AIRBORNE TRANSMISSION OF SARS-CoV-2
A VIRTUAL WORKSHOP OF THE ENVIRONMENTAL HEALTH MATTERS INITIATIVE
AUGUST 26-27, 2020

Thursday, August 27

10:00 **Welcome Back and Recap**

10:10 CQ3: **What factors determine personal exposure to infectious particles?**
Session Chair: *John Volckens, Colorado State University*

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UNIVERSITY OF LEICESTER Citizens of Change

Speakers (15 minutes each)
Yuguo Li, *University of Hong Kong*
Shelly Miller, *University of Colorado, Boulder*
Julian Tang, Honorary Associate Professor, University of Leicester, Leicester, UK

There is much we don't know about the transmission of SARS-CoV-2, the virus that causes COVID-19. We know it can spread from an infected person's sneeze or cough. But what do we know about transmission via speech and exhaled breath? How long do infectious particles linger in the air? How far can they travel? This workshop will delve into the rapidly evolving science on the spread of the virus, as part of a larger body of COVID-19 related work at the National Academies, including the *Rapid Expert Consultation on the Possibility of Bioaerosol Spread of SARS-CoV-2 for the COVID-19 Pandemic* (April 1, 2020). This event will serve as a forum for interdisciplinary discussion, explanations of the basic foundational science, and clarification of terminology used differently among the relevant fields, all of which will be useful to those looking to understand the state of the science on SARS-CoV-2. We will feature experts in aerosol science, virology, infectious disease, and epidemiology

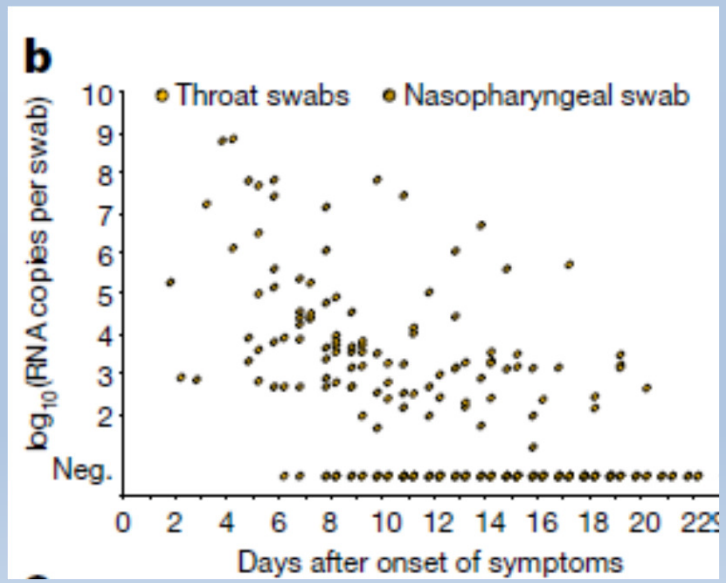
Respiratory Viruses (AusDiagnostics, 16-WELL (Ref 20602))
Influenza A
Influenza B
Influenza A typing H1/H3
Parainfluenza 1, 2, 3 & 4
Respiratory Syncytial Virus A & B
Adenovirus groups B, C, E, some A, D
Rhinovirus & Enterovirus
Enterovirus
Metapneumovirus
Coronavirus 229E, HKU-1, NL63 & OC43
Bocavirus

http://www.ausdiagnostics.com/uploads/6/9/8/2/69822307/9150r05_easy-plex_384_system__high-plex__ifu_160803.pdf

