



Concepts of Industrial Hygiene

Exposure / PPE / Warnings

Applied to COVID-19 & Masks

Stephen E. Petty, P.E., C.I.H., C.S.P. - EES Group, Inc.

September 4, 2021

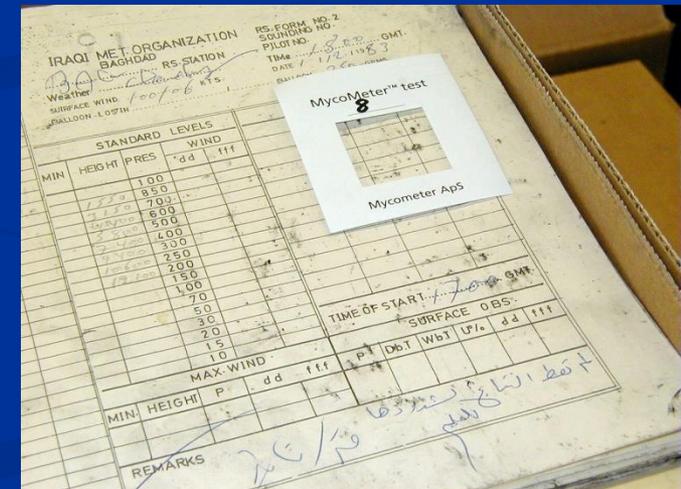
BACKGROUND



- **President and Owner of EES Group, Inc. (Forensic Engineering Company – Since 1996 – 25 years)**
- **Section Manager and Sr. Research Engineer, Columbia Gas (10 years)**
- **Sr. Research Engineer, Battelle (10 years).**

PETTY QUALIFICATIONS

- Education: B.S. Ch. E., M.S. Ch. E. (honors at both levels) and M.B.A. (1st in Class)
- Sr. Research Scientist – Battelle
- Sr. Research Engineer/Section Manager - R&D – Columbia Gas
- President, EES Group – Engineering EHS Company, Columbus, OH. – 100s of projects
- CIH (National Certification), C.S.P. & Professional Engineer (OH, FL, PA, WV, KY, and TX)
- National Exposure/PPE Expert (e.g., Monsanto Roundup, DuPont C-8); ~400 Cases
- Selected to determine general causation outside of litigation on dozens of projects (e.g., Iraqi Docs – Allegany Ballistics Lab – Columbus Blue Jackets; Prof. Hockey locker room – Columbus College of Art & Design, CMH Airport RA)
- Adjunct Professor – Franklin University (Teach Environmental and Earth Sciences)
- Nine U.S. Patents – mostly wrt Heat Pumps.



PETTY QUALIFICATIONS

➤ Memberships:

- American Industrial Hygiene Association (AIHA)
- American Board of Industrial Hygiene (ABIH)
- American Conference of Governmental Ind. Hygienists (ACGIH)
- American Institute of Chemical Engineers (AIChE)
- American Society of Refrigeration, Air Conditioning and Refrigeration Engineers (ASHRAE); Member ASHRAE 40 Std. and TC 8.3
- American IAQ Council
- Sigma Xi.



PETTY PODCASTS

All this information detailed in Video Petty Podcasts
Podcasts #2 through #6:

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PETTY PODCAST
By Stephen Petty, PE, CIH, CSP

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Children & Masks; CDC Document Review (2 of 4) - Ep. 12
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Welcome to the Petty Podcast! Stephen Petty, host of the Petty Podcast, explains our mission and what will make this show stand apart in the podcasting industry. Stephen will be applying his knowledge as an engineer and health & safety expert to breakdown recent events (ie. COVID-19, Surfside condo collapse, etc.) to better explain elements of these events and offer science-backed solutions.

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In Google you should find us at Rumble & YouTube - the links are:

<https://rumble.com/c/PettyPodcasts> - not censored – see #5-6 and #11-14

https://www.youtube.com/channel/UCwPHggMiWwjpqd5dA-Og_Ag - censored!

SCHOOL DISTRICT SUPPORT

**Oakstone Academy (Special Needs School) – Westerville, OH
– Dr. Becky Morrison – Two Podcasts – No Masks /
Engineering Controls – Implemented August 2020:**



Dr Becky and Stephen Petty Pt 1
YouTube · Dr Douglas G Frank
Mar 22, 2021

3 key moments in this video



Dr Becky and Stephen Petty Pt 2
YouTube · Dr Douglas G Frank
Mar 22, 2021

Part 1 Video Link (Dr. Morrison): <https://rumble.com/vkhlrn-dr-becky-oakstone-academy-and...>

Part 2 Video Link (Stephen Petty): <https://youtu.be/oYEo4T6V25w>

LITIGATION SUPPORT

1. Boone County, Kentucky – Testified on May 17, 2021 against the Governor’s Mask Mandate



Filing # 125367129 E-Filed 04/21/2021 04:23:35 PM

IN THE CIRCUIT COURT OF THE EIGHTH JUDICIAL CIRCUIT
IN AND FOR ALACHUA COUNTY, FLORIDA

JUSTIN GREEN,

Case No. 2020-CA-1249

Plaintiff,

v.

ALACHUA COUNTY,

Defendant.

PLAINTIFF'S EXPERT WITNESS DISCLOSURE

COMES NOW JUSTIN GREEN ("Plaintiff"), notifying all interested parties of the retention of Plaintiff's Expert Witness, Stephen E. Petty, P.E., C.I.H., C.S.P., and saying:

Attached hereto are the following exhibits:

Exhibit A – *Curriculum Vitae* of Stephen E. Petty, P.E., C.I.H., C.S.P.

Exhibit B – List of Prior Cases Wherein Expert Testified

Exhibit C – Expert Witness Report of Stephen E. Petty, P.E., C.I.H., C.S.P.

2. Alchua County, FL – County Mask Mandate – Named Expert – On Hold – 4/21/2021

3. Polk County Public Schools, FL – Filed Affidavit Against Masks and for Engineering Controls– 6/1/21

DEFINITION OF INDUSTRIAL HYGIENE (AIHA)

“That science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stressors arising in or from the workplace, which may cause sickness, impaired health and well-being, or significant discomfort among workers or among the citizens of the community.”

Key Tenants of the Field of Industrial Hygiene (to stop or limit exposures):

1. Anticipation
2. Recognition
3. Evaluation
4. Control.

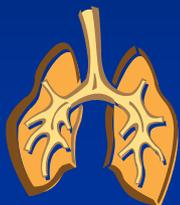
INDUSTRIAL HYGIENE (IH)

- **Field Associated with Exposure, PPE, and Warnings**
- **Not Recognized by Much of the Public, Media, & Governmental Officials – Thus Media often rely on M.D.s Instead for Information on Controlling Exposures**
- **Not Associated with Dentistry!**

EXPOSURE ROUTES

Exposure, in General, Can Occur from One of Four Primary Pathways – For COVID it is the Inhalation Path:

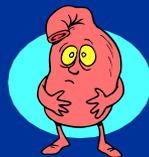
➤ Inhalation



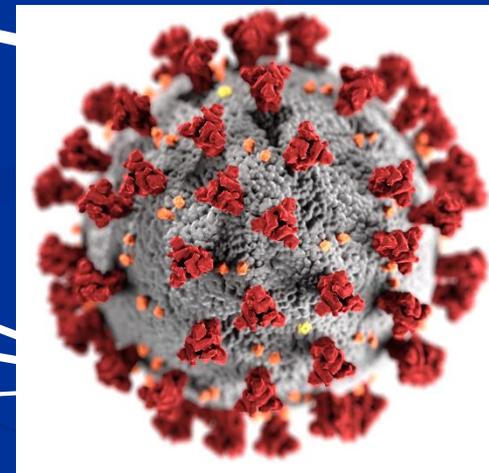
➤ Dermal



➤ Ingestion



➤ Intravenous.



