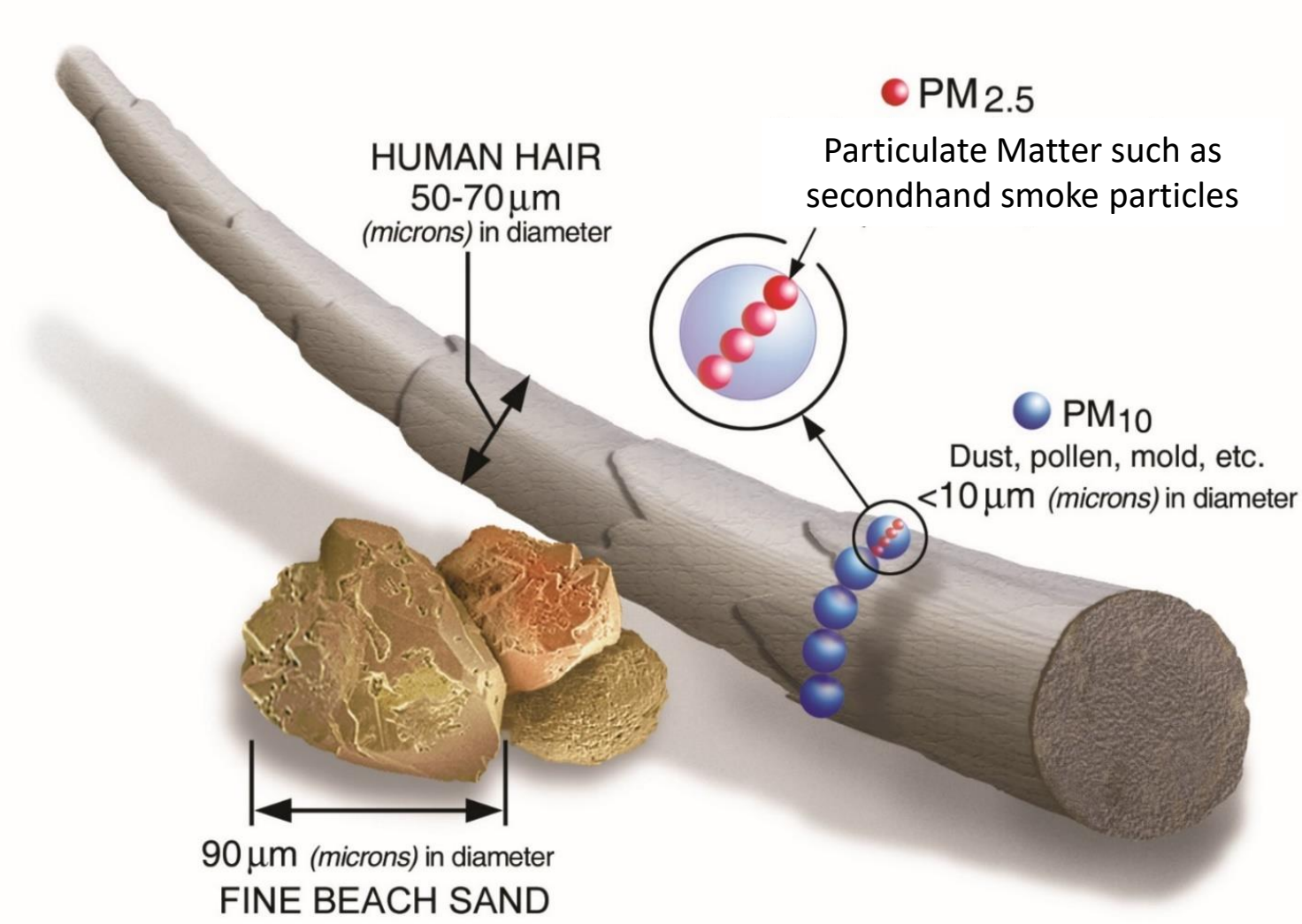
- Particle size distribution of SARS-CoV-2, the virus that causes COVID-19.
- Use of masks for “source control" and personal protection.
- Discussion of evidence for portable air cleaners and partitions.

Definitions

- Aerosols (industrial hygiene): Solid or liquid particles suspended in air.[1] They can range in sizes from microscopic to visible.
- Larger droplets: Some of which are visible and that fall out of the air rapidly within seconds to minutes while close to the source. [2]
- Smaller droplets and particles (formed when small droplets dry very quickly in the airstream): Can remain suspended for many minutes to hours and travel far from the source on air currents. [2]
- Droplets: Liquid particles > 5 microns[3] (i.e., micrometers).
- Droplet nuclei: Dried residual of droplets, particles ≤ 5 microns[3] .

