Size characteristics of particles generated by people

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This presentation

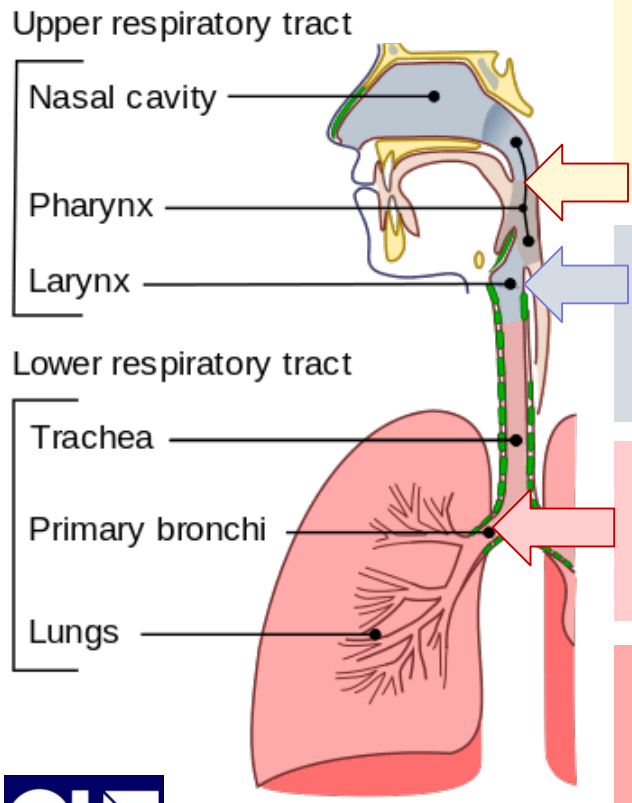
1. The source: particle atomization in respiratory activities

2. Instrumentation and study designs

3. Particle size distribution and emission rates

4. Knowns and unknowns

The source: particle atomization in respiratory activities



Saliva in the mouth is aerosolised during interaction of the tongue, teeth palate and lips during speech articulation

Fluid bathing the larynx is aerosolised during voicing due to vocal fold vibrations

Fluid blockages form in respiratory bronchioles during exhalation

These burst during subsequent inhalation produce the aerosol

After formation, the droplets undergo process in the respiratory tract before they are respired

Deposition – changing initial size distribution

Surface deformation (Oratis et al. 2020 A new wrinkle on liquid sheets: Turning the mechanism of viscous bubble collapse upside down. *Science*, 369:6504, 2020)

Instrumentation for particle monitoring

Ranging in size over several orders of magnitude

Condensation Particle Counters	Scanning Mobility Particle Sizers	Aerodynamic Particle Counters	Optical Particle Counters/Spectrometers

Real time - in line analysis (air sampled into the instrument)

