



National Institute of Occupational
and Environmental Health



Ministry of Health



Health Environment
Management Agency



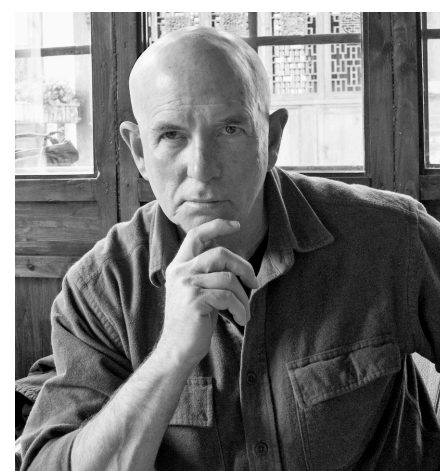
Recent Advances in Aerosol Science with Special Reference to SARS-CoV-2 Occupational Exposures

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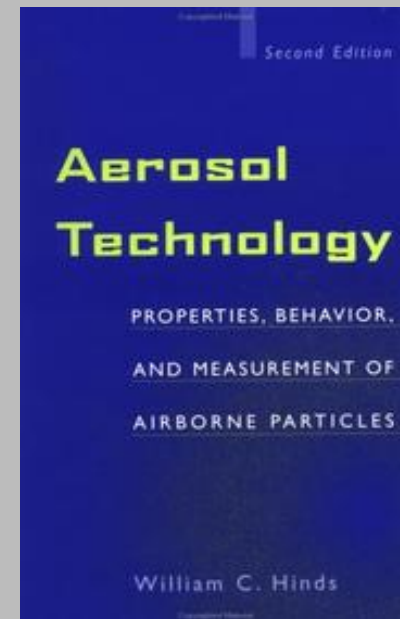
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Topics

- The Classical Definition of Aerosols & Description of their Properties;
- Size Characteristics and some diseases caused by aerosols;
- The discussion of aerosols and disease has a long history
- The Dichotomy/Polydisperse Models of Bio-aerosols, Size-Deposition in the Respiratory Tract
- Behavior of Droplet Nuclei (0.1- 5.0 μm) and Droplets (5.0 - 100 μm) in Ideal Conditions: Stokes Law
- What are Aerosol Generating Procedures?
- “It Is Time to Address Airborne Transmission of COVID-19”
- The Literature on Aerosol Transmission
- The Response by OEHS Professional and Volunteer Organizations
- Conclusions Based on the Evidence
- Selected References from the Literature

Part 1: 1998 Definition of Aerosols & Description of their Properties



“An aerosol is defined in its simplest form as a collection of solid or liquid particles suspended in a gas. Aerosols are two-phase systems, consisting of the particles and the gas in which they are suspended.”

Aerosols “include a wide range of phenomena such as dust, fume, smoke, mist, fog, haze, clouds, and smog.”

“The toxicity of inhaled particles depends on their physical & chemical properties, therefore an understanding of the properties of aerosols is required to evaluate airborne particulate hazards.

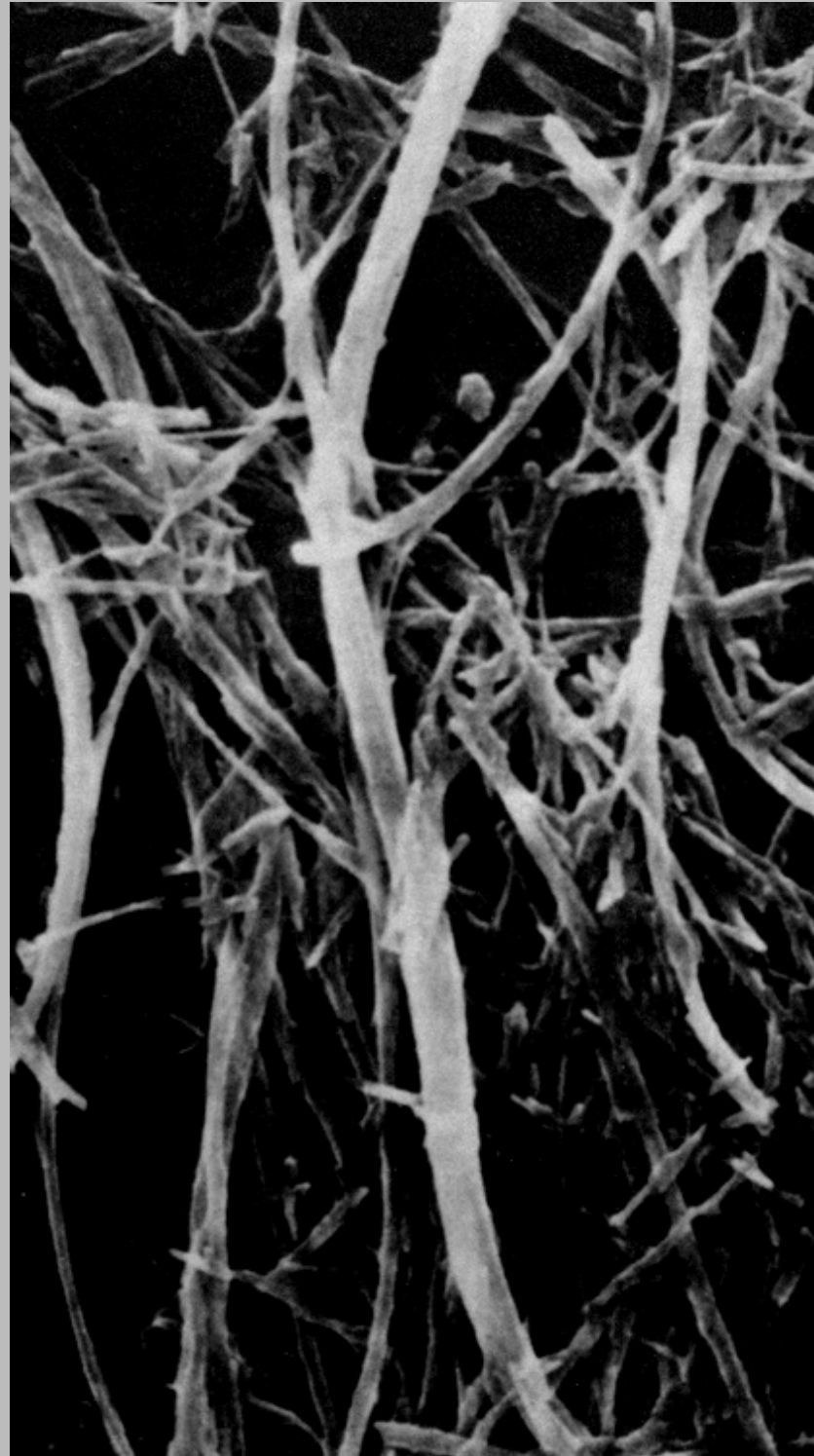
Takeaway Point: Every OEHS scientist and professional needs a grounding in aerosol science to prevent occupational diseases.