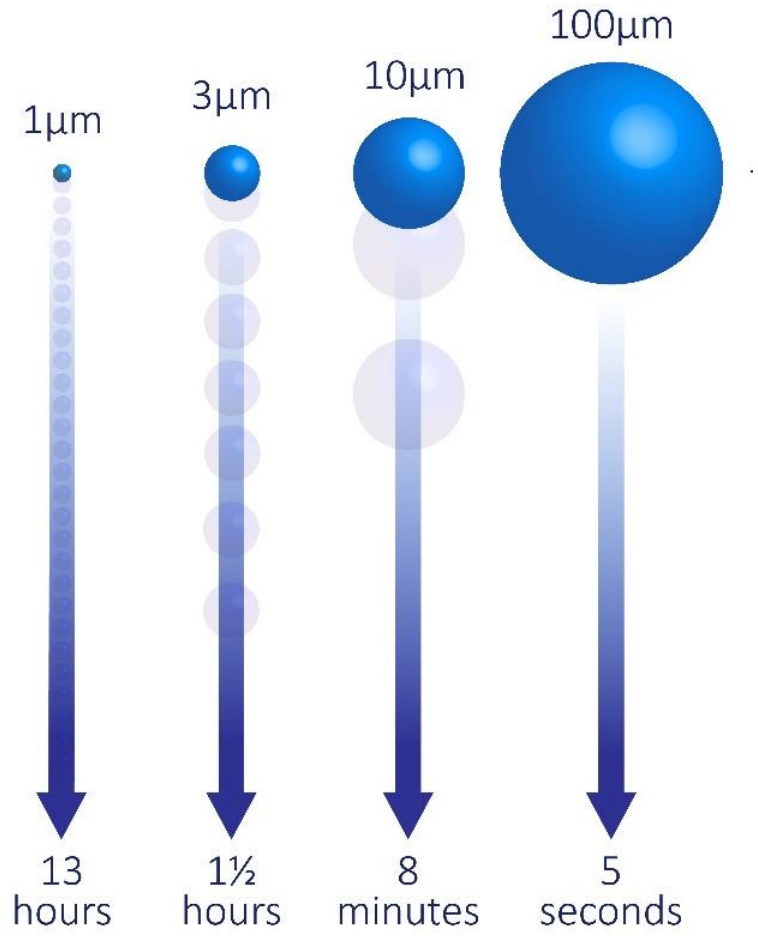
1 Fundamentals of Industrial Hygiene, National Safety Council, 2012
2 https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html
3 https://www.cdc.gov/infectioncontrol/guidelines/environmental/index.html

Particle sizes



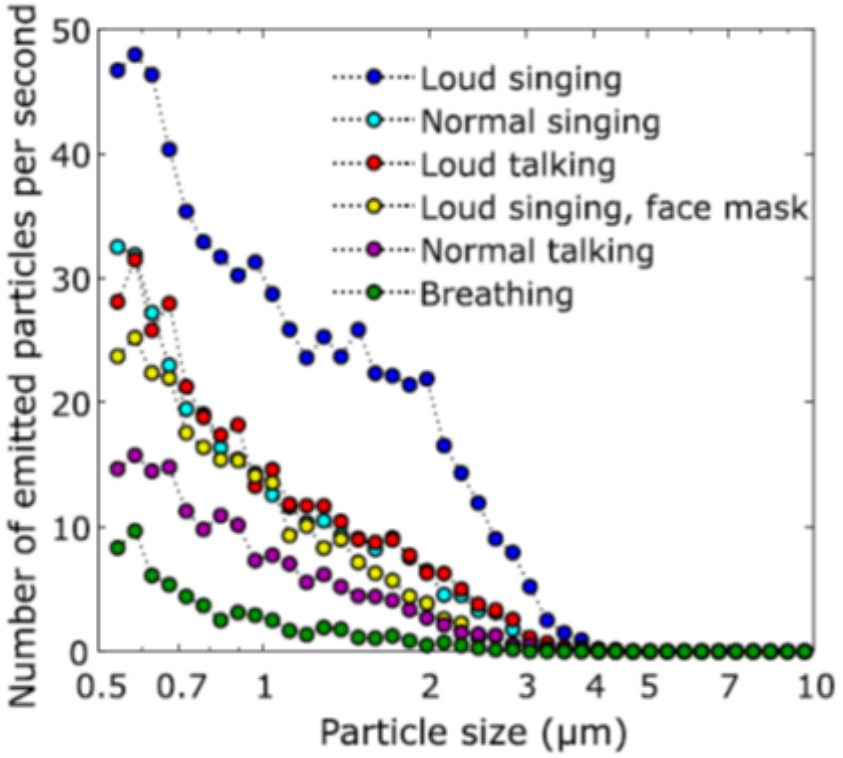
https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