EXPOSURE

Exposure is a function of 2 main parameters:

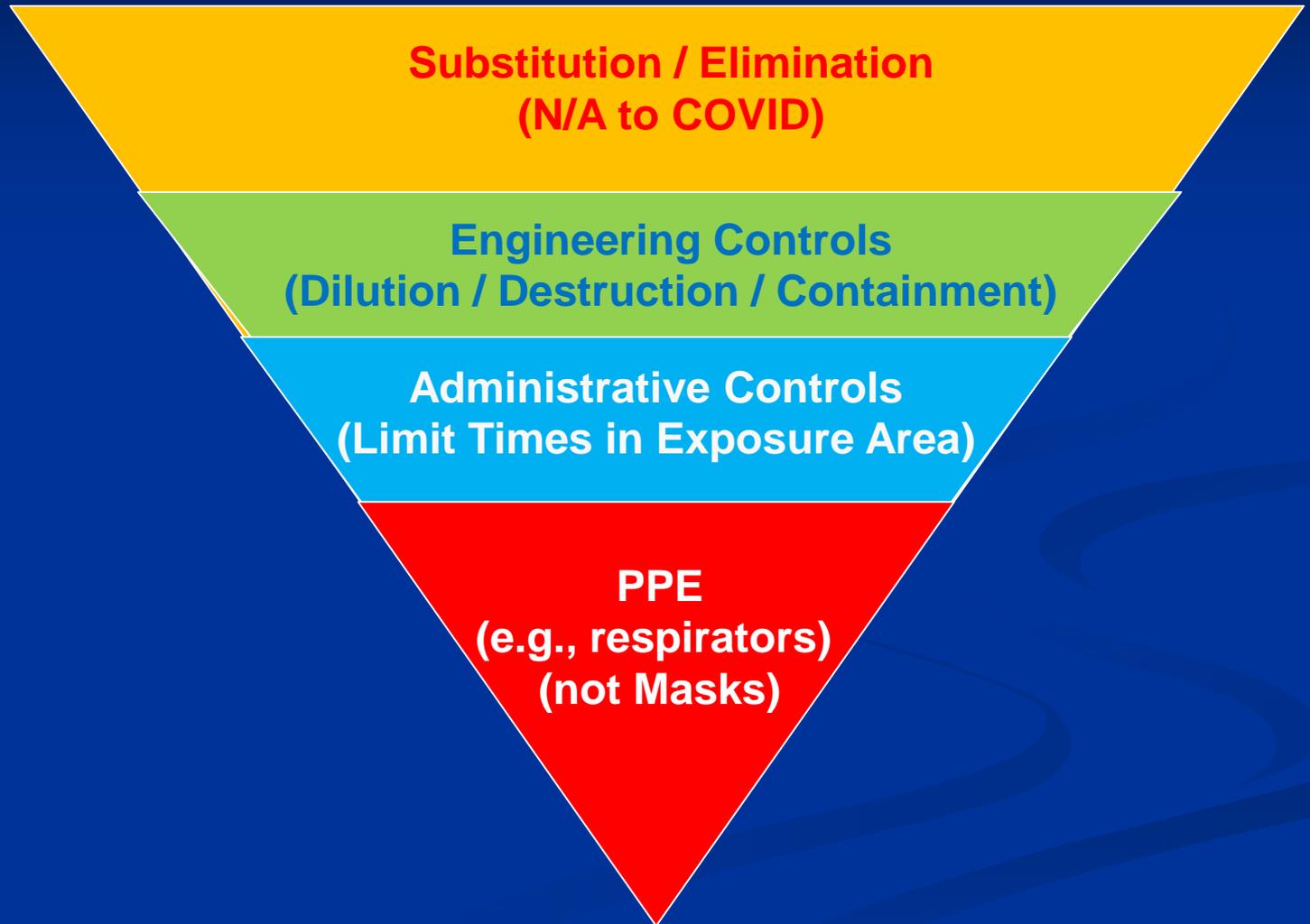
1. Concentrations – lower is better.

2. Time(s) – less time better.

Distance – further away from source is better - sometimes.

IH HIERARCHY OF CONTROLS – To Minimize Exposure(s)

Most Effective



Least Effective

Masks

SO WHERE ARE THE BOUDARIES?

Not PPE – Cannot be Sealed



PPE – Can be Sealed



N-95



Half Face
Respirator

Masks are not Respirators: Terms often Conflated

Masks vs PPE – What Does OSHA Say?

OSHA Confuses the Public – Says Wear Masks on Pg. 1 but on Pg. 6 says they are not protective.....

Additional Considerations for PPE

Interim guidance for specific types of workers and employers includes recommended PPE ensembles for various types of activities that workers may perform. In general:

- *PPE may be needed when engineering and administrative controls are insufficient to protect workers from exposure to SARS-CoV-2 or other workplace hazards and essential work operations must continue.*
- *If workers need respirators, they must be used in the context of a comprehensive respiratory protection program that meets the requirements of OSHA's Respiratory Protection standard (29 CFR 1910.134) and includes medical exams, fit testing, and training.*
 - ***Surgical masks are not respirators and do not provide the same level of protection to workers as properly-fitted respirators. Cloth face coverings are also not acceptable substitutes for respirators.***

Masks are not Respirators: - Terms often Conflated – Leak around edges and cannot be fit tested. CDC says the same!

Masks vs PPE – CDC Says the Same Thing

CDC Also Confuses the Public – Says Wear Masks but says...

Understanding the Difference



Surgical Mask



N95 Respirator

Testing and Approval	Cleared by the U.S. Food and Drug Administration (FDA)	Evaluated, tested, and approved by NIOSH as per the requirements in 42 CFR Part 84
Intended Use and Purpose	Fluid resistant and provides the wearer protection against large droplets, splashes, or sprays of bodily or other hazardous fluids. Protects the patient from the wearer's respiratory emissions.	Reduces wearer's exposure to particles including small particle aerosols and large droplets (only non-oil aerosols).
Face Seal Fit	Loose-fitting	Tight-fitting
Fit Testing Requirement	No	Yes
User Seal Check Requirement	No	Yes. Required each time the respirator is donned (put on)
Filtration	Does NOT provide the wearer with a reliable level of protection from inhaling smaller airborne particles and is not considered respiratory protection	
Leakage	Leakage occurs around the edge of the mask when user inhales	
Use Limitations	Disposable. Discard after each patient encounter.	

MASK

vs

RESPIRATOR

Does NOT provide the wearer with a reliable level of protection from inhaling smaller airborne particles and is not considered respiratory protection

Filters out at least 95% of airborne particles including large and small particles

Leakage occurs around the edge of the mask when user inhales

When properly fitted and donned, minimal leakage occurs around edges of the respirator when user inhales

Masks Not Good for Fire Smoke Particles but OK for Small COVID-19 Particles

Cloth masks will not protect you from wildfire smoke.