Source: *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles* (1998)

First Edition 1982, Third Edition 2022

Multiple Occupational Diseases Caused by Aerosols

Familiar Example: Asbestos fibers as Long as 50 μm



“Most aerosols are polydisperse, with a wide range of particle sizes, and statistical measures should be used to characterize their particle size.”

“Aerodynamic properties of fibers as long as 50 μm or as big as 3 μm in diameter can reach the alveolar region and are considered respirable.....the fibers align themselves with the streamlines and "snake" their way through the narrow airways to the alveolar region. Once lodged in an alveolus, large asbestos fibers cannot be removed by normal clearance mechanisms.”

Other Common examples of aerosols that can cause occupational diseases or compromise lung function:

- Spray painting,
- Welding,
- A new hazard: Cleaning restaurant tables with ammonia or thymol based sprays during the time of COVID-19.

The Scientific Appreciation of Bio-Infectious Aerosols Has a Long History



Jennison, M.W.: Atomizing of mouth and nose secretions into the air as revealed by high-speed photography. In *Aerobiology*, F.R. Moulton (ed.), pp. 106-128: American Association for the Advancement of Science, 1942.

ISO 7708: 1995 (reviewed 2017) Air Quality – Particle size fraction definitions for health related sampling.

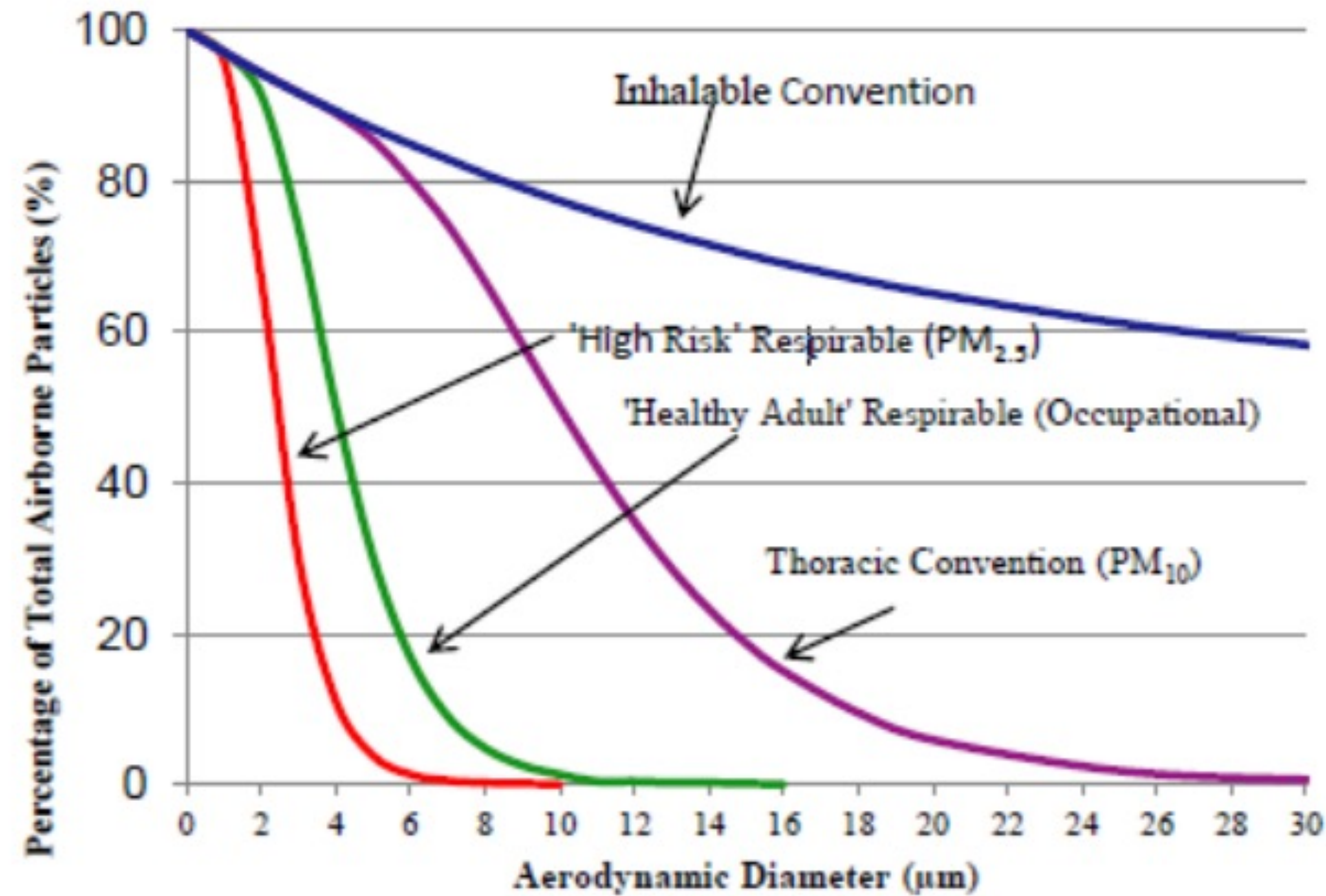
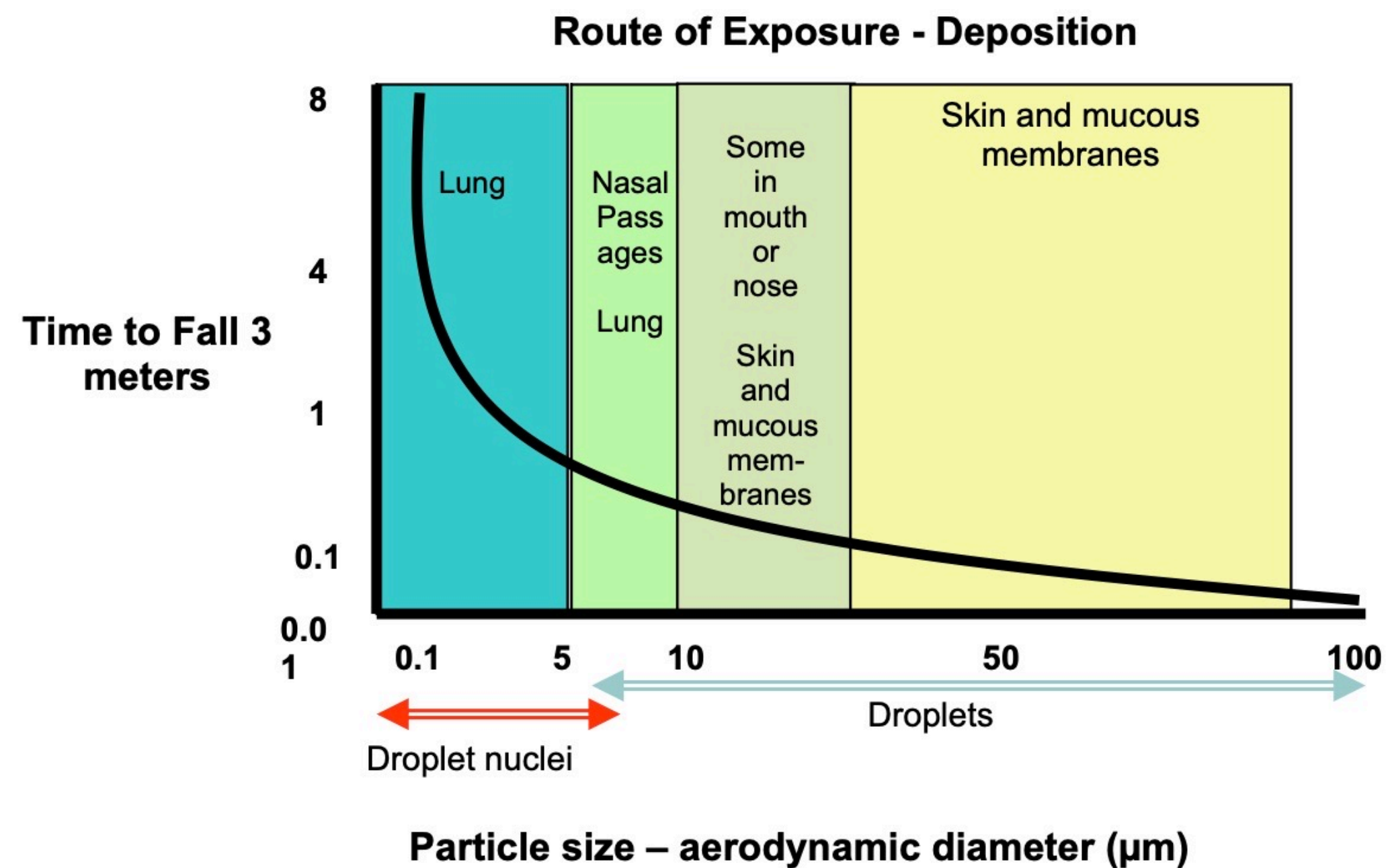


Figure 2.9: Particle size distributions and collection efficiency curves according to ISO, 7708 1995 (Adapted from: ISO 1995, p7)

Droplet Nuclei (0.1- 5.0 μm) and Droplets (5.0 - 100 μm) based on Stokes Law in Ideal Conditions



“Suspension in air can be more prolonged if the air is stirred.”

“Particles much larger than 10 μm will in fact be carried away by air currents or air jets well beyond the canonical 2 m distance.”

“Coughing, or even exhalation, injects a hot, humid air jet into cooler, drier air; humidity and heat have a buoyancy effect that will keep small particles suspended longer and carried away further, especially for particles less than 10 μm .”

Source: Tellier, 2022 [COVID-19: the case for aerosol transmission](#).

Source: *Protecting the Faces of Health Care Workers* (2004),
Occupational Health and Safety Agency for Healthcare in BC
Retrieved from [PAHO/WHO](#)

Summary: The two-phase systems (particles & air in which they are suspended) includes the dynamic four-dimensional changes in temperature & humidity, plus the turbulence caused by ventilation & human movement.