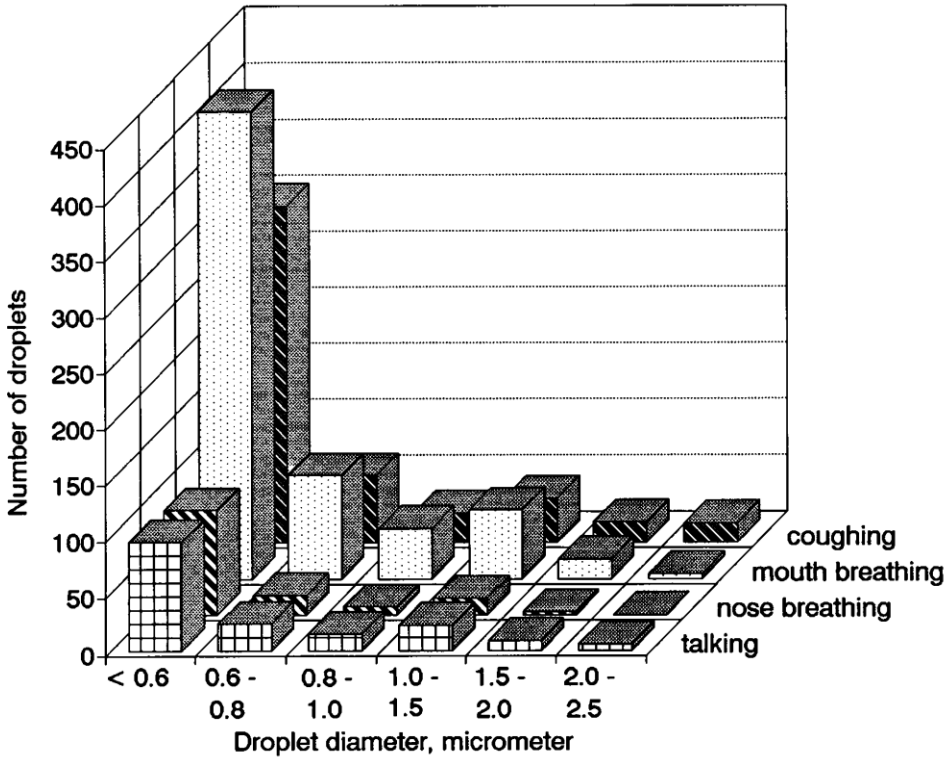
Large particles settle quickly.
Small particles can stay airborne for hours in still air.



Time to settle from 5 feet

What are sizes of particles exhaled?





- The particle size distribution is similar for talking, breathing, and coughing.
- There are <u>more</u> particles in mouth breathing and coughing than nose breathing and talking.

Alsved et al. 2020, Exhaled respiratory particles during singing and talking. *Aerosol Sci Technol*, https://doi.org/10.1080/02786826.2020.1812502

Papineni, R.S. & Rosenthal, F.S. (1997). The size distribution of droplets in the exhaled breath of healthy human subjects. *Journal of Aerosol Medicine*, *10*, 105–116.

What are sizes of particles exhaled (coughs and sneezes)?

Older study (1946)

Diameter Range (μm)	Number of Particles in a Cough	Number of Particles in a Sneeze
1–2	50	26,000
2–4	290	160,000
4–8	970	350,000
8–16	1600	280,000
16–24	870	97,000
24–32	420	37,000
32–40	240	17,000
40–50	110	9000
50–75	140	10,000
75–100	85	4500
100–125	48	2500
125–150	38	1800
150–200	35	2000
200–250	29	1400
250–500	34	2100
500–1000	12	1000
1000–2000	2	

Source: Data from Duguid, "The Size and Duration of Air-Carriage of Respiratory Droplets and Droplet-Nuclei." *Journal of Hygiene 4*:471–480, Table 3 (1946).

Small particles outnumber large particles.

Newer study (1997)

Diameter Range (μm)	Number of Particles in a Cough
<0.6	290
0.6–0.8	50
0.8–1.0	25
1.0–1.5	35
1.5–2.0	10
2.0–2.5	10

Source: Data from Papineni and Rosenthal, "The Size Distribution of Droplets in the Exhaled Breath of Healthy Human Subjects." *Journal of Aerosol Medicine 10*:105–116, 1997, Figure 5.

Older study could not detect smaller particles well, but can still see trend.

Which buildings had SARS-CoV-2 in air samples?