Cloth **masks** that are used to slow the spread of COVID-19 by blocking respiratory droplets offer little protection against wildfire smoke. They might not catch small, harmful particles in smoke that can harm your health.

N95 and KN95 respirators can provide protection from wildfire smoke and from getting and spreading COVID-19. CDC does not recommend the use of N95 respirators in non-healthcare settings because N95 respirators should be reserved for health care workers. **KN95 respirators** are commonly made in China and are similar to N95 masks commonly used in the United States. Look for KN95 masks that meet **requirements** similar to those set by CDC's National Institute for Occupational Safety and Health (NIOSH) for respirators.

Particles from smoke tend to be very small, with a size range near the wavelength of visible light (0.4–0.7 micrometers) – Cloth masks won't work.

But COVID-19 Particles are ~0.1 microns (micrometers) – smaller sized particles but will work.

WHAT – Does this make any sense?

CLOTH MASKS NOT EFFECTIVE BUT STILL USE THEM

Effectiveness of Cloth Masks for Protection Against Severe Acute Respiratory Syndrome Coronavirus 2 by Abrar A. Chughtai, Holly Seale, and C. Raina Macintyre, 2020 – Published by CDC)

States: “In 2015, we conducted a randomized controlled trial to compare the efficacy of cloth masks with that of medical masks and controls (standard practice) among healthcare workers in Vietnam (4). Rates of infection were consistently higher among those in the cloth mask group than in the medical mask and control groups. This finding suggests that risk for infection was higher for those wearing cloth masks.”

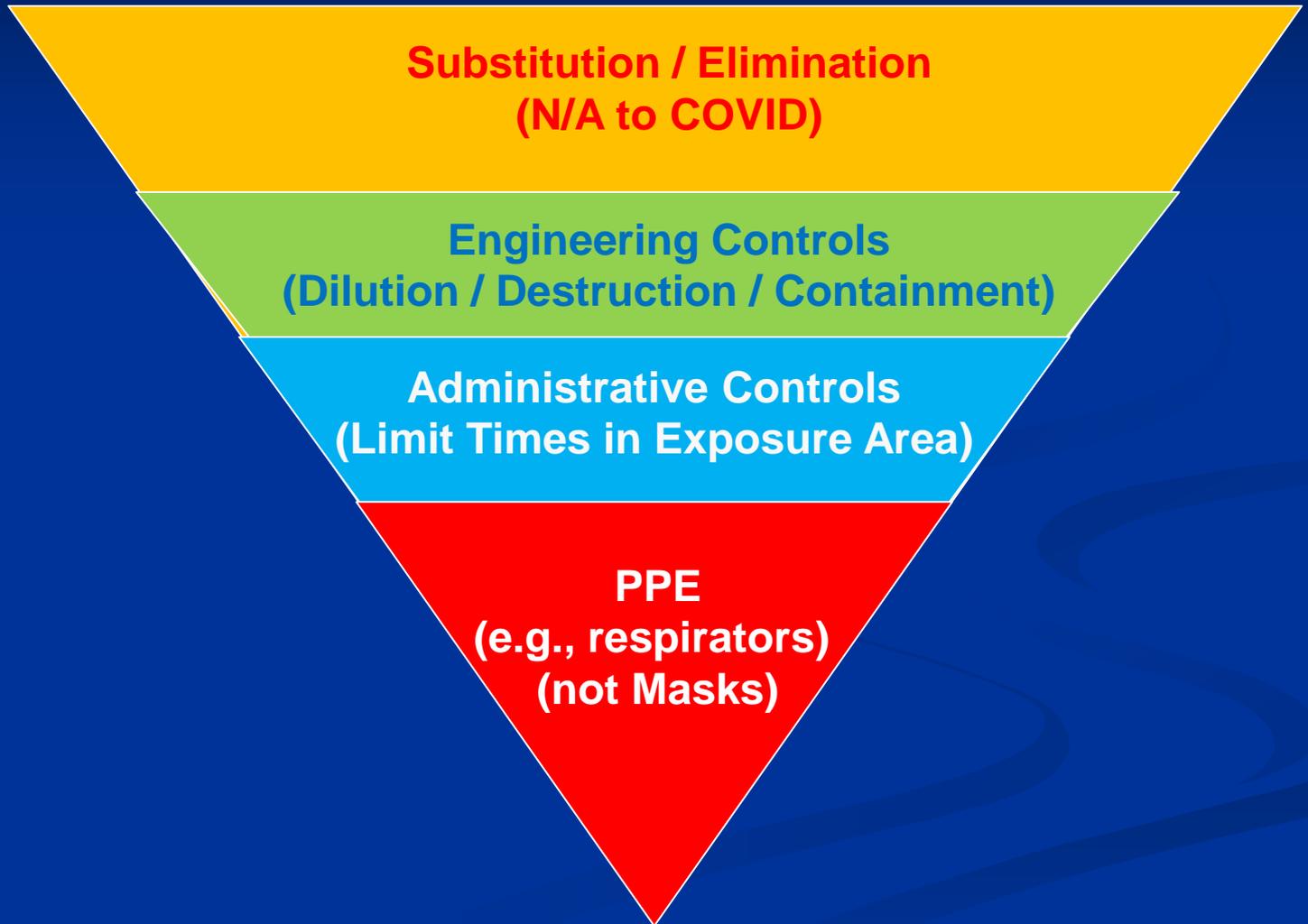
Yet, they say use mask because: “The *primary transmission routes* for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) are thought to be inhalation of respiratory droplets and close contact.”

NO, Not Surfaces or Droplets, but Aerosols!

Some Very New Analyses Regarding Masks

RECALL IH HIERARCHY OF CONTROLS – To Minimize Exposure(s)

Most Effective



Substitution / Elimination
(N/A to COVID)

Engineering Controls
(Dilution / Destruction / Containment)

Administrative Controls
(Limit Times in Exposure Area)

PPE
(e.g., respirators)
(not Masks)

Masks

Least Effective

AIHA GUIDANCE DOCUMENT

American Industrial Hygiene Association (AIHA)