https://phil.cdc.gov/Details.aspx?pid=10188

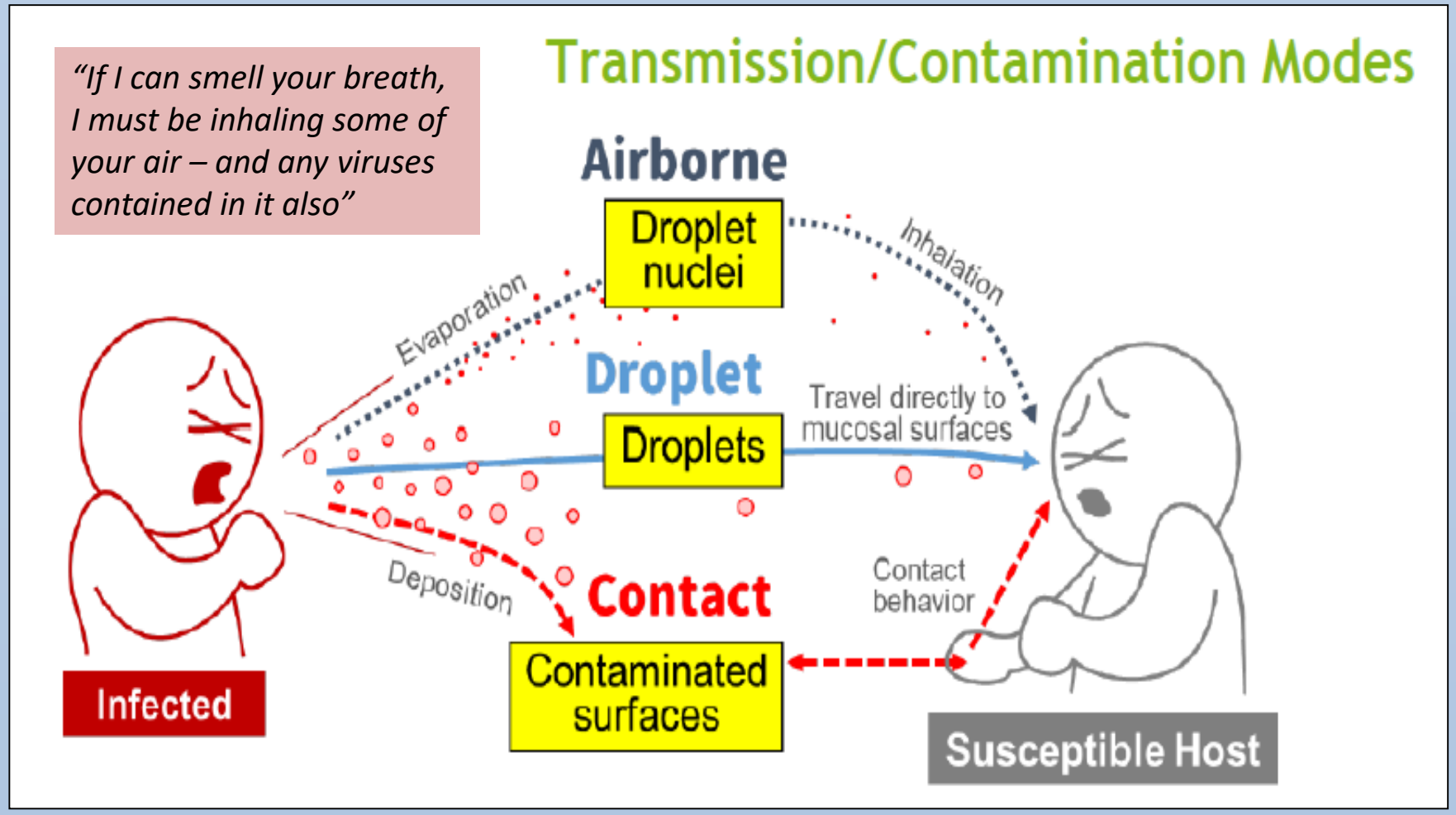
Diagnostic nose/ throat swabs can detect all these respiratory viruses – exhalation activities will naturally aerosolise these viruses from the oral cavity –