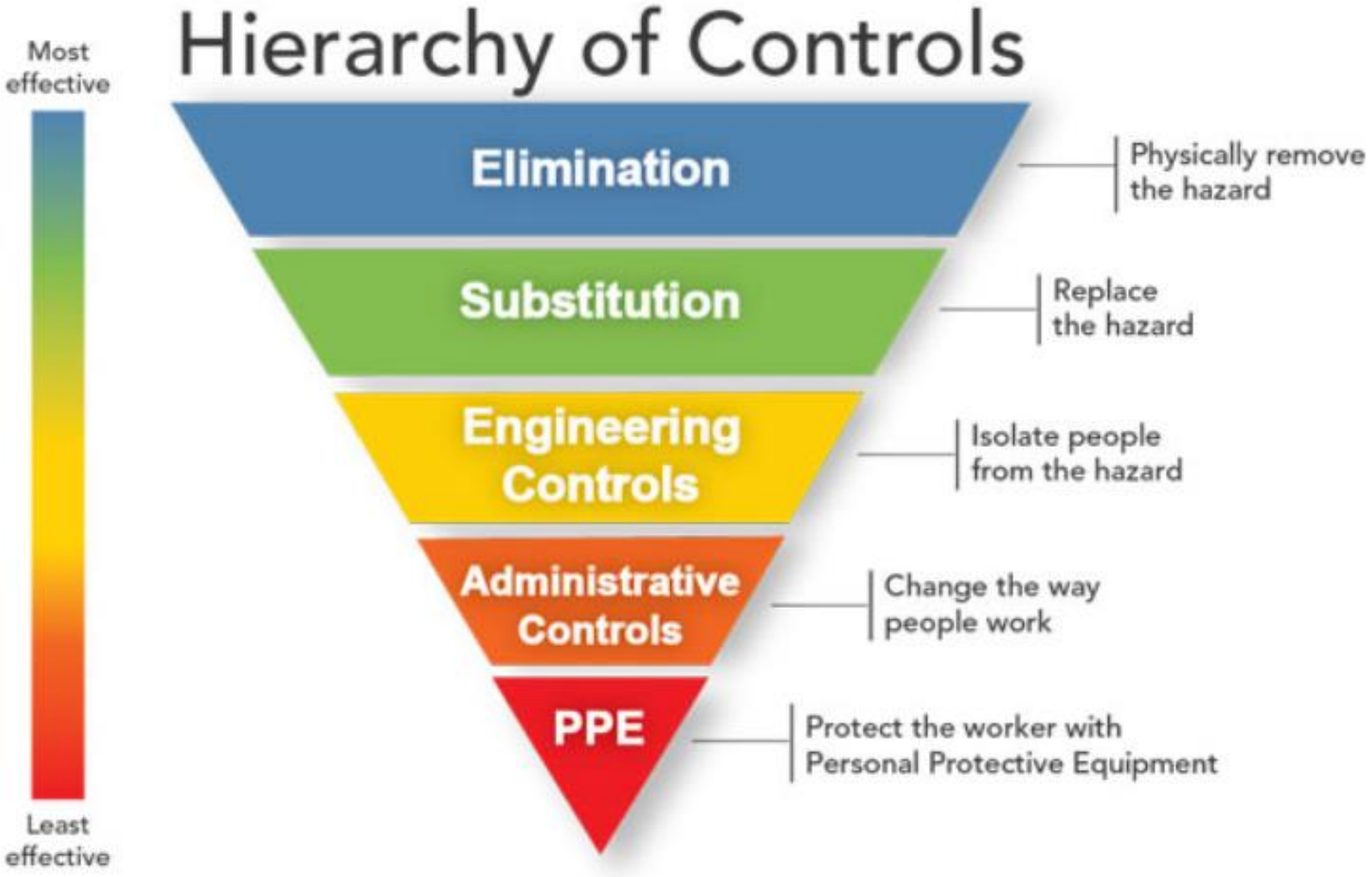
First Author (Date)	Type of Building	SARS-CoV-2 Recovered (RNA detected, but infectivity not assessed)
Santarpia (2020)	Hospital	• 67% of air samples in hallways had detectable virus RNA. • Air samplers worn by staff were all positive despite most patients not having a cough while sampling occurred.
Ong (2020)	Hospital	• No air samples were positive, but had high air exchange rates (12 per hour) compared with homes (usually 0.35 to 1 per hour)
Liu (2020)	Hospital	• SARS-CoV-2 RNA mainly resided in two size ranges: (0.25 to 1.0 µm) and (> 2.5 µm) • Highest concentration in a temporary toilet room, 1 m^2 in area without ventilation.

- Santarpia et al., Transmission Potential of SARS-CoV-2 in Viral Shedding Observed at the University of Nebraska Medical Center. https://doi.org/10.1101/2020.03.23.20039446
- Ong SWX et al., Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient. JAMA 2020
- Liu, Y. et al. Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. *Nature* https://doi.org/10.1038/s41586-020-2271-3 (2020).

How long does SARS-CoV-2 “survive” in air?

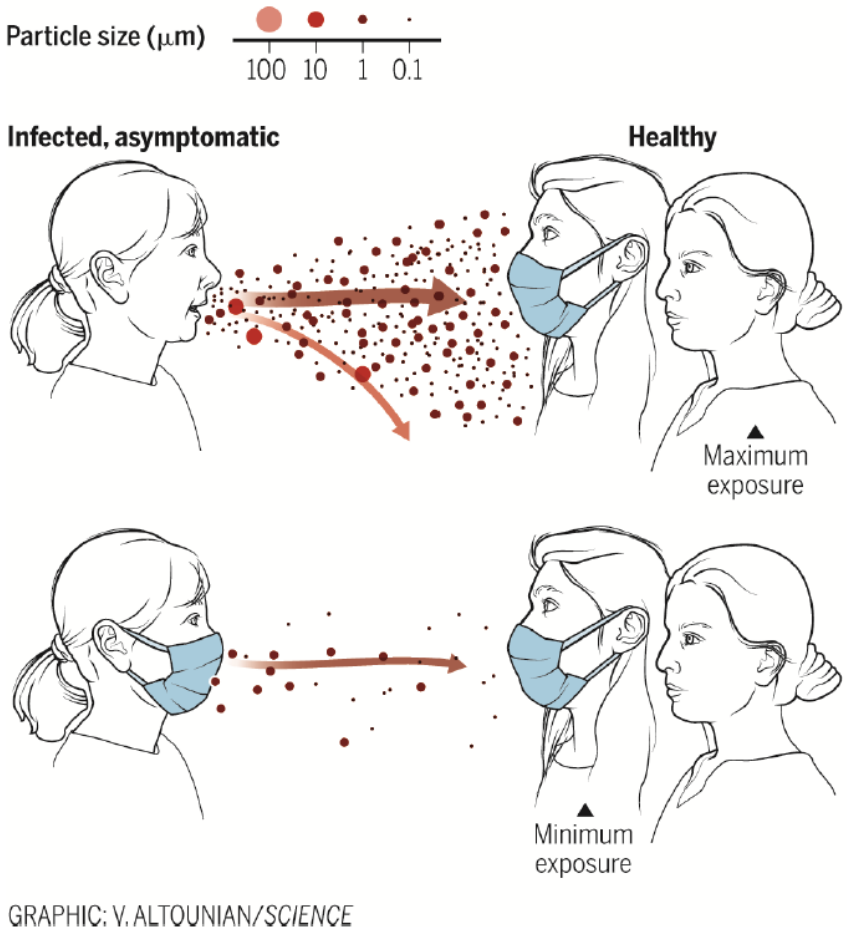
First Author (Date)	Hours Tested	Results
Van Doremalen (2020)	Up to 3 hours	• Particle sizes tested were < 5 µm • Measurements at 0, min, 30 min, 1 h, 2 h, and 3 h • Detected infectious SARS-CoV-2 at all time points
Fears (2020)	Up to 16 hours	• Particle sizes tested were 1–3 µm • Temperature 23°C ± SD 2°C and 53% ± SD 11% relative humidity • Measurements at 10 min, 30 min, 2 h, 4 h, and 16 h • Detected infectious SARS-CoV-2 at all time points