HEALTHIER WORKPLACES | A HEALTHIER WORLD

Reducing the Risk of COVID-19 Using Engineering Controls

Guidance Document

aiha.org

Version 4 | September 9, 2020

September 9, 2020 Guidance on COVID-19 from AIHA

AIHA VERSION – Hierarchy of Controls

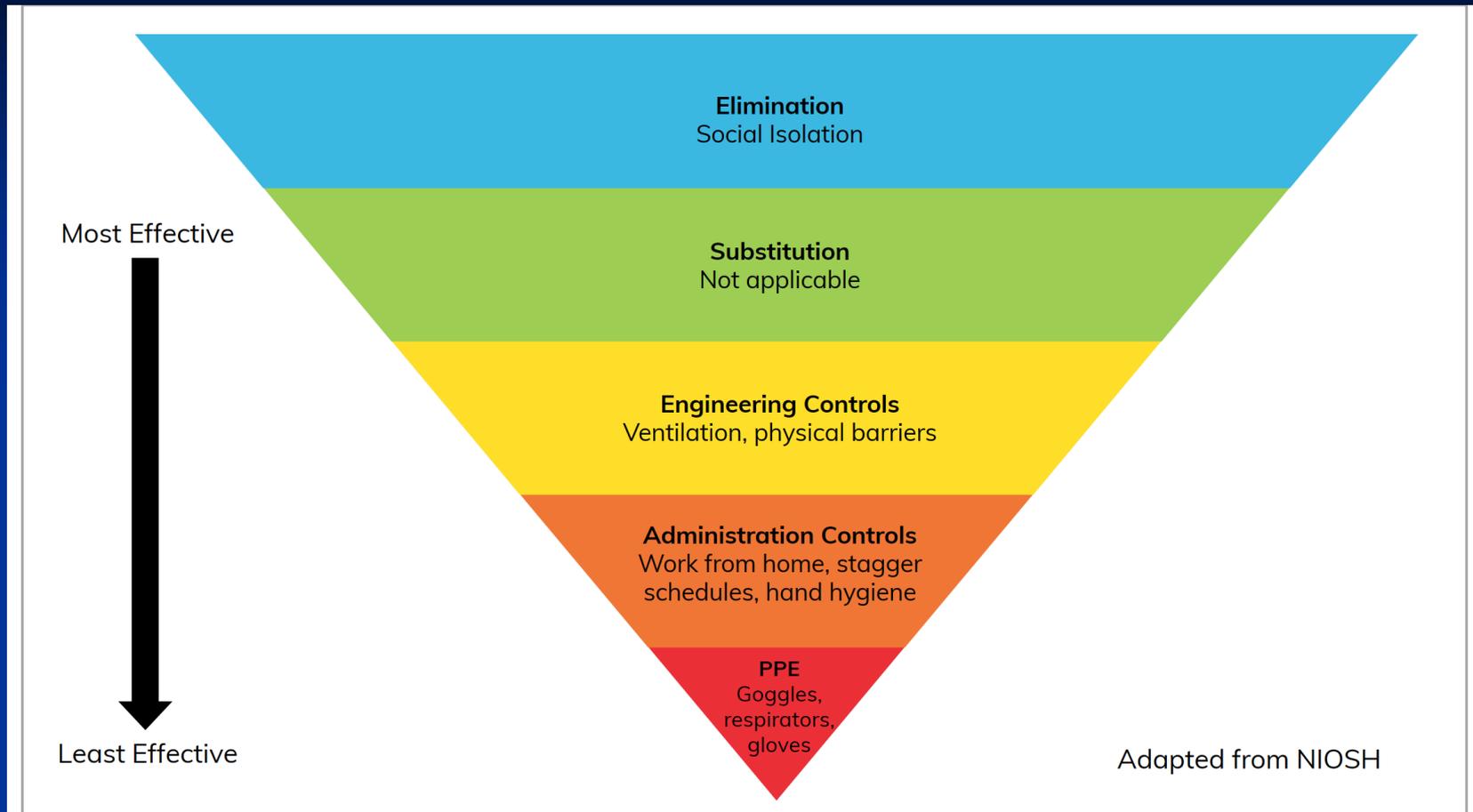


Figure 1: Applying the Hierarchy of Controls for COVID-19.



AIHA – Relative Risk Reductions

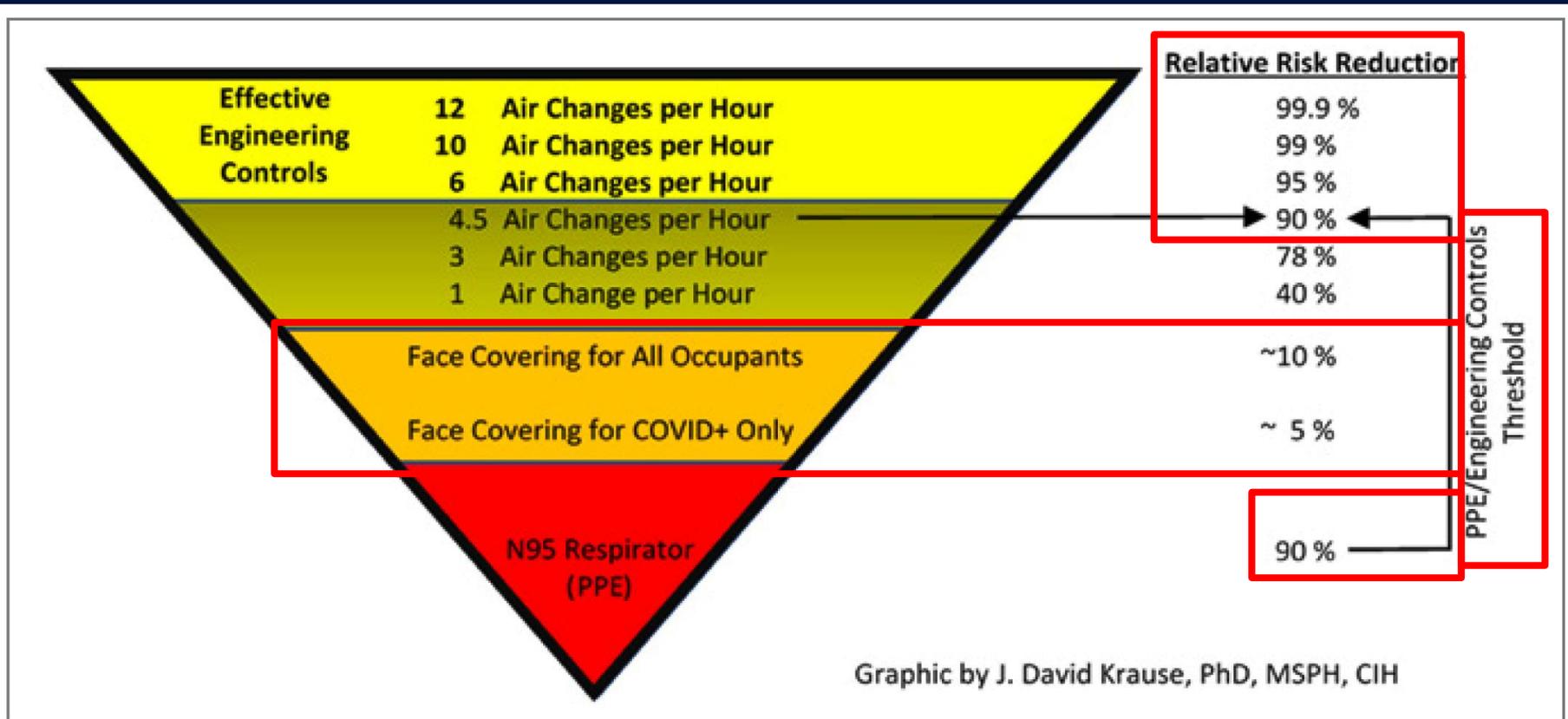


Figure 2*

*To learn how the relative risk reduction estimates were derived for Figure 2, download the [SUPPLEMENT for Reducing the Risk of COVID-19 using Engineering Controls](#).