Typical viral loads have been reported as 10^2-10^9 cop/swab



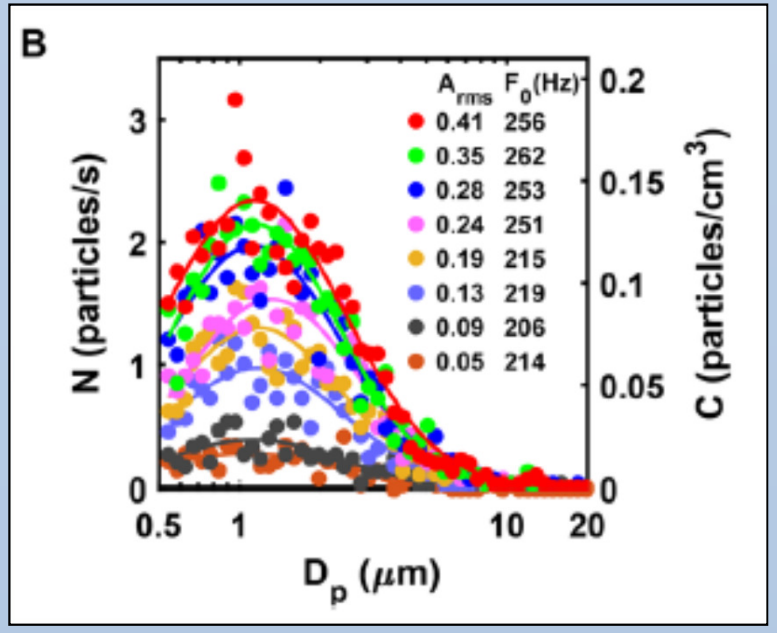
https://www.nature.com/articles/s41586-020-2196-x.pdf

"If I can smell your breath, I must be inhaling some of your air – and any viruses contained in it also"

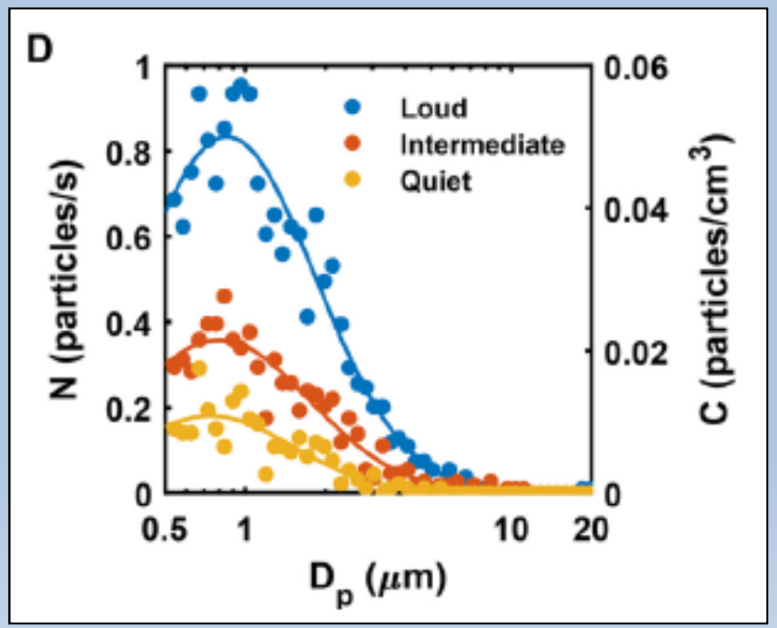


There is a continuum of droplet sizes moving from larger to smaller droplets in aerosols that are airborne – viruses (and other pathogens) can be carried in all of them and be transmitted via breathing, talking, laughing, coughing, sneezing, etc.

https://www.rehva.eu/fileadmin/user_upload/2020.04.28_COVID-19_BuildUp_webinar_by_REHVA.pdf