- van Doremalen, N et al., 2020. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. New England Journal of Medicine. (preprint material with methods is found here: https://www.medrxiv.org/content/10.1101/2020.03.09.20033217v2)
Fears SC et al., Persistence of severe acute respiratory syndrome coronavirus 2 in aerosol suspensions. Emerg Infect Dis. 2020 Sep [date cited]. https://doi.org/10.3201/eid2609.201806



Source: https://www.cdc.gov/niosh/topics/hierarchy/default.html

What is source control?



Graphic by V. ALTOUNIAN/*SCIENCE*. From "Reducing transmission of SARS-CoV-2" by Prather et al., *Science* 27 May 2020:eabc6197 (DOI: 10.1126/science.abc6197). Reprinted with permission from AAAS.

What is the evidence that source control works?

First author (year)	Type of aerosol tested	Type of masks tested	Size distribution examined	Conclusion that facemasks serve as source control
Green et al (2012)	• Bacteria	Surgical mask	Yes (~ 1-4 µm)	Yes (48—76% efficiency)
Davies et al (2013)	<u>Experiment #1</u> • Viruses (single-stranded RNA virus) • Bacteria	Homemade Masks & surgical mask	Yes • Viruses ~0.02 µm • Bacteria ~ 1 µm	Yes (50-90% efficiency for viruses and 58-96% efficiency for bacteria)
	<u>Experiment #2</u> • Microorganisms exhaled from healthy humans (mainly bacteria)	Homemade Masks & surgical mask	Yes – > 7 µm – 4.7-7 µm – 3.3-4.7 µm – 2.1-3.3 µm – 1.1-2.1 µm – 0.65-1.1 µm	Yes (across all size fractions)

What is the evidence that source control works? (continued)

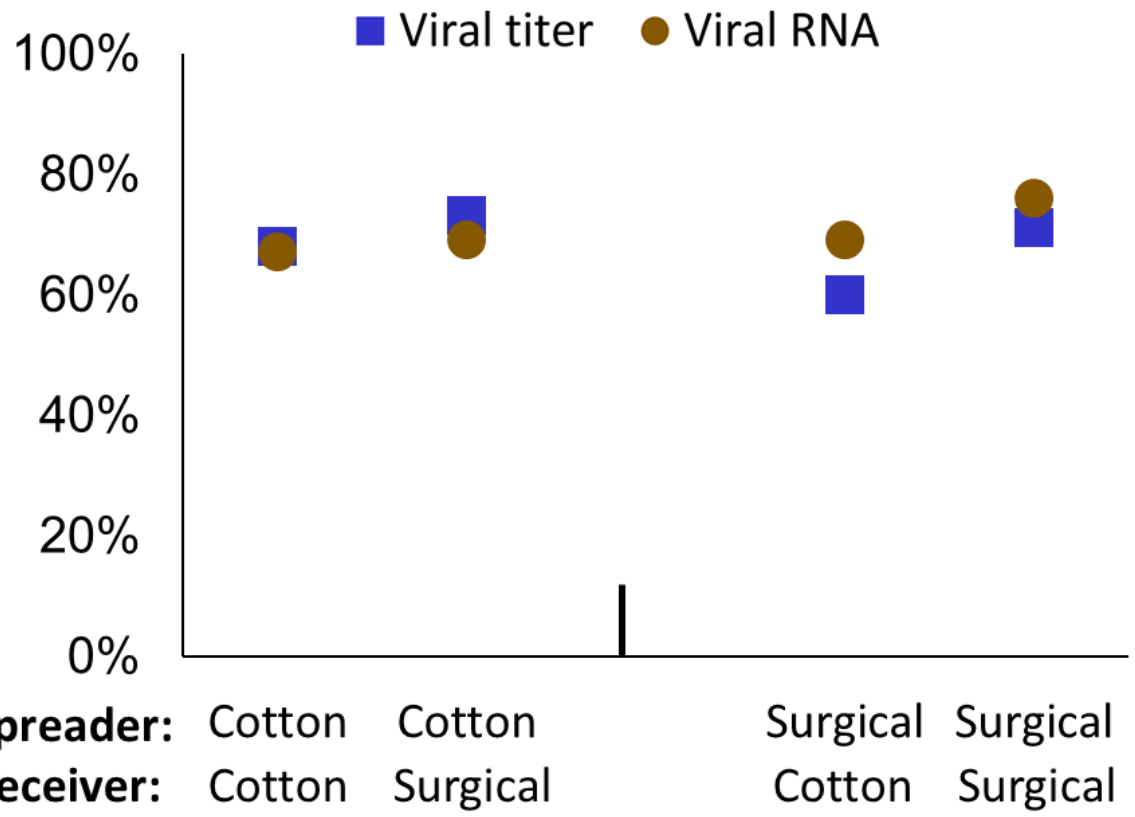
First author (year)	Type of aerosol tested	Type of masks tested	Size distribution examined	Conclusion that facemasks serve as source control
Mansour et al (2013)	Salt aerosols	Surgical mask & N95	Yes (0.1-10 µm)	Yes
Konda et al (2020)	Salt aerosols	Surgical masks, N95, and a variety of fabrics	Yes (0.3 µm cutpoint)*#	Yes (depended on size fraction and type of material)
Leung et al (2020)	• Coronavirus • Influenza • Rhinovirus	Surgical mask & N95	Yes (5 µm cutpoint)*	Yes (depended on size fraction and type of virus)