The Droplet Theory Only Works in Still Air

“The settling time for aerosols of a specific size to reach the ground can be estimated on the assumption that the surrounding air is at rest.”

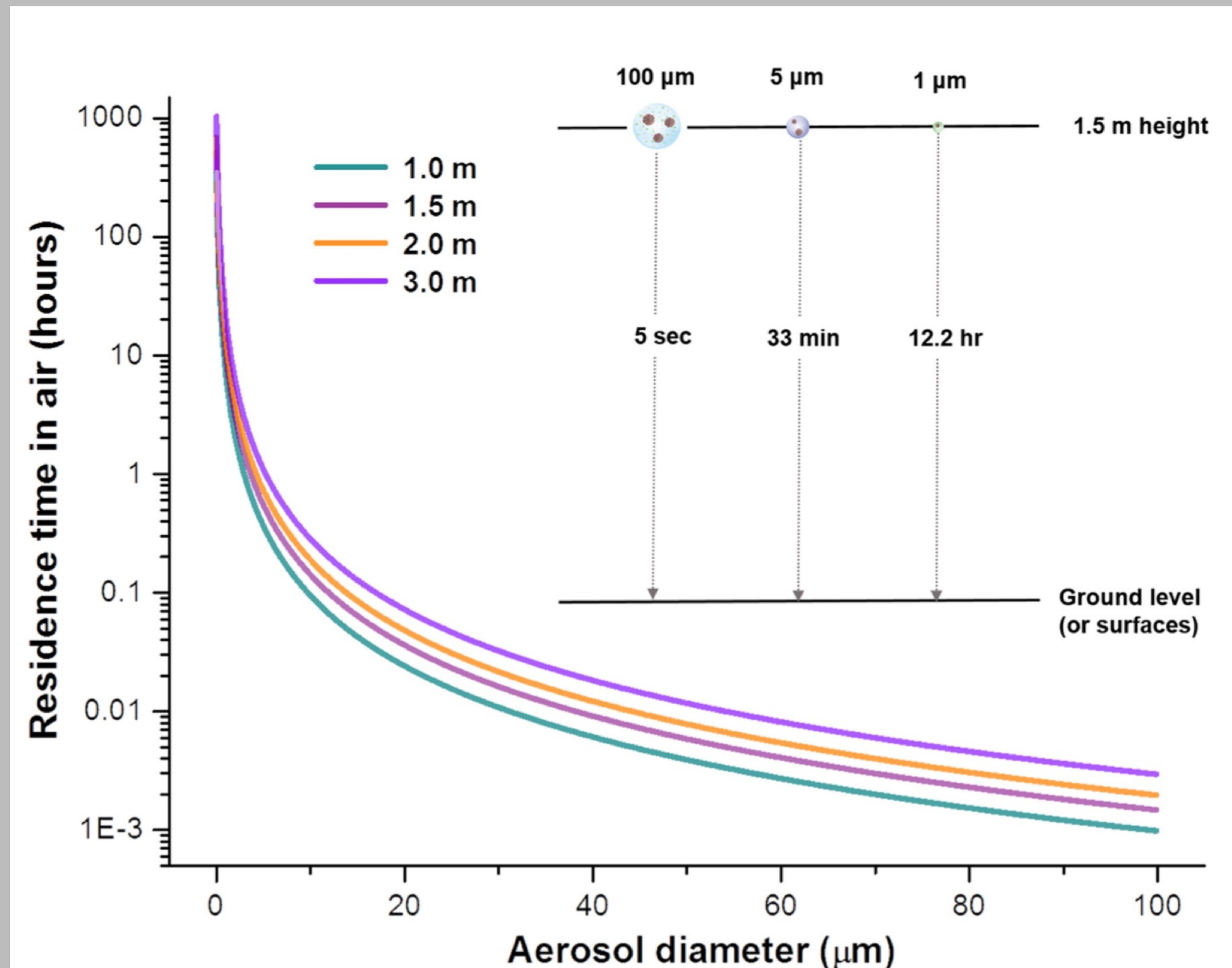


Fig. 3. How long can aerosols linger in air? Residence time of aerosols of varying size in still air can be estimated from Stokes' law for spherical particles (116). For example, the time required for an aerosol of 100, 5, or 1 μm to fall to the ground (or surfaces) from a height of 1.5 m is 5 s, 33 min, or 12.2 hours, respectively.

“The transport of virus-laden aerosols is affected by the physical-chemical properties of aerosols themselves and environmental factors, including temperature, relative humidity, ultraviolet radiation, airflow, and ventilation.”

What are Aerosol Generating Procedures?



Aerosol Generating Procedures (AGP) include surgery & postmortem procedures with high-speed devices, intubation and extubation procedures, and bronchoscopy.

“Procedures (e.g., intubation) can change the volume, size, distribution and speed of particles expelled as well as changing their origin from different parts of the respiratory tract.”

“Expelled particles can spread widely in a room in a short time after a cough, and cases are recorded where infectious material has dispersed through ventilation systems or windows.”

Source: [Jackson et al.](#)

W.H.O.: Occupational Exposure to SARS-CoV-2

“SARS-CoV-2 mainly spreads between people when an infected is in close contact with another person. The virus can spread from an infected person’s mouth or nose in small liquid particles ranging from larger ‘respiratory droplets’ to smaller ‘aerosols’ when the person coughs, sneezes, sings, breathes heavily or talks.....

“Aerosol transmission can occur in specific situations in which medical procedures that generate aerosols are performed. There is [inconclusive evidence about aerosol transmission](#) in health-care settings in the absence of aerosol generating procedures.”

source: [W.H.O.](#)

Part 2

The Evidence in Occupational or Social Setting is Massively in Favor of Aerosol Transmission

-Laboratory studies on aerosolized SARS-CoV-2 and MERS-CoV have been shown to remain infectious for hours in aerosols.”