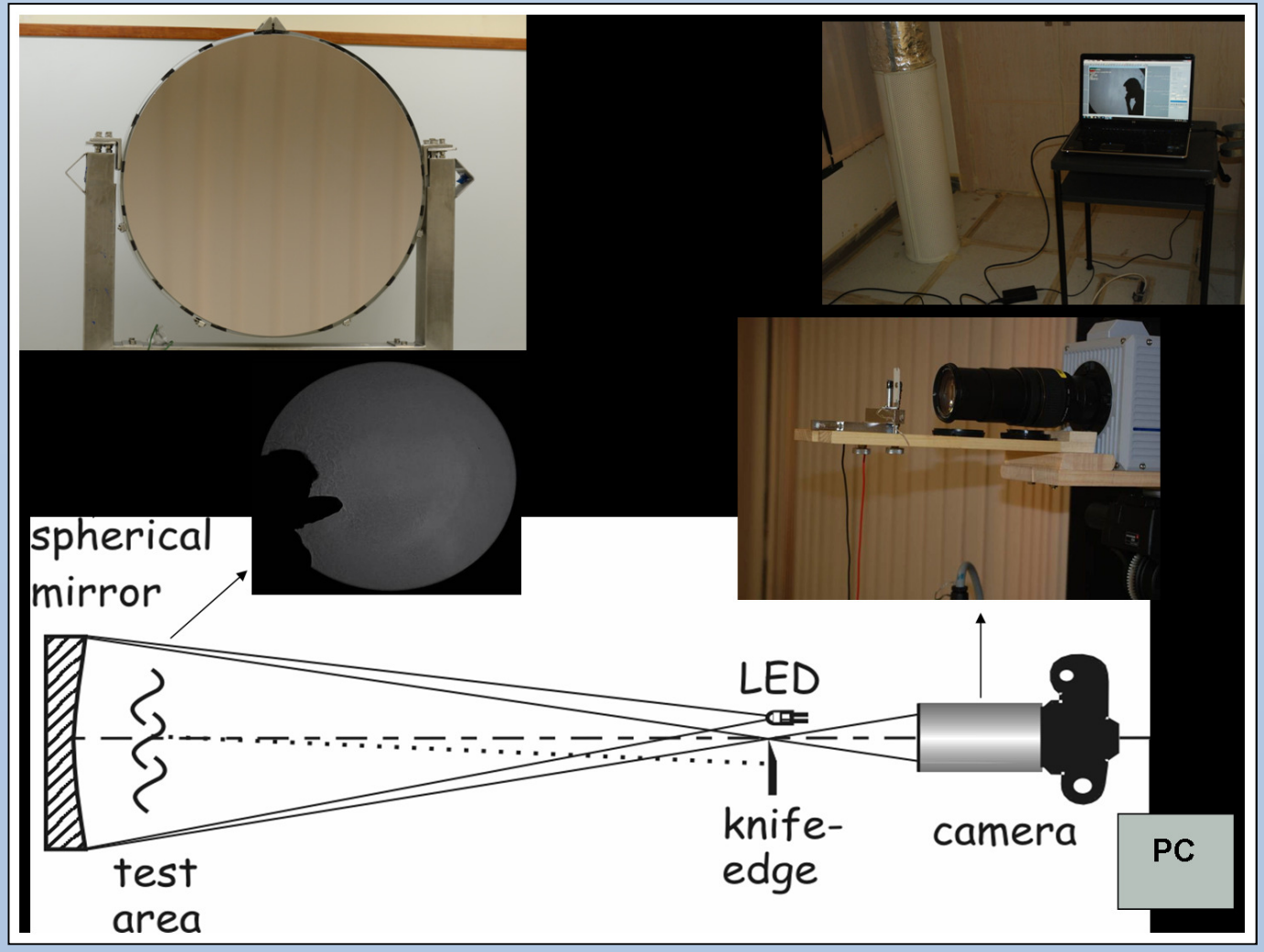


Droplet size distribution (mostly <10 µm diameter) when saying a single syllable (as in 'saw') at 8 different and increasing amplitudes (6 repeats at each).