* Cutpoint defines particle sizes smaller or larger than a given particle diameter (e.g., cutpoint = 5 µm means that particles were differentiated into two categories: those ≤ 5 µm and those > 5 µm).

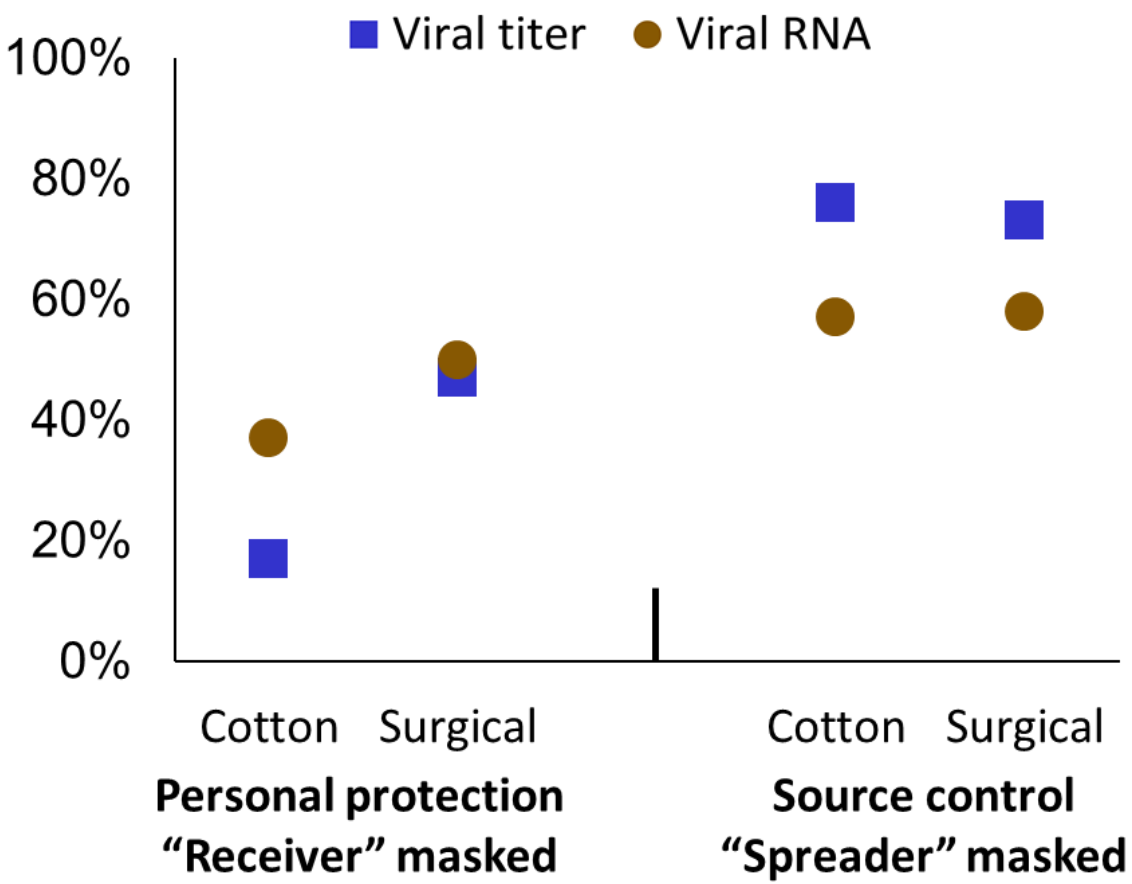
A wide range of particle sizes were described, but most of the results focused on the particles greater than or less than 0.3 µm.