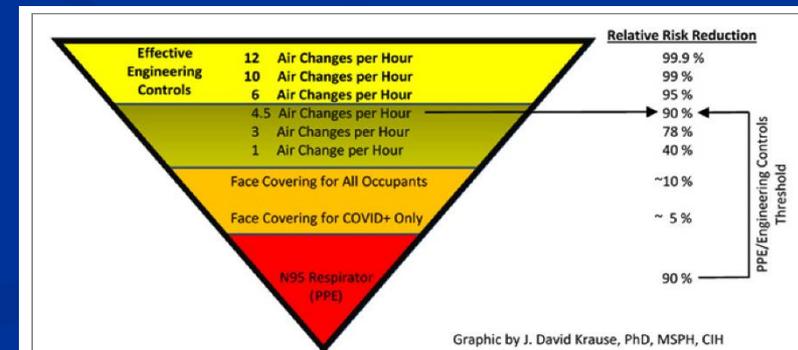
AIHA – What Does This Mean?

Exposure Controls Must Have a Relative Risk (RR) Reduction Threshold of 90%!

Masks only have RR of ~5% to ~10% and Do Not Meet 90% Threshold.

≥ 6 ACH – Ventilation has RR of 90+%.

N-95s – Maybe Not!



AIHA – Mask Remarks

“While not evaluated in this study, face seal leakage is further known to decrease the respiratory protection offered by fabric materials. Aerosol penetration for face masks made with loosely held fabric materials occurs in both directions (inhaled and exhaled). Due to their loose fitting nature and the leakage that occurs even when a face mask is properly worn, a modifying factor of 25% was applied. (???)”

AIHA – Mask Remarks

“The impact of typical leakage and frequent non-compliance with proper use and wear, is the basis for a generous estimate of 5-10% relative risk reduction for face masks and cloth face coverings.”

AIHA – Concluding Remarks

...In light of the limited level of relative risk reduction offered by face coverings and masks the AIHA has recommended engineering controls be used to reduce the risk of exposure in indoor environments,
which is anticipated to reduce the transmission of disease, even in non-healthcare settings.

MERV \geq 17 Filtration Systems Recommended.

OTHER NEGATIVE EFFECTS OF WEARING MASKS

Review

Is a Mask That Covers the Mouth and Nose Free from Undesirable Side Effects in Everyday Use and Free of Potential Hazards?

Kai Kisielinski ¹, Paul Giboni ², Andreas Prescher ³, Bernd Klosterhalfen ⁴, David Graessel ⁵, Stefan Funken ⁶, Oliver Kempster ⁷ and Oliver Hirsch ^{8,*}

OTHER NEGATIVE EFFECTS OF WEARING MASKS

Increased risk of adverse effects when using masks:

Internal diseases

COPD
Sleep Apnea Syndrome
advanced renal Failure
Obesity
Cardiopulmonary Dysfunction
Asthma

Psychiatric illness

Claustrophobia
Panic Disorder
Personality Disorders
Dementia
Schizophrenia
helpless Patients
fixed and sedated Patients

Neurological Diseases

Migraines and Headache Sufferers
Patients with intracranial Masses
Epilepsy

Pediatric Diseases

Asthma
Respiratory diseases
Cardiopulmonary Diseases
Neuromuscular Diseases
Epilepsy

ENT Diseases

Vocal Cord Disorders
Rhinitis and obstructive Diseases

Dermatological Diseases

Acne
Atopic

Occupational Health Restrictions

moderate / heavy physical Work

Gynecological restrictions

Pregnant Women

Figure 5. Diseases/predispositions with significant risks, according to the literature found, when using masks. Indications for weighing up medical mask exemption certificates.

OTHER NEGATIVE EFFECTS OF WEARING MASKS

Abstract: Many countries introduced the requirement to wear masks in public spaces for containing SARS-CoV-2 making it commonplace in 2020. Up until now, there has been no comprehensive investigation as to the adverse health effects masks can cause. The aim was to find, test, evaluate and compile scientifically proven related side effects of wearing masks. For a quantitative evaluation, 44 mostly experimental studies were referenced, and for a substantive evaluation, 65 publications were found. The literature revealed relevant adverse effects of masks in numerous disciplines. In this paper, we refer to the psychological and physical deterioration as well as multiple symptoms described because of their consistent, recurrent and uniform presentation from different disciplines as a Mask-Induced Exhaustion Syndrome (MIES). We objectified evaluation evidenced changes in respiratory physiology of mask wearers with significant correlation of O₂ drop and fatigue ($p < 0.05$), a clustered co-occurrence of respiratory impairment and O₂ drop (67%), N95 mask and CO₂ rise (82%), N95 mask and O₂ drop (72%), N95 mask and headache (60%), respiratory impairment and temperature rise (88%), but also temperature rise and moisture (100%) under the masks. Extended mask-wearing by the general population could lead to relevant effects and consequences in many medical fields.

RESPIRATORS CAN BE FIT TESTED AND SEALED

Under OSHA, Respirators Intended as Respiratory Protection
(29 CFR 1910.134)

Worst



N-95 (Worst)



1/2 Face/
Full Face



Air

Purifying



Supplied

Air



Best

EVEN SUPPLIERS OF N95s WARN AGAINST USE FOR AEROSOLS & INFECTIOUS DISEASE

Use For

Particles such as those from grinding, sanding, sweeping, sawing, bagging, or processing minerals, coal, iron ore, flour, metal, wood, pollen, and certain other substances. Liquid or non-oil based particles from sprays that do not also emit oil aerosols or vapors. Follow all applicable local regulations. For additional information on 3M use recommendations for this class of respirator please consult the 3M Respirator Selection Guide found on the 3M Personal Safety Division website at www.3M.com/respiratorselector or call 1-800-243-4630 in U.S.A. In Canada call 1-800-267-4414.

Do Not Use For

Do not use for gases and vapors, oil aerosols, asbestos, or sandblasting; particulate concentrations that exceed either 10 times the occupational exposure limit or applicable government regulations, whichever is lower. In the U.S., do not use when the Occupational Safety and Health Administration (OSHA) substance specific standards, such as those for, arsenic, cadmium, lead in the construction industry, or 4,4'-methylene dianiline (MDA), specify other types of respiratory protection. This respirator does not supply oxygen.

Biological Particles

This respirator can help reduce inhalation exposures to certain airborne biological particles (e.g. mold, *Bacillus anthracis*, *Mycobacterium tuberculosis*, etc.) but cannot eliminate the risk of contracting infection, illness or disease. OSHA and other government agencies have not established safe exposure limits for these contaminants.

Even an N95 Respirator is not recommended for larger asbestos particles, aerosols, or to stop illness or disease.

How can a mask do this? It CANNOT.

IMPORTANT

Before use, see

Use For

Particles such as metal, wood, aerosols or vapors. For more information visit www.3M.com

Do Not Use

Do not use for oil aerosols, asbestos, or sandblasting. Do not use for gases and vapors. Do not use for sandblasting. Do not use for sandblasting.

Biological

This respirator can help reduce inhalation exposures to certain airborne biological particles (e.g. mold, *Bacillus anthracis*, *Mycobacterium tuberculosis*, etc.) but cannot eliminate the risk of contracting infection, illness or disease.

Use Instructions

1. Failure to follow instructions may result in injury or death.
2. In the U.S., this respirator is not designed to be used by children.
3. The part of the respirator that seals against the face is made of soft foam. Do not use if the foam is cracked, damaged, or missing.
4. Leave the respirator in its original packaging until you are ready to use it.
5. Store the respirator in a clean, dry place. Do not store in a plastic bag or other airtight container.
6. Inspect the respirator before each use. Do not use if the respirator shows signs of damage or if the seal is broken.
7. Conduct a seal check before use. If you cannot achieve a proper seal, do not use the respirator.
8. Dispose of the respirator after use. Do not reuse.