Droplet size distribution (mostly <10 µm diameter) when reading the Rainbow passage at 3 different and increasing amplitudes – representative plot from a single individual.

https://www.nature.com/articles/s41598-019-38808-z



Visualisation of exhaled airflows in real-time from human volunteers using schlieren/shadowgraph mirror-camera set-up
– across a 1 m distance (= mirror diameter)

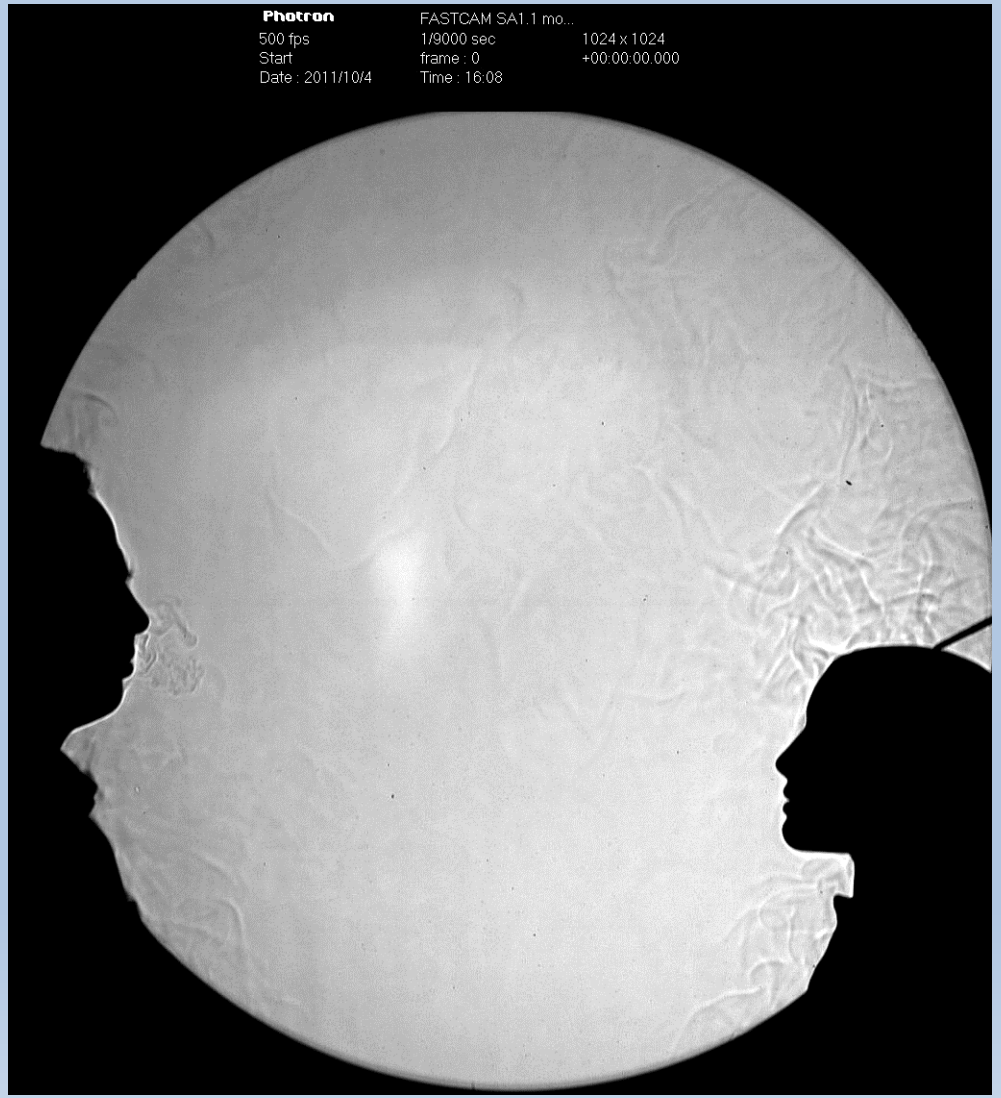
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0034818