Laboratory Assessment of Cloth Masks Effectiveness: Two-Headed Experimental Masking Evaluation using SARS-CoV-2

Relative Percentage Reduction in Collection Received Cotton and Surgical Masks: Combined



Relative Percentage Reduction in Collection Received Cotton and Surgical Masks: Separately



Ueki et al. 2020, mSphere; doi.org/10.1128/mSphere.00637-20.

Portable air cleaners

Pros

- Helps in small areas.
- Removes small particles that float in air for long periods of time (< 10 microns, but especially less than 2.5 microns).

Cons

- Less effective when intake or discharge is blocked (e.g., by furniture or behind curtains) or when placed near an open window.
- Large particles that have already settled to ground are not filtered.

Partitions

SECTIONS | StarTribune

CORONAVIRUS

U works to pinpoint how indoor spaces, ventilation affect COVID-19 hot spots

By Jeremy Olson Star Tribune | JULY 6, 2020 — 10:06AM

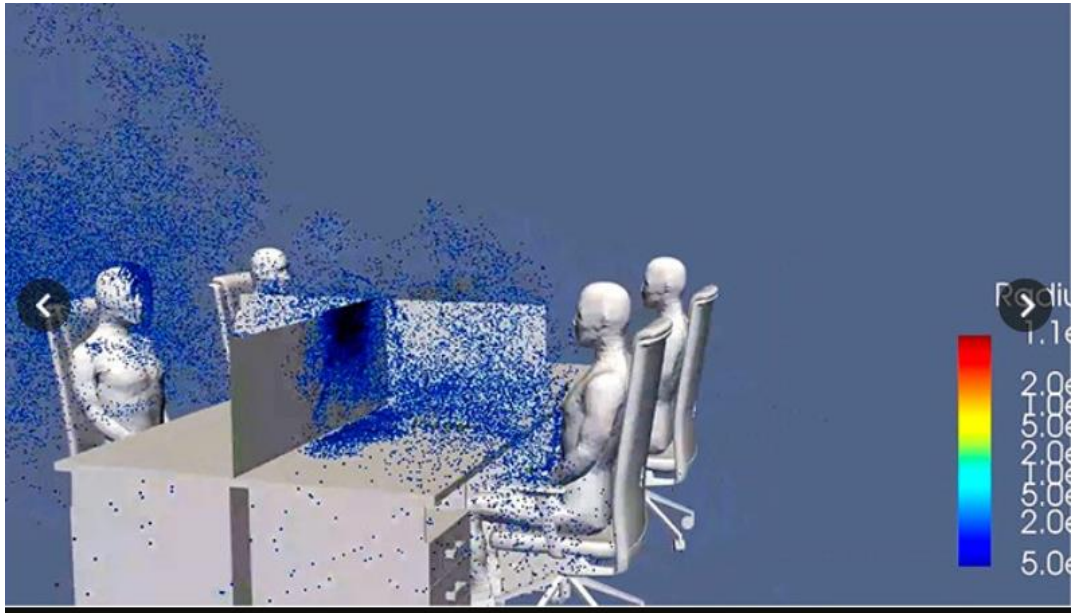
GLEN STUBBE – STAR TRIBUNE

Pros vs. Cons

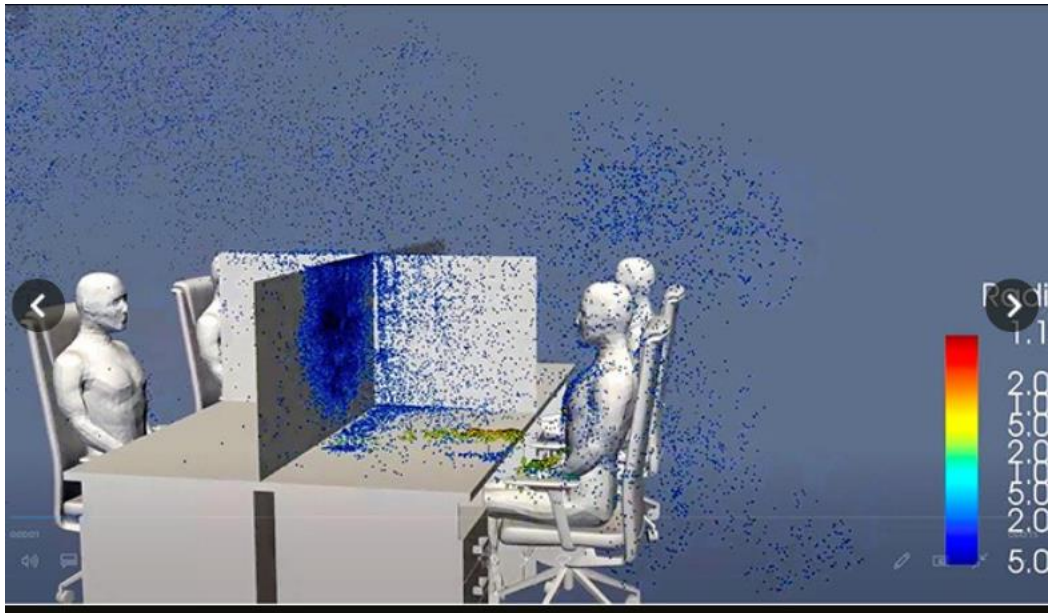
- **Can prevent spread of larger particles from sneezes and coughs**
- If air is not mixed well, can create dead zones
- Can block air flow for others and increase their exposure*
- Should not be used as the only method to decrease virus transmission