Laser diffractometers

Fast photography

Real time - detection based on light scattering in the emission plume

Multistage Impactors

Cyclones

Laboratory analysis of the composition

QUT

STUDY DESIGNS

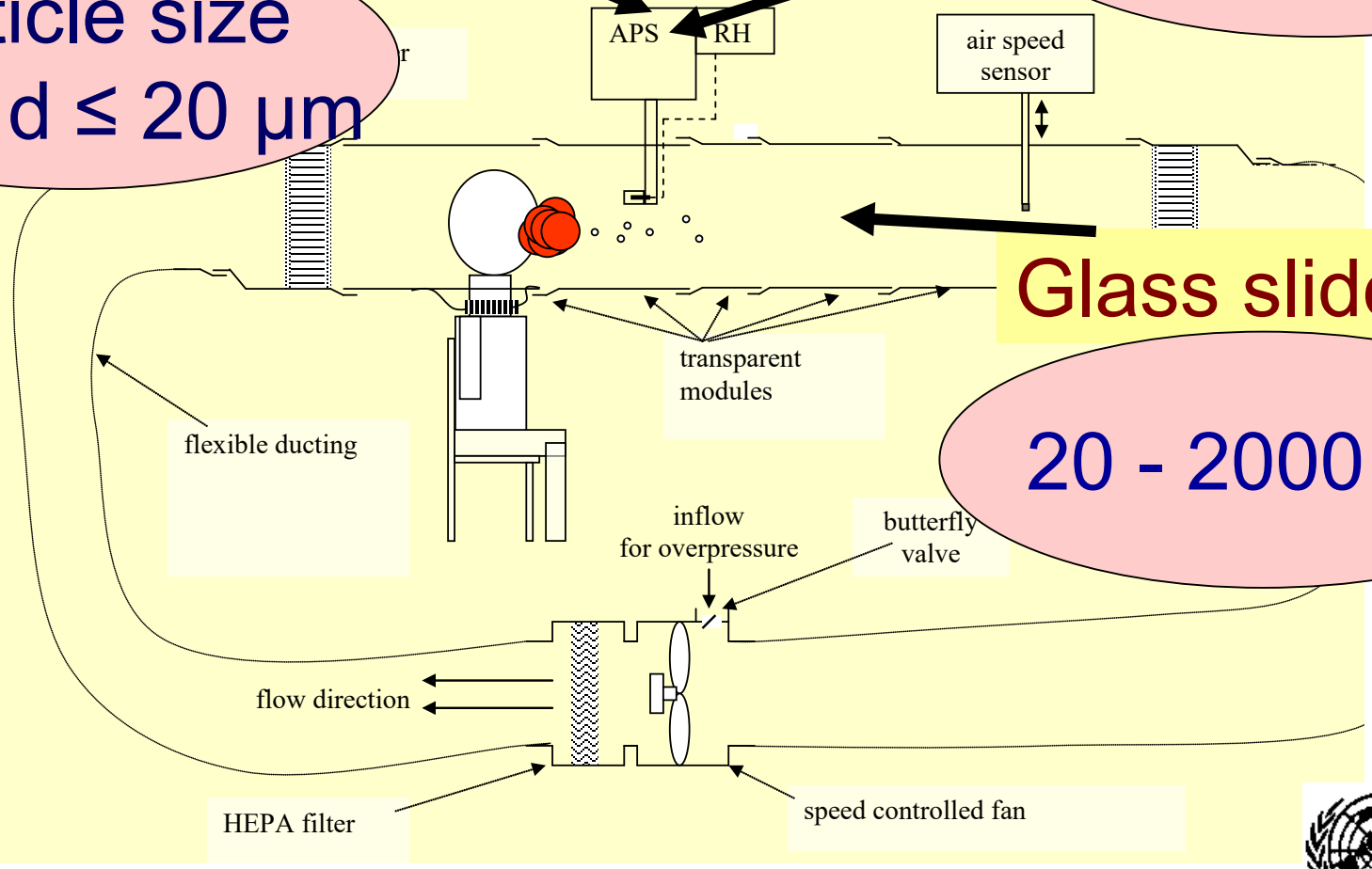
Study designs: 1