Talking – exhalation flows – and garlic breath…

https://www.youtube.com/watch?v=OsBGaWdHHyg

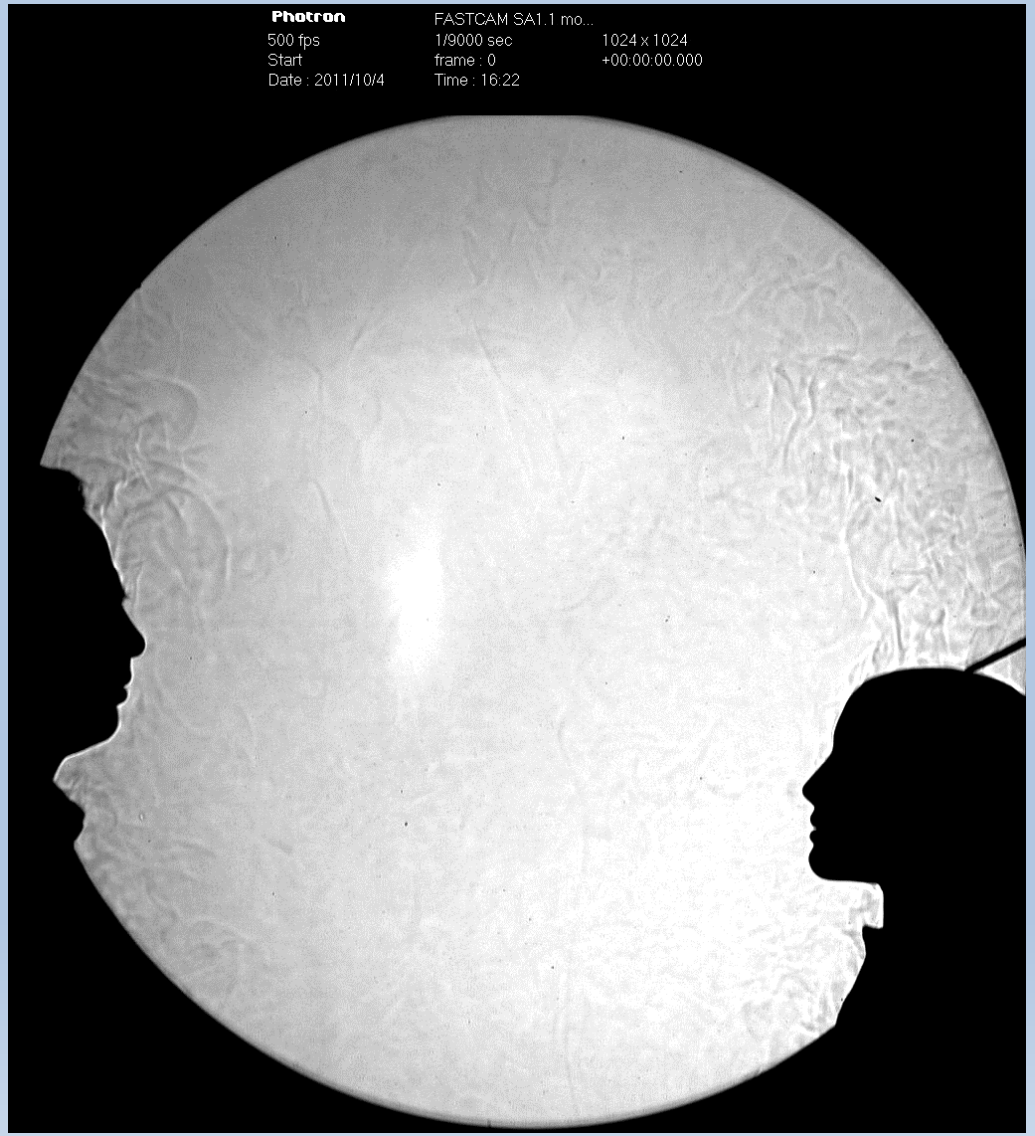
Nose breathing – exhalation flows – during conversation…

https://www.youtube.com/watch?v=g9oQzqTPnu8