* Gilkeson, C. A., Camargo-Valero, M. A., Pickin, L. E., & Noakes, C. J. (2013). Measurement of ventilation and airborne infection risk in large naturally ventilated hospital wards. Building and Environment, 65, 35–48.

Partition height can help, but small particles can bypass the partition



A simulated image by a supercomputer Fugaku, in which a person at right front coughs and droplets reach others when the height of a partition is 120 centimeters. (Provided by Riken Center for Computational Science and Toyohashi University of Technology. Supported by Kyoto Institute of Technology and Osaka University)



A simulated image by a supercomputer Fugaku, in which a person at right front coughs and droplets rarely reach others when the height of a partition is 140 centimeters. (Provided by Riken Center for Computational Science and Toyohashi University of Technology. Supported by Kyoto Institute of Technology and Osaka University)

http://www.asahi.com/ajw/articles/13440482

Coronavirus Disease 2019 (COVID-19)

Centers for Disease Control and Prevention

Resources and Updates [live links]

- Coronavirus (COVID-19) landing page
- People Who Are at Increased Risk for Severe Illness
  - People of Any Age with Underlying Medical Conditions
  - Older Adults
- Businesses and Workplaces
- Colleges, Universities, and Higher Learning
- Considerations for Restaurants and Bars
- Cleaning and Disinfection for Community Facilities
- Keeping Current on COVID-19: updates and resources
- Masks

References

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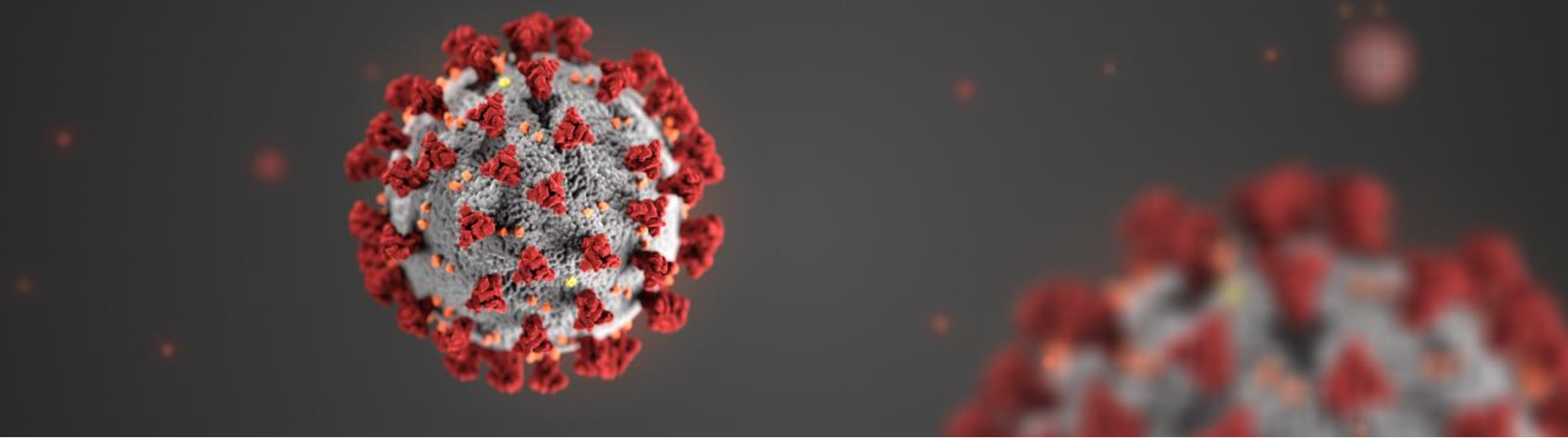
- Green CF, Davidson CS, Panlilio AL, et al. Effectiveness of selected surgical masks in arresting vegetative cells and endospores when worn by simulated contagious patients. *Infect Control Hosp Epidemiol.* 2012;33(5):487-494.
- Konda A, Prakash A, Moss GA, Schmoldt M, Grant GD, Guha S. Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks. *ACS Nano.* 2020;14(5):6339-6347.
- Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. . *Nature Medicine.* 2020;26:676-680.
- Mansour MM, Smaldone GC. Respiratory source control versus receiver protection: impact of facemask fit. *J Aerosol Med Pulm Drug Deliv.* 2013;26(3):131-137.

Celebrating Thanksgiving

- Safest way to celebrate is at home with the people you live with.
- Open windows, wear masks when not eating, limit the number of guests.

https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/holidays/thanksgiving.html



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

Thank you

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.