UV-APS

IMI

2 - 2000 µm

Particle size
0.5 ≤ d ≤ 20 µm

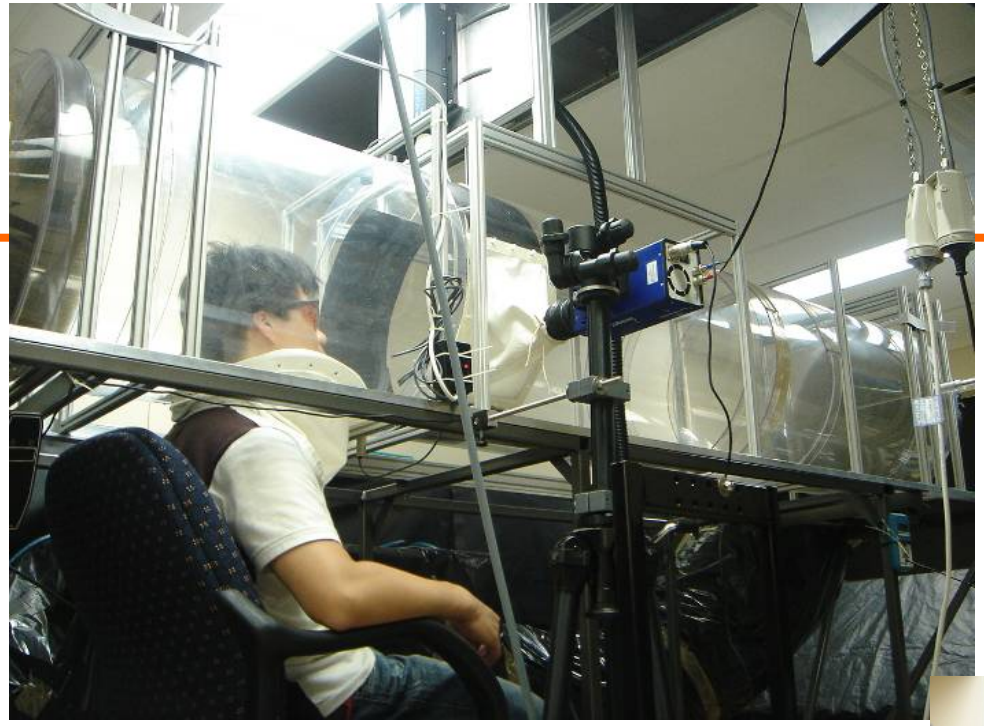


Glass slides

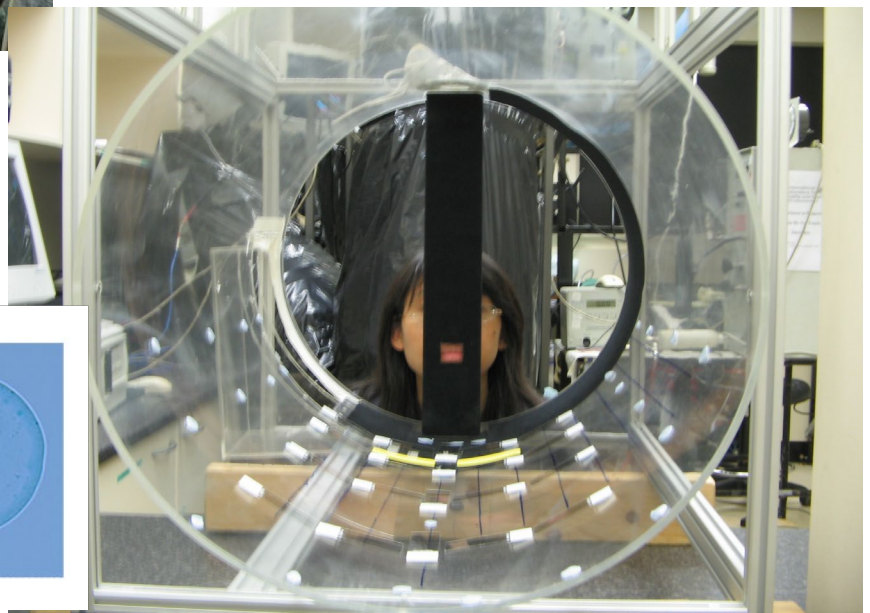
20 - 2000 µm

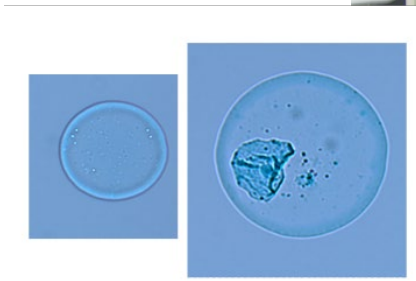
Johnson & Morawska 2009; Morawska et al 2009