Use Limitations

1. This respirator does not supply oxygen. Do not use in oxygen deficient atmospheres.
2. Do not use when concentrations of contaminants are immediately dangerous to life or health, are unknown or when concentrations exceed 10 times the permissible exposure limit (PEL) or according to specific OSHA standards or applicable government regulations, whichever is lower.
3. Do not alter, wash, abuse or misuse this respirator.
4. Do not use with beards or other facial hair or other conditions that prevent a good seal between the face and the sealing surface of the respirator.
5. Respirators can help protect your lungs against certain airborne contaminants. They will not prevent entry through other routes such as the skin, which would require additional personal protective equipment (PPE).
6. This respirator is designed for occupational/professional use by adults who are properly trained in their use and limitations. This respirator is not designed to be used by children.
7. Individuals with a compromised respiratory system, such as asthma or emphysema, should consult a physician and must complete a medical evaluation prior to use.
8. When stored in accordance with temperature and humidity conditions specified the product may be used until the "use by" date specified on packaging.

Storage Conditions and Shelf Life

Before use, store respirators in the original packaging, away from contaminated areas, dust, sunlight, extreme temperatures, excessive moisture and damaging chemicals. When stored in accordance with temperature and humidity conditions specified the product may be used until the "use by" date specified on packaging. Always inspect product and conduct a user seal check before use as specified in these *User Instructions*. If you cannot achieve a proper seal, do not use the respirator.



End of Shelf Life
Use respirators before the "use by" date specified on packaging



Storage Temperature Range
-20°C (-4°F) to +30°C (+86°F)

Shah et al., 2021 – Effectiveness of Masks

Physics of Fluids

ARTICLE

scitation.org/journal/phf

Experimental investigation of indoor aerosol dispersion and accumulation in the context of COVID-19: Effects of masks and ventilation

Cite as: Phys. Fluids **33**, 073315 (2021); doi: [10.1063/5.0057100](https://doi.org/10.1063/5.0057100)

Submitted: 17 May 2021 · Accepted: 2 July 2021 ·

Published Online: 21 July 2021



View Online



Export Citation



CrossMark

Yash Shah, John W. Kurelek, Sean D. Peterson, and Serhiy Yarusevych^{a)}

Shah et al., 2021 – Effectiveness of Masks

Abstract: Filtration Efficiencies:

- High-efficiency masks (R95 & KN95): 60% and 46% respectively.
- Cloth Masks (10%).
- Surgical masks (12%).

Not Conservative Because:

- Used 1 μm particles (COVID-19 $\sim 0.1 \mu\text{m}$).
- Sealed mask – no gaps – “Hole(y) Mask” Podcast.

Shah et al., 2021 – Effectiveness of Masks

Abstract: Engineering Controls Better:

The results also suggest that, while higher ventilation capacities are required to fully mitigate aerosol build-up, even relatively low air-change rates (2 h^{-1}) lead to lower aerosol build-up compared to the best performing mask in an unventilated space.

Note the use of the term “aerosol.”

OSHA 29 CFR 1910.134 – Respiratory Protection Standard (RPS)

<u>OSHA 1910.134 RPS Parameters</u>	<u>Mask</u>	<u>Respirator</u>
Medical Clearance to Wear	No	Yes
Ability to Wear Facial Hair – Beard	Yes	No
Initial Fit Test Requirement	No	Yes
Annual Requirement to Fit Test	No	Yes
Change-out Criteria for Filter/Cartridge	No	Yes
Training on Use of Mask/Respirator	No	Yes
Training on Storage of Mask/Resp.	No	Yes
Audit of Effectiveness of Program	No	Yes

CONCLUSION: Masks do not meet key OSHA RPS Requirements!

CDC vs Petty

CDC:

Surfaces → *Droplets* → *Aerosols?*

2020

2021

Petty:

Aerosols → *Aerosols* → *Aerosols*

It's Always Been About the Little Guys (Aerosols - $< 5 \mu\text{m}$)

RECALL SEEING DUST IN THE AIR



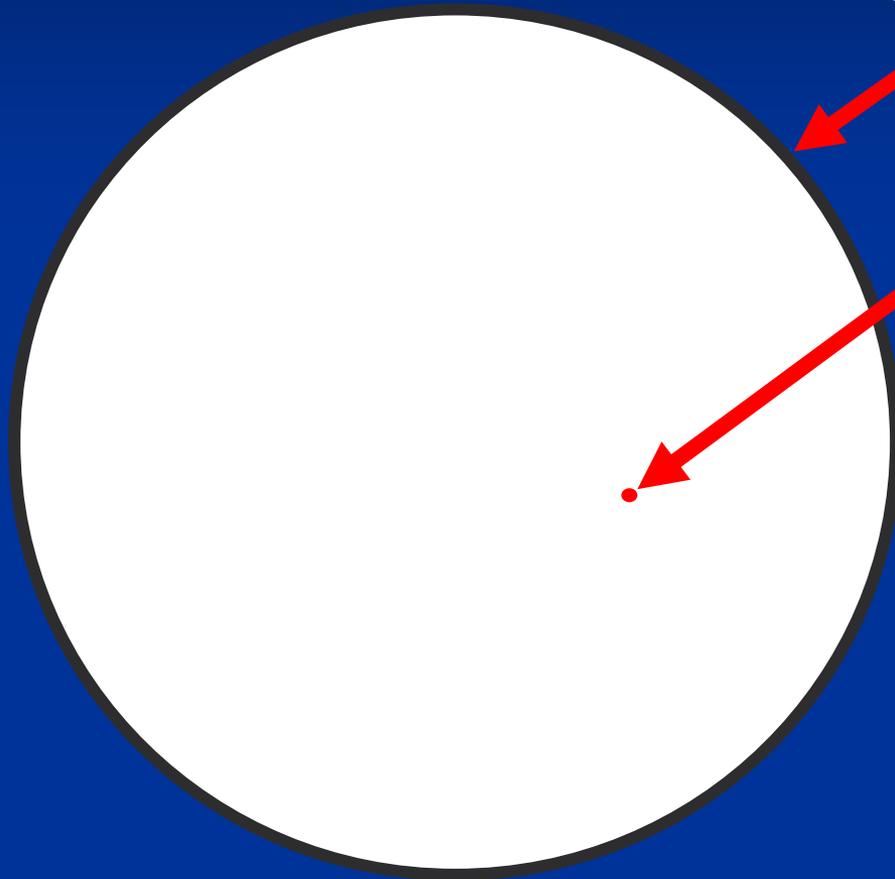
Visible Dust in Sunlight: $>50 \mu\text{m}$;

~500 times larger than COVID-19



How Big is a Micron vs Human Hair Diameter?

**Black Ring is Cross Section
of Human Hair**



**1 Micron – Small Red Dot
COVID – 1/10 Micron**

~40,000 times smaller in area

& ~1,000 times smaller in diameter

than the cross-section of human hair.

Can you get a human hair past the side of your mask?