-SARS-CoV-2 in exhaled aerosols: “Singing, talking or even normal breathing produce a large number of aerosols and in fact mostly small aerosols .”

-Detection of SARS-CoV-2 in of clinical environments air samples: “Deposited in vent openings, air ducts and exhaust filters from COVID-19 patient rooms at distances and under a geometry that would preclude deposition from large droplets that followed ballistic trajectories.”

The Evidence in Occupational or Social Setting is Massively in Favor of Aerosol Transmission

-Outbreaks involving aerosol transmission:

- Choir practice in the USA
- Diamond Princess cruise ship
- Restaurant in Wuhan

- Meat packing plants
 - proximity of workers in assembly lines,
 - shared transportation
 - shared housing
 - cold air is typically recirculated

From SARS 2003::

- Well-documented transmission in Hong Kong's Amoy Gardens residential towers in the remote field via "via a chimney effect, "through the sewage-disposal system, person-to-person contact, and the use of communal facilities such as elevators and staircases" (see References)

A Shot Heard Around the World: Morawska & Milton + 239 Scientists:

It Is Time to Address Airborne Transmission of COVID-19 2020-07-06

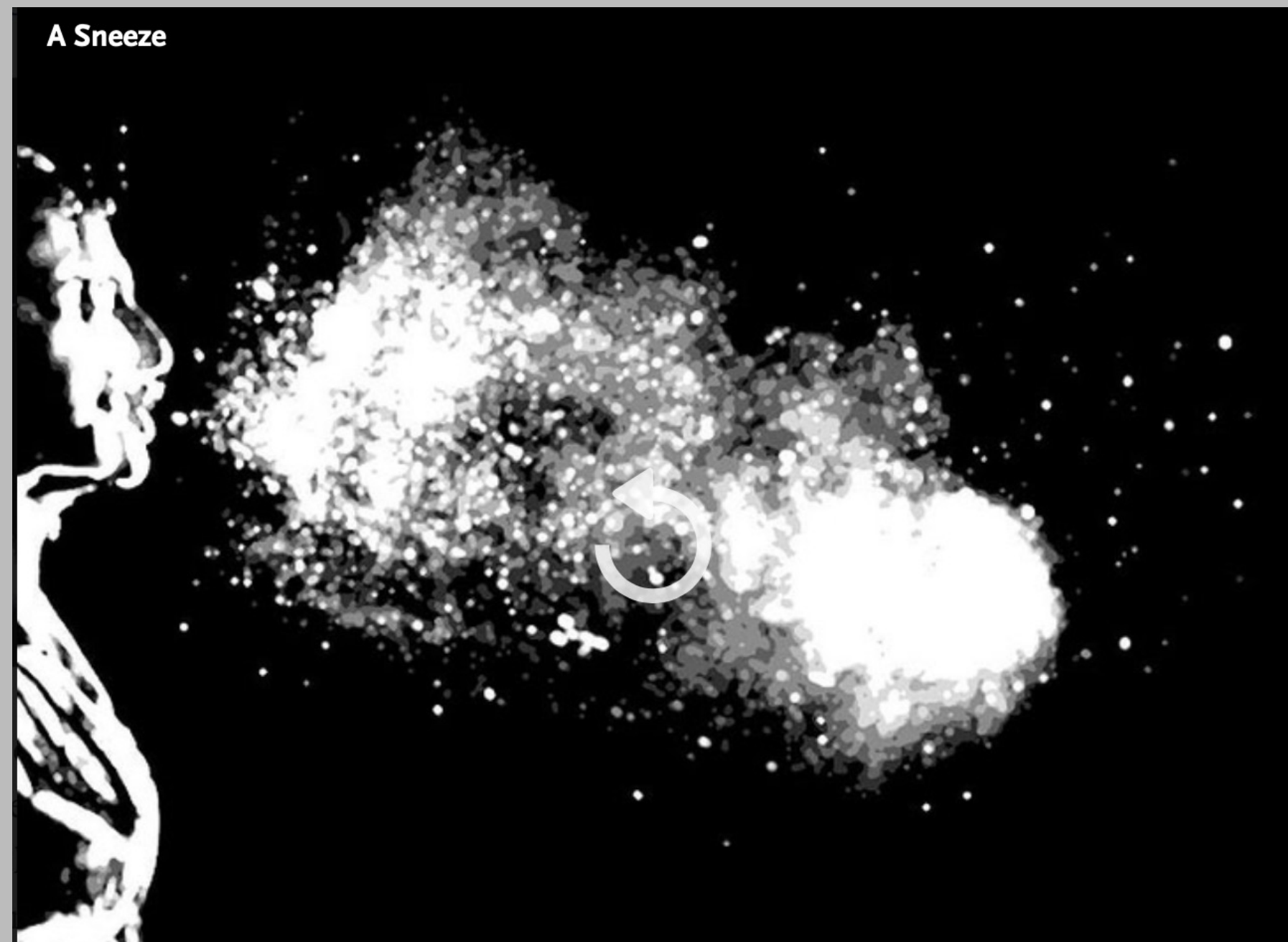
“We appeal to the medical community and to the relevant national and inter-national bodies to recognize the potential for airborne spread of coronavirus disease 2019 (COVID-19).”