APS and IMI measurements

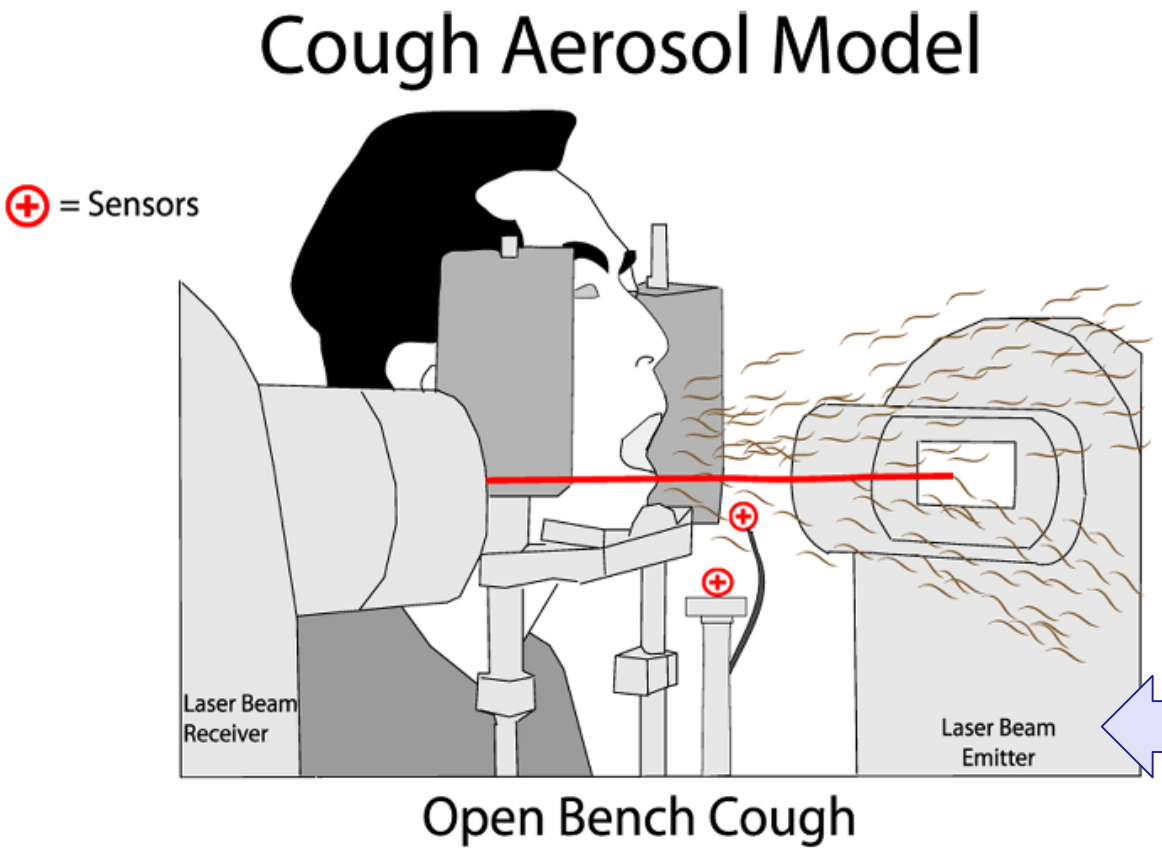


DDA measurements





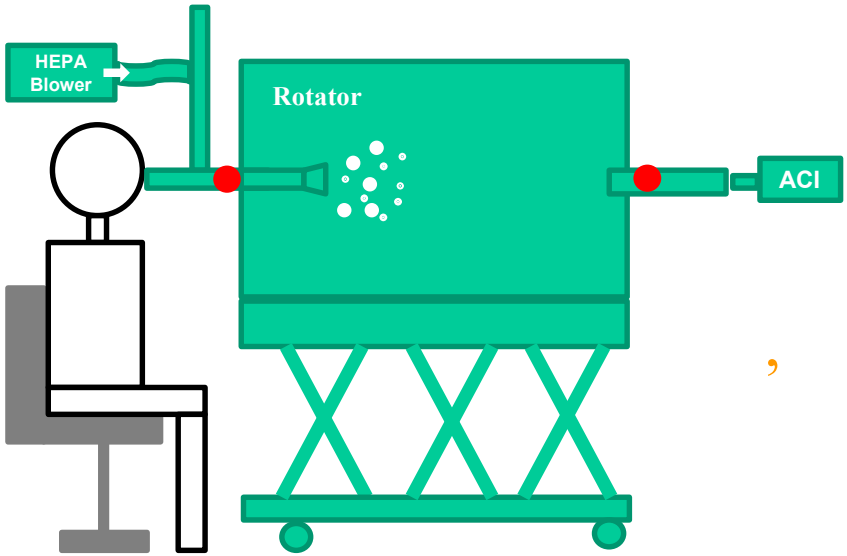
Study designs: 2

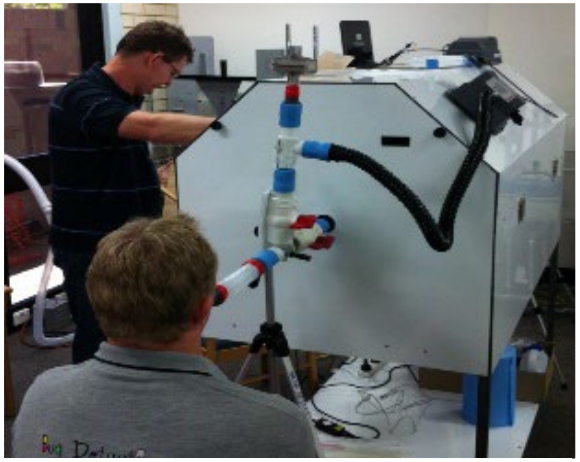


Laser and sensor arrangements for Cough Aerosol direction using a laser diffraction system (Spraytec, Malvern, UK)

Zayas et al., 2012. Cough aerosol in healthy participants: fundamental knowledge to optimize droplet-spread infectious respiratory disease management. BMC pulmonary medicine, 12(1), pp.1-12.

Study designs: 3





Johnson et al. 2016. A novel method and its application to measuring pathogen decay in bioaerosols from patients with respiratory disease; *PloS One*