RELATIVE SIZES OF PARTICLES

Thickness of Human Hair:
~100 μm



100 Microns-
Strand of human
hair

• 10 Microns-
Size of typical dust mite



50 Microns-
Smallest size the
human eye can see

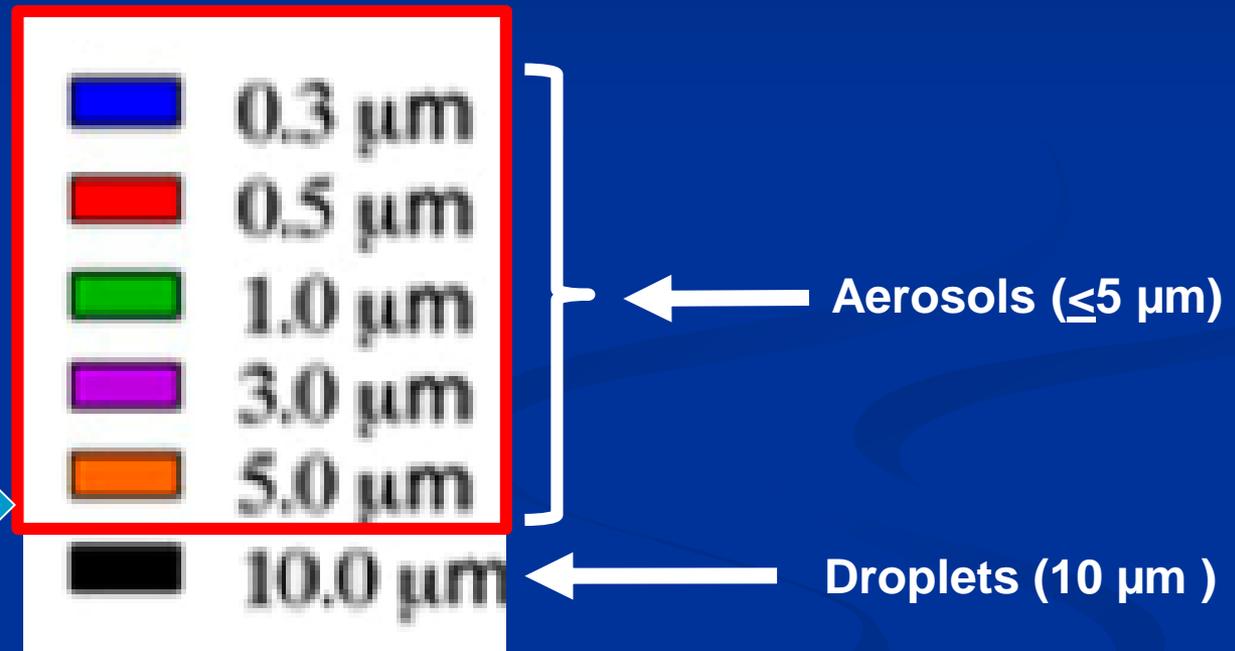
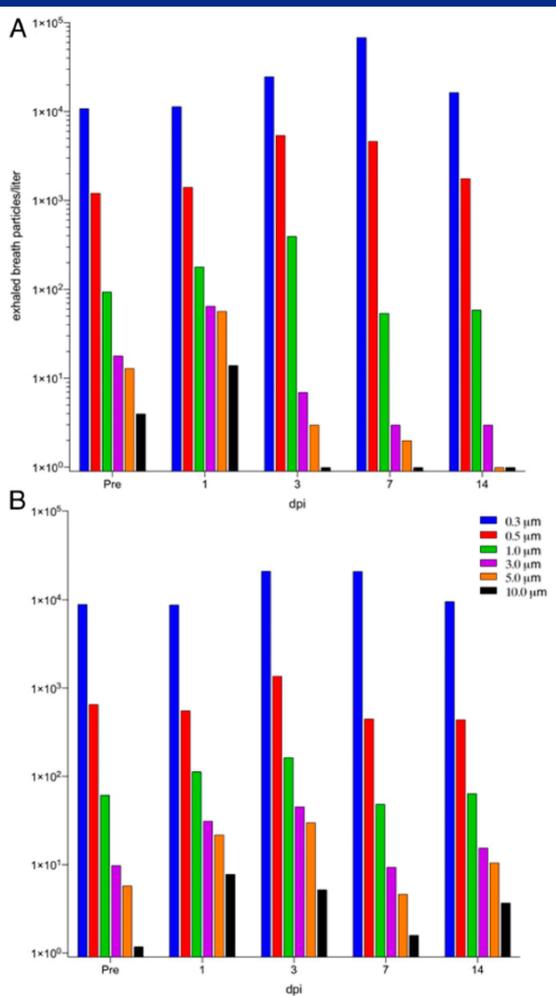
100 Microns- Thickness of a sheet of
standard paper

Visible Dust: $>50 \mu\text{m}$;