“The current guidance from numerous international and national bodies focuses on hand washing, maintaining social distancing, and droplet precautions. [Most public health organizations, including the World Health Organization do not recognize airborne transmission except for aerosol-generating procedures performed in healthcare settings.](#)”

[“Airborne transmission appears to be the only plausible explanation for several super-spreading events investigated that occurred under such conditions.”](#)

Recommendation: “Provide sufficient and effective ventilation (supply clean outdoor air, minimize recirculating air) particularly in public buildings, workplace environments, schools, hospitals, and aged care homes according to the standard of ASHRAE (the American Society of Heating, Ventilation, and Air-Conditioning Engineers).

from: Turbulent Gas Clouds and Respiratory Pathogen Emissions



“Recent work has demonstrated that **exhalations, sneezes, and coughs not only consist of mucosalivary droplets** following short-range semi-ballistic emission trajectories but, importantly, **are primarily made of a multiphase turbulent gas cloud that entrains ambient air and traps and carries within it clusters of droplets with a continuum of droplet sizes.**”

“Owing to the forward momentum of the cloud, pathogen-bearing droplets are propelled much farther than if they were emitted in isolation without a turbulent puff cloud trapping and carrying them forward. Given various combinations of an individual patient’s physiology and environmental conditions, such as humidity and temperature, **the gas cloud and its payload of pathogen-bearing droplets of all sizes can travel 23 to 27 feet (7-8 m).**”

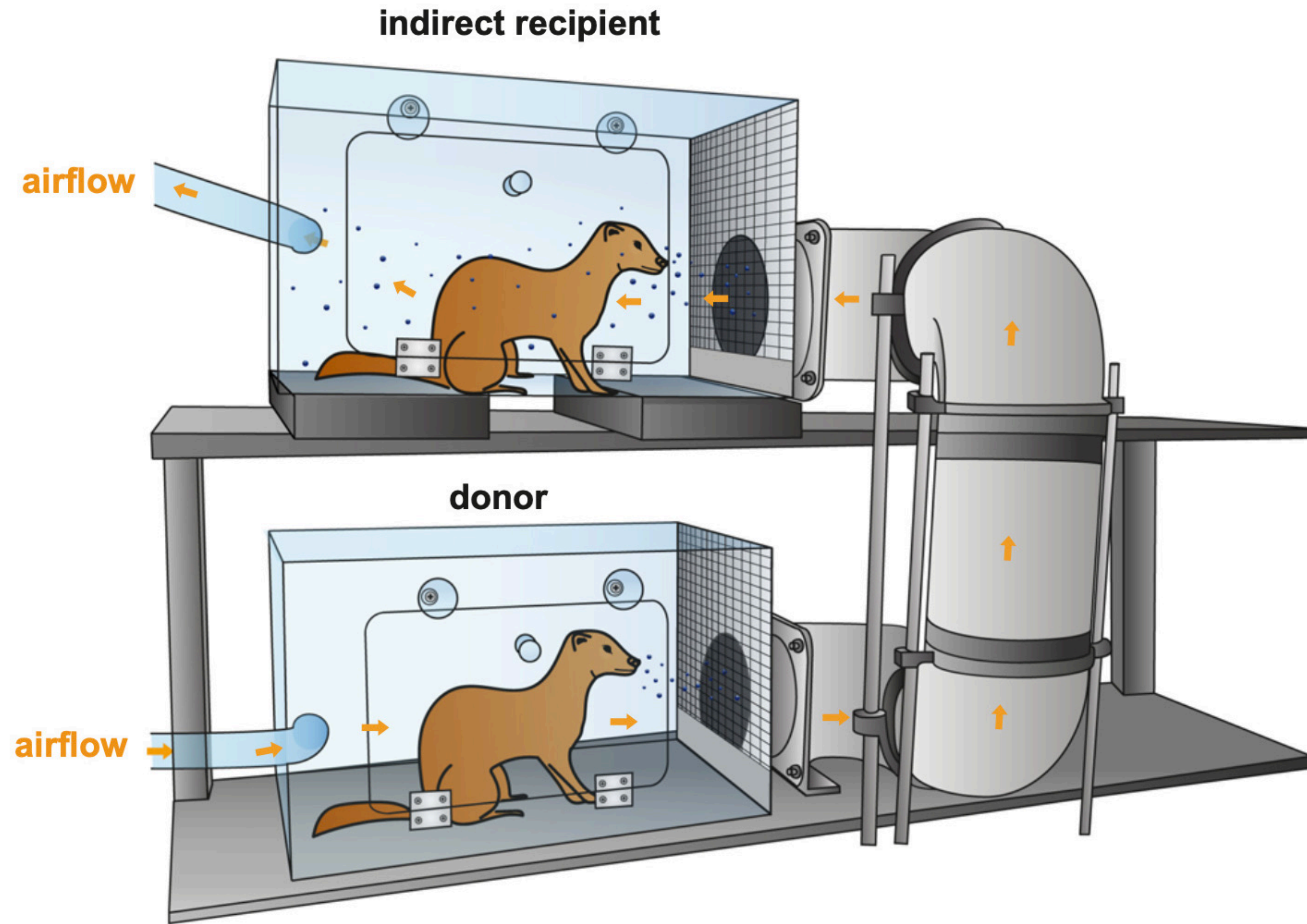
Importantly, the range of all droplets, large and small, is extended through their interaction with and trapping within the turbulent gas cloud, compared with the commonly accepted dichotomized droplet model that does not account for the possibility of a hot and moist gas cloud.

A Rosetta Stone for Understanding Infectious Drops and Aerosols

-US aerosol scientist Donald Milton

"Because particles much larger than 5 μm (whether liquid droplets or the dried residual material of a respiratory droplet) can be suspended in air and wafted on air currents, such particles are true aerosols. So, the common medical use of the term "aerosols" to mean only particles $\leq 5 \mu\text{m}$ is out of sync with what we know from modern aerosol physics."