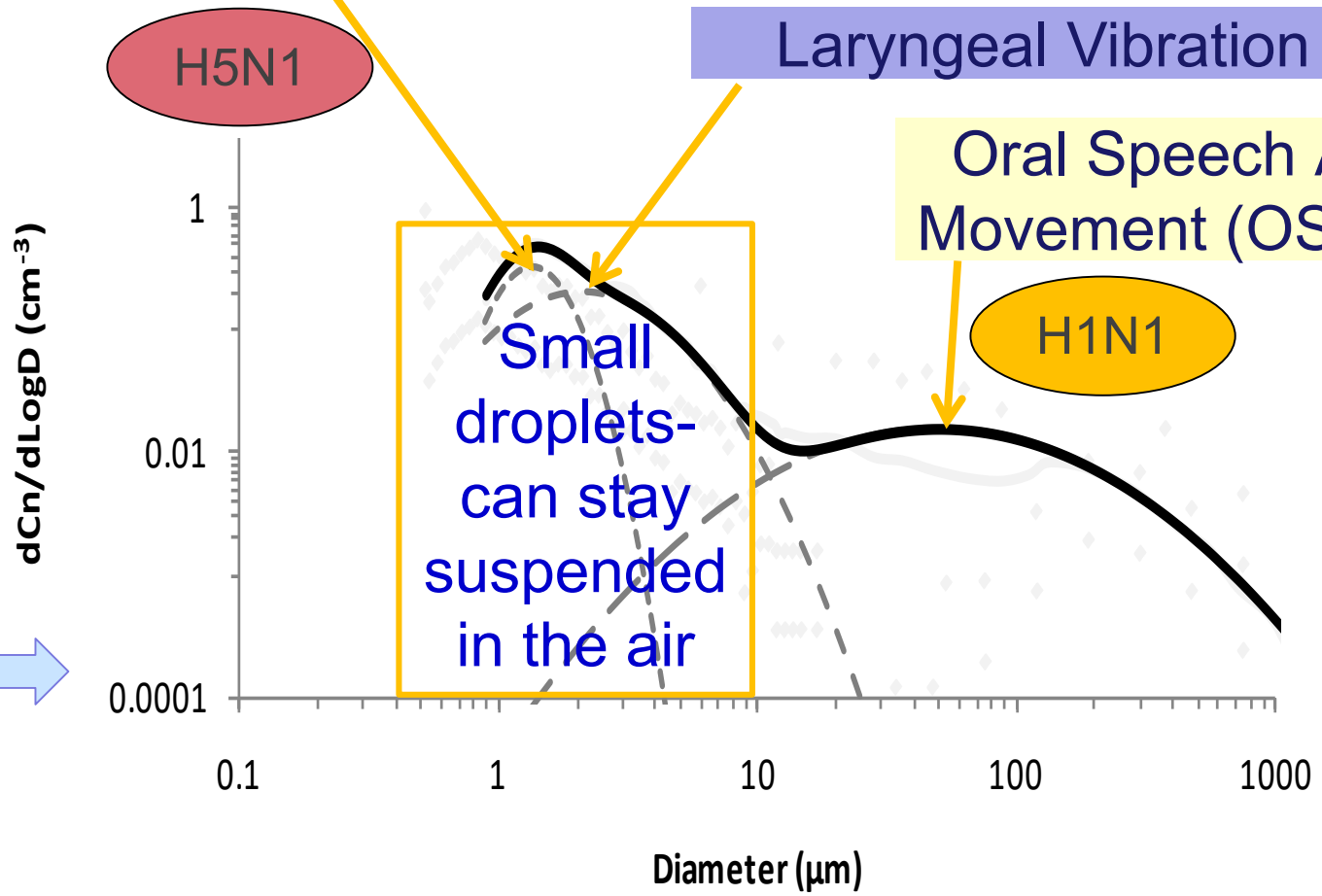
SIZE DISTRIBUTIONS

Number size distribution: speech

Bronchial Fluid Film Burst Mode (BFFB)

Laryngeal Vibration (LV) Mode

Oral Speech Articulation Movement (OSAM) Mode



Note: the scale

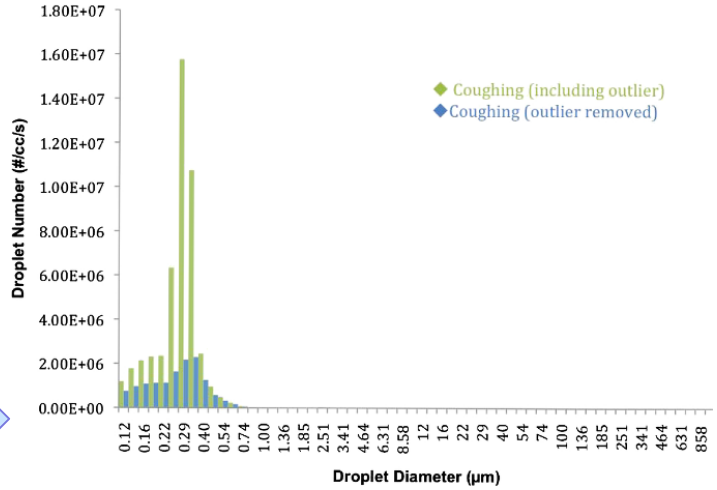
Morawska et al., 2009. Size distribution and sites of origin of droplets expelled during expiratory activities. *Journal of Aerosol Science*, 40: 256-269, 2009.

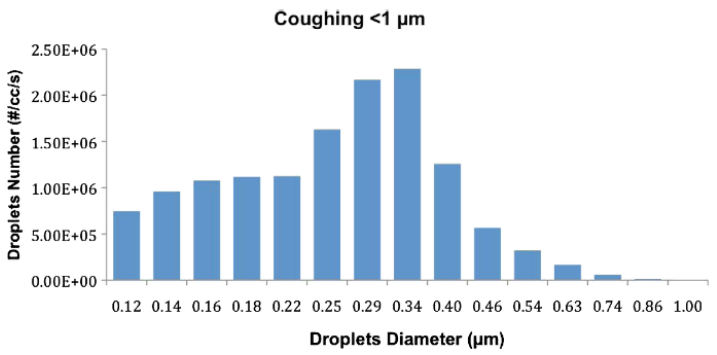
Number size distribution: cough

Full spectrum characterization of cough aerosol number versus droplets diameter per second