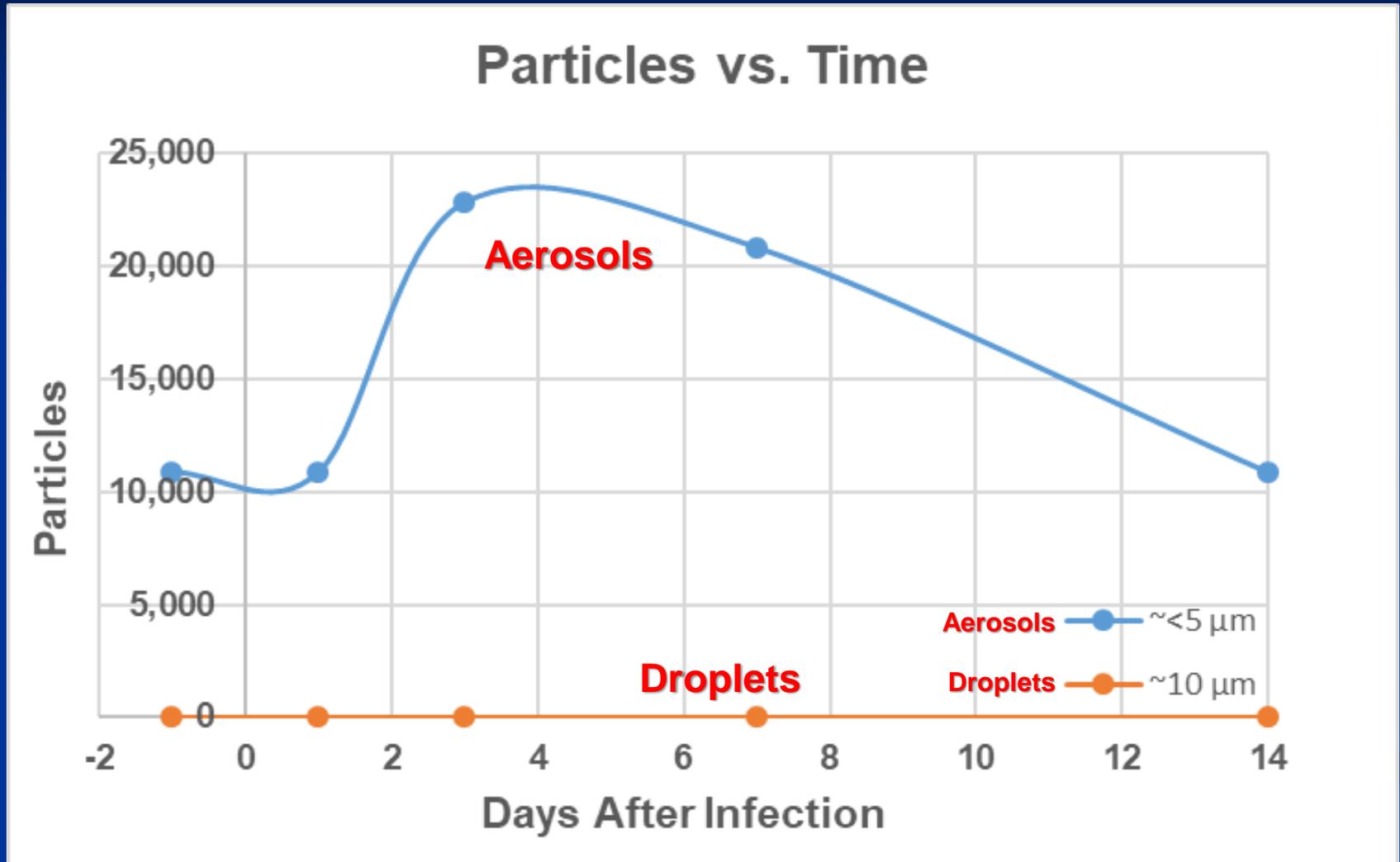
Thickness of Paper:
~100 μm

Edwards et al. – 2/23/2021 – Cont.

Data Presented by Size – in Colored Bars



Edwards et al. – Data Simplified



Edwards et al. – Data Simplified

>99.9% Particles were Aerosols (small guys)

	Aerosols	Droplets	% Aerosols
Day After Infection	$\sim \leq 5 \mu\text{m}$	$\sim 10 \mu\text{m}$	% Small
-1	10,898	1.5	99.99%
1	10,900	9	99.92%
3	22,847	7	99.97%
7	20,847	3	99.99%
14	10,870	6	99.94%

RECALL LITTLE GUYS vs. BIG GUYS

“Big Guys” are Droplets: >5 to $10\ \mu\text{m}$



VS.

“Little Guys” are Aerosols: $\leq 5\ \mu\text{m}$

Little guys are more prevalent and problematic

Edwards et al. – 2/23/2021

Conclusions

Our finding that the proportion of small respiratory droplets (i.e., aerosols) [were the majority of particles exhaled in all subjects]...

Proceedings from the National Academy of Sciences Press – Edwards et al. – 2/23/2021

CONCLUSIONS FROM THE PAPER:

Our finding that the proportion of small respiratory droplets (i.e., aerosols) [were the majority of particles exhaled in all subjects].....

There may be an elevated risk of the *airborne transmission of SARS-CoV-2 by way of the very small droplets that transmit through conventional masks and traverse distances far exceeding the conventional social distance of 2 m (~7')*.

Exhaled aerosol numbers appear to be not only an indicator of disease progression, but a marker of disease risk in non-infected individuals.

SMALL PARTICLES TAKE A LONG TIME TO FALL FIVE FEET IN STILL AIR



SMALL PARTICLES TAKE A LONG TIME TO FALL FIVE FEET IN STILL AIR

Stokes Law – How Fast Do Small Particles Fall?

$$V_s = 0.0052 * \text{Specific Gravity} * \text{Diameter}^2$$

Where:

V_s = Falling velocity in ft./min.

Specific Gravity – Density of the particle – virus is ~1.42

Diameter – Diameter of the particle in microns for particles <100 microns

Stokes Law (see Industrial Ventilation Workbook, D. Jeff Burton, 4th edition, 1997)

See also: [https://www.thelancet.com/pdfs/journals/lanres/PIIS2213-2600\(20\)30323-4.pdf](https://www.thelancet.com/pdfs/journals/lanres/PIIS2213-2600(20)30323-4.pdf) – Fennelly - Particle sizes of infectious aerosols: implications for infection control – Lancet – Sept. 2020.

SMALL PARTICLES TAKE A LONG TIME TO FALL FIVE FEET IN STILL AIR

Droplets fall fast – 0.1 to 10 minutes

Particle Size (μm)	Time to Fall 5' (minutes)
10	9.6
25	1.5
100	0.1

Assumes still air; in moving air times would be even longer.

SMALL PARTICLES TAKE A LONG TIME TO FALL FIVE FEET IN STILL AIR

Aerosols Fall Slowly: 0.03 to 59 days

Particle Size (μm)	Time to Fall 5' (days)	Type of Particle
0.09	58.9	Aerosol
0.12	46.4	
0.2	16.7	
1	0.67	
5	0.027	

COVID

COVID-19 Fall Very Slowly: 46.4 to 58.9 days

Assumes still air; in moving air times would be even longer.

WHY ARE AEROSOLS – SMALL PARTICLES SO IMPORTANT?

1. Aerosols (very small particles - <5 microns) can stay suspended for hours to days.
2. Since they stay suspended for so long, they can actually *accumulate* in concentration in indoor air rather than dropping out if you assumed they were droplets.
3. This effectively renders the 6' rule useless. This also renders masks essentially useless; they do not filter out aerosols and they cannot be fitted (gaps around the edges).

REAL INDUSTRIAL HYGIENE SOLUTIONS

EXPOSURE CONTROL – DILUTION BY VENTILATION OR MAXIMUM FRESH AIR

Dilution of Virus by Dilution and/or Ventilation – More Fresh Air!

- *Spend More Time or Meet Outdoors* – condition of maximum fresh air and dilution of virus – avoid indoors.
- *Ventilation* – Residential and Commercial – Crack open windows or doors – especially with company.



EXPOSURE CONTROL – DILUTION BY VENTILATION OR MAXIMUM FRESH AIR

Dilution of Virus by Dilution and/or Ventilation – More Fresh Air!

- Ventilation – Commercial and Industrial – Increase fresh air – set fresh air dampers to maximum openings on HVAC systems to maximize fresh air intake – over-ride energy controls – will increase energy costs.



EXPOSURE CONTROL – DESTRUCTION OR REMOVAL OF VIRUS

Destruction or Removal:

- *Needle Point Ionization Technology* (e.g., Nu-Calgon I-Wave) – add to HVAC intake fans to kill viruses, mold, and bacteria (<https://www.iwaveair.com/sites/default/files/17-S26-PathogensFlyer.pdf>).
- Ionized Hydrogen Peroxide Systems (e.g., RGF's Reme Halo in-duct air purifier - <https://www.rgf.com/products/air/remehalo/#undefined>).



EXPOSURE CONTROL – DESTRUCTION OR REMOVAL OF VIRUS

Destruction or Removal:

- **Ultraviolet-C (UVC) Lamps**
(<https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-lights-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus>).
- **Very High Efficiency Filters (at least MERV-13 filters)**
(<https://www.ashrae.org/file%20library/technical%20resources/covid-19/guidance-for-the-re-opening-of-schools.pdf>).



FOUR THINGS TO REMEMBER!

1. **Personal Protective Equipment (PPE) is the least desirable way to protect people.**
2. **Masks are not PPE.**
3. **Scientific evidence suggests COVID-19 particles are mostly small aerosols not droplets, which means respirators, not masks, needed to protect the lungs and would make the 6' rule effectively meaningless.**
4. **Smaller particles are likely a greater cause of disease since they get past PPE and can reach deep into the lungs.**

Use Engineering Controls of **Dilution and **Destruction**.**

THANK YOU

Questions Please

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