Aerosol Transmission of SARS-CoV-2: an Animal Experiment



From Kutter, et al., March 2021. *SARS-CoV and SARS-CoV-2 are transmitted through the air between ferrets over more than one meter distance.* <https://www.nature.com/articles/s41467-021-21918-6>

The Mass Experience of Wuhan HCW using Modified Level 3 (Ebola-type) Safe Work Procedures

- A total of 42,000 medical volunteers deployed from all Provinces.
- **Adoption of Modified Level 3 (Ebola-type) Safe Work Procedures;.***
- Extensive training in a 27-step procedure for on/off of PPE.
- Constant nucleic acid testing.
- Objective: No patient can infect a HCW, No HCW self-inoculates.
- Results: Zero infections/mortality for 42,000 medical volunteers.
- **Achieved without vaccine.**

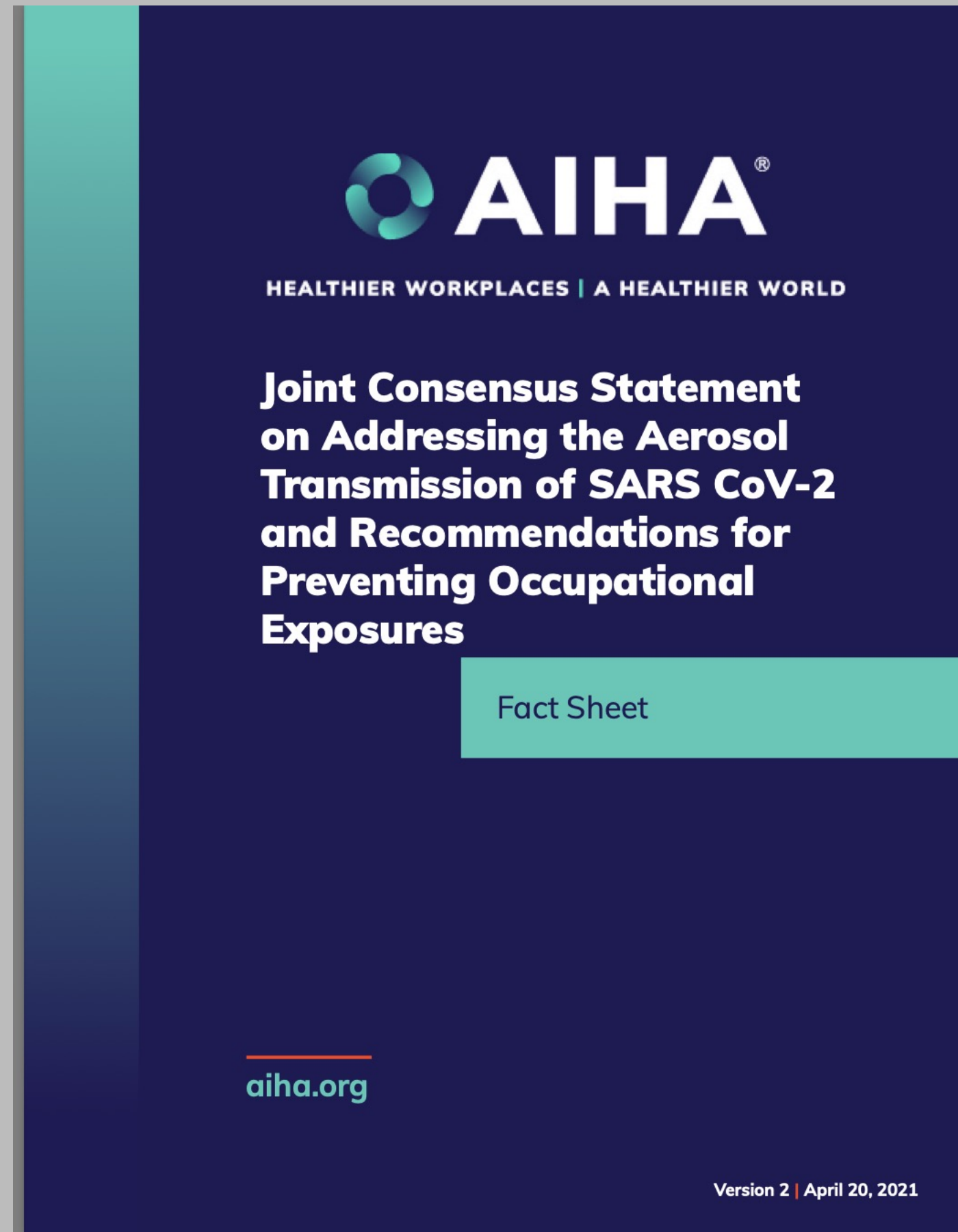


** [https://www.ajicjournal.org/article/S0196-6553\(20\)30771-9/fulltext](https://www.ajicjournal.org/article/S0196-6553(20)30771-9/fulltext)

Part 3

The Responses of OEHS Scientists and Volunteer Organizations

Multiple Quantitative & Qualitative Studies on Aerosols



“AIHA and eight other leading scientific organizations have endorsed recommendations for Occupational Safety and Health Administration (OSHA), Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH) to create specific guidelines for workers and communities related to the aerosol transmission of the virus SARS-CoV-2, which causes the disease COVID-19.

“The recommendations respond to the [federal agencies' delay in acknowledging the capability for the SARS-CoV-2 virus to infect people via the inhalation of virus-laden aerosols](#)—that is, small airborne droplets—and issue appropriate guidance.

“As of October 2020, the World Health Organization (WHO) and the CDC had yet to alter protection guidelines for workers and communities to address SARS-CoV-2 aerosol transmission.”