Quantities of measured droplets in size category < 1 µm per second

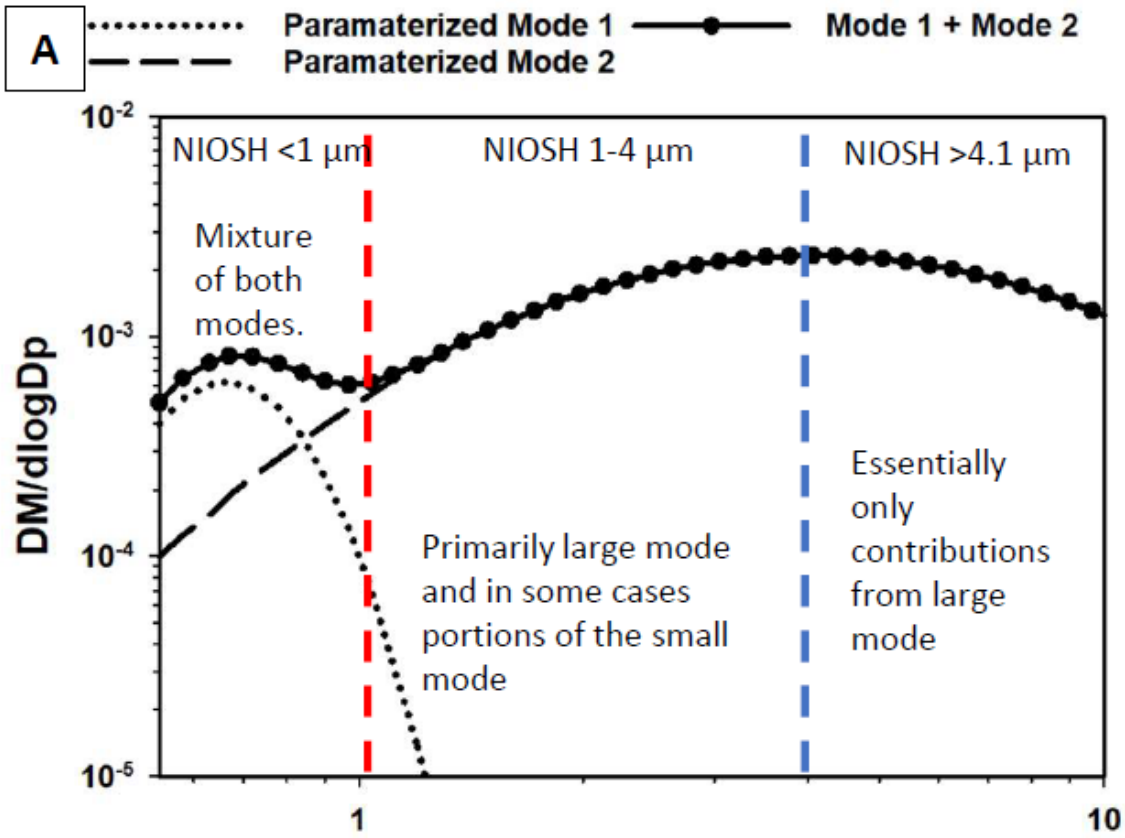
Note: the scale





Zayas et al., 2012. Cough aerosol in healthy participants: fundamental knowledge to optimize droplet-spread infectious respiratory disease management. *BMC Pulmonary Medicine,* 12(1), pp.1-12.

Mass size distributions - mixed acuity COVID-19 rooms



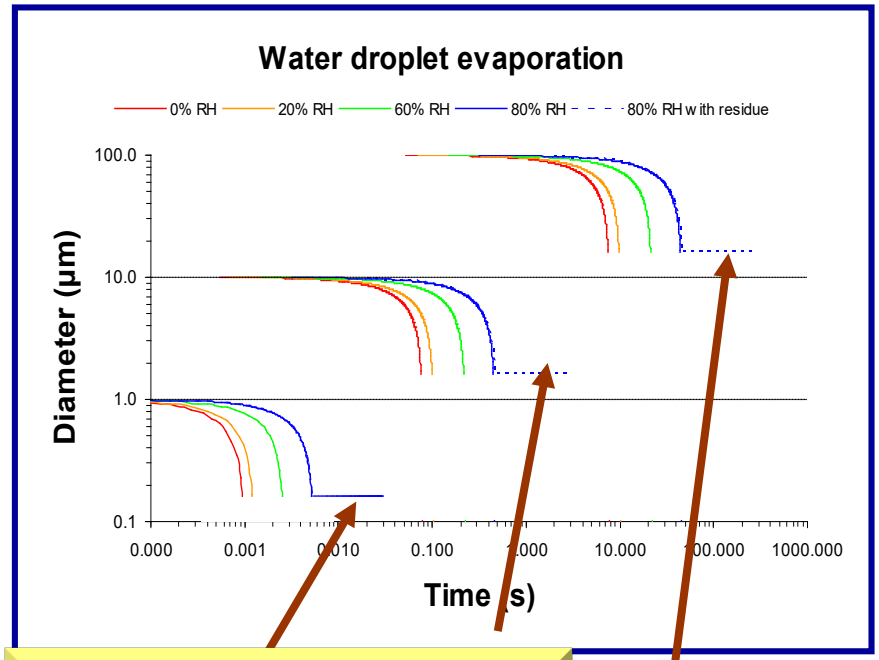
Aerosol size distribution:
Aerodynamic Particle Sizer (TSI APS 3321)
0.542- 20 µm, 52 size bins

Sample collection for virology testing:
NIOSH BC251 sampler
3 stages, cut-off sizes - the red and blue lines

Santarpia et al., 2020. The Infectious Nature of Patient-Generated SARS-CoV-2 Aerosol. *medRxiv*

Droplets versus droplet nuclei

Respiratory liquids are water based



Evaporate very fast!

Droplet nuclei (of 0.86% NaCl solutions)

Composition of respiratory droplets:

- Water
- Salts
- Mucus
- Pathogens

Evaporate very fast!

The process more complex than for salt solution

Evaporation to ~ 30 to 50% of the initial size (Nicas et al., 2005)

Nicas et al., 2005. Toward understanding the risk of secondary

Morawska, L. 2006. Droplet Fate in Indoor Environments, Or C

We Prevent the Spread of Infe

respirable pathogens. *Journal*

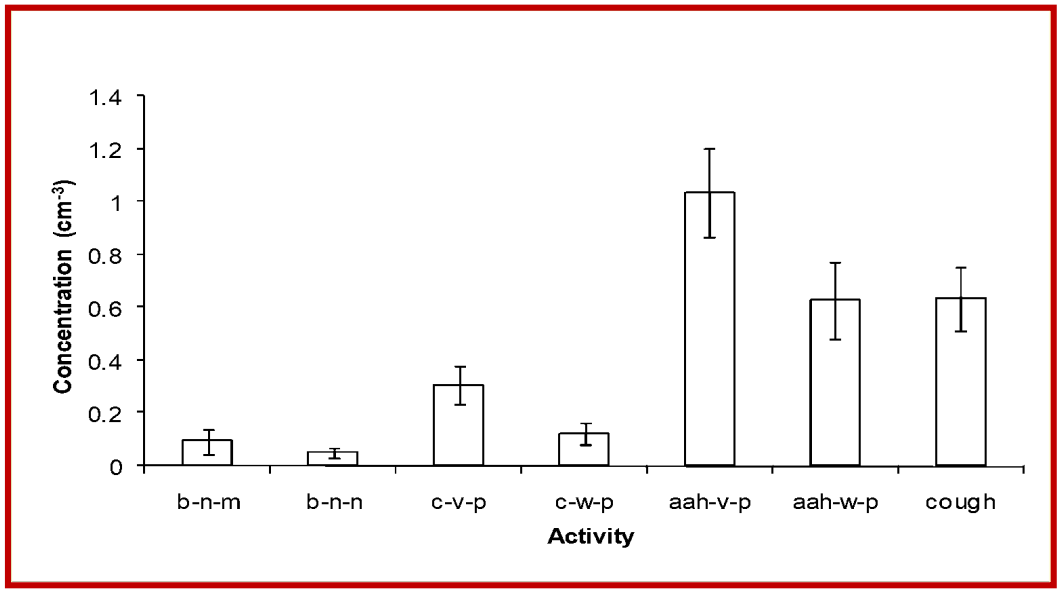
pp.143-

What we measure is usually already droplet nuclei

EMISION RATES

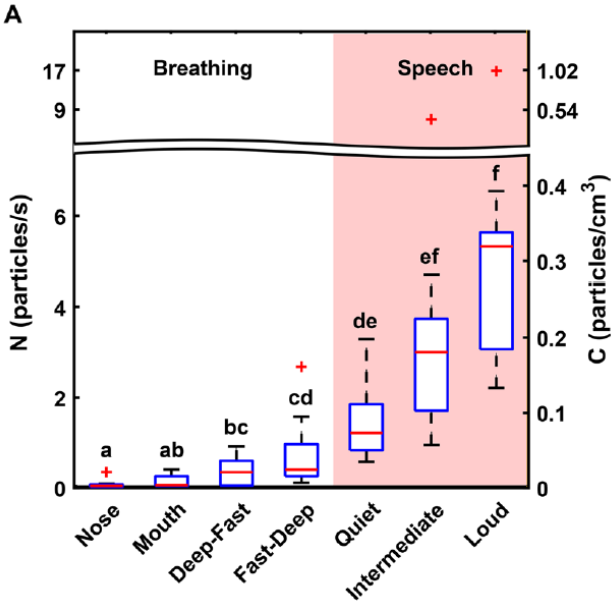
Concertation of particles - respiratory activities

b – breathing
n- nose
m – mouth
c- counting
v- voice
w- whisper

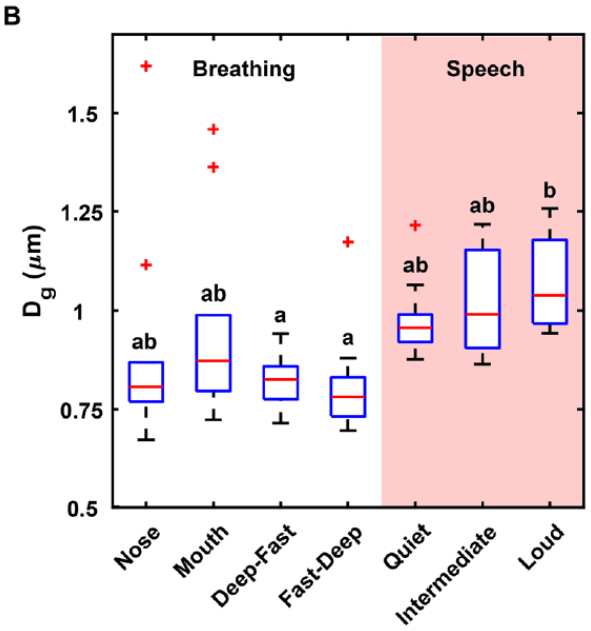


Morawska et al 2009. Size distribution and sites of origin of droplets expelled during expiratory activities. *Journal of Aerosol Science*, 40: 256-269.

Concentrations/emission rates: breathing and speech



Emission rate/concentration

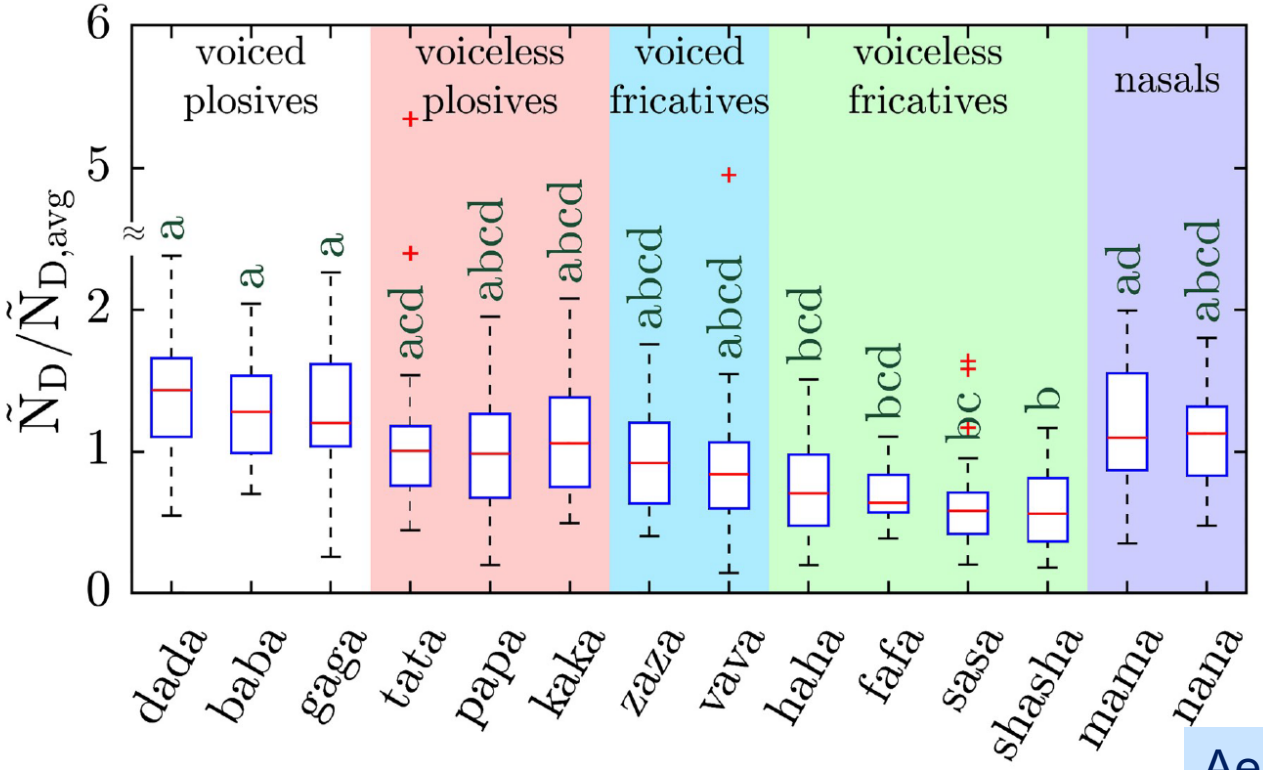


Geometric mean diameters

Particle size distribution: TSI APS 3321
0.542- 20 μm, 52 size bins

Asadi et al., 2019. Aerosol emission and superemission during human speech increase with voice loudness. *Scientific Reports,* 20;9(1):1-0

Emission rate of disyllabic words



Aerosol size distribution:
(TSI APS 3321)
0.542- 20 µm, 52 size bins

Asadi et al., 2020. Effect of voicing and articulation manner on aerosol particle emission during human speech. *PloS One,* 15(1), p.e0227699

Summary: knowns and unknowns

Thank you!