Workplace Health Without Borders, April, 2020



Workplace Health Without Borders

April 11, 2020

The Honourable Patty Hajdu
Minister of Health
Government of Canada
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Dr. Theresa Tam
Chief Public Health Officer
Public Health Agency of Canada
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Dear Minister Hajdu and Dr. Tam:

As President of [Workplace Health Without Borders](#) (WHWB) International and representing the international WHWB Board of Directors, I want to thank you for all you are doing to combat COVID-19 in Canada. I am also writing to express our concern about messaging from the World Health Organisation (WHO), as expressed in their [Coronavirus disease 2019 \(COVID-19\) Situation Report – 66](#) (26 March 2020), and subsequent messaging from Canadian officials, especially as it impacts frontline healthcare workers around the world.

WHWB (International) was started by a group of occupational hygienists who recognised that their skills were needed in parts of the world where their specialist training was not available.

We were founded in Toronto in 2011 as a not-for-profit organization, to help address occupational health and hygiene issues in the developing world. We now have well established branches in the US, UK and Australia.

WHWB (International) has a well-developed a [strategic framework](#). Since our formation in 2011, our global activities have escalated and we continue to increase our international pool of volunteers. Our vision: **“a world in which workers, their families, and communities do not get ill because of their work”** and mission: **“to prevent work-related disease and injury around the world through shared expertise, knowledge and skills”** provides direction for our global membership.

Imagine a world where workers do not get sick because of their work

Workplace Health Without Borders, 75 Courtneypark Drive West, Unit 1, Mississauga, ON, Canada, L5T 1X7
www.whwb.org

“We are concerned that official Canadian messaging regarding airborne transmission of COVID-19 is not consistent with the science on the transmission of influenza and coronavirus, which strongly indicates that aerosol transmission is a route of infection.”

We would like to bring your attention to the following paper: which states, In terms of science, closer collaboration between virologists, epidemiologists, and aerosol scientists is necessary; and in terms of outreach, improved efforts to inform the public that every individual emits potentially infectious aerosols all the time, not just when sneezing or coughing is necessary” (Asadi et al. 2020) .

“Unfortunately the current messaging being provided at the national and international level is behind the known emerging science about the transmission of COVID-19, including as an aerosol. The hazard is not being suitably characterized to those at greatest risk, nor is the precautionary principle being followed.”



COVID IS AIRBORNE

Canadian Experts Share Their Recommendations

The SARS-CoV2 virus is in the air — at close range and further away.

This clear science can no longer be denied.

Occupational health specialists and others from Canada and around the world have delivered this message since the pandemic began.

EVENTS

MASK SMART

PROTECT YOURSELF and OTHERS TODAY (and TOMORROW)

Tuesday, March 1, 2022
12:00 pm

Presenters:
John Oudyk,
Occupational Hygienist
Dr. Simon Smith,
Respirator expert
Dr. Kevin Hedges,
Occupational Hygienist

REGISTER

REALITY CHECK, MODELLING & SURVEILLANCE TO GUIDE FUTURE RESPONSES

Presented by:
Occupational Health Clinics for
Ontario Workers (OHCOW)

REGISTER

VENTILATION and RISK ASSESSMENT for COVID-19 PREVENTION

Presented by:
Workplace Health Without
Borders (WHWB), including John
Oudyk, OHCOW Hygienist

REGISTER

THE T-CELLS ARE NOT ALRIGHT

An Interview with
Dr. Anthony Leonardi,
T-cell Researcher

Presented by:
Dr. Kashif Pirzada
Masks4Canada co-founder

WATCH VIDEO

Part 4 Recommendations & Conclusions

An aerosol is defined in its simplest form as a collection of solid or liquid particles suspended in a gas. Aerosols are two-phase systems, consisting of the particles and the gas in which they are suspended.

The dichotomous division of aerosols into droplets and aerosols of different size ranges is artificial.

SARS-CoV-2- containing liquid aerosols in size range of 0.1- 100 μm in the near, far, and remote fields are potent agents COVID-19.

Exposure to aerosolized SARS-CoV-2 in the near, far, and remote fields are a potent causal factors for COVID-19).

In the Occupational Environment SARS-CoV-2 is a preventable disease.

Dilution & local exhaust ventilation, isolation techniques, and Level 3 PPE are means to prevent occupational transmission

Closing Thoughts

“Pending the completion of the global vaccination endeavor, a comprehensive program for interruption of SARS-CoV-2 must include control of aerosol transmission.....There are now large amounts of data supporting the contention that viruses with proven pandemic capacity within two virus families, *Orthomyxoviridae* and *Coronaviridae*, are **efficiently transmitted by aerosols**.”

source: Tellier, December 2021, [COVID-19: The Case For Aerosol Transmission](#)

Congratulations to the Vietnam National Institute of Occupational and Environmental Health 10th Scientific Conference and 40th Anniversary!

Kevin and Laurence thank you for protecting the people of the World

Thank You for your kind attention!

Discussion



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**World Health
Organization**
Western Pacific Region

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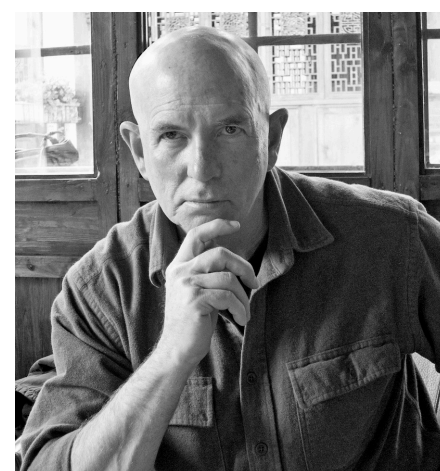
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Discussion Period

Please see the attached References

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Workplace Health Without Borders <https://whwb.org>

World Health Network <https://www.worldhealthnetwork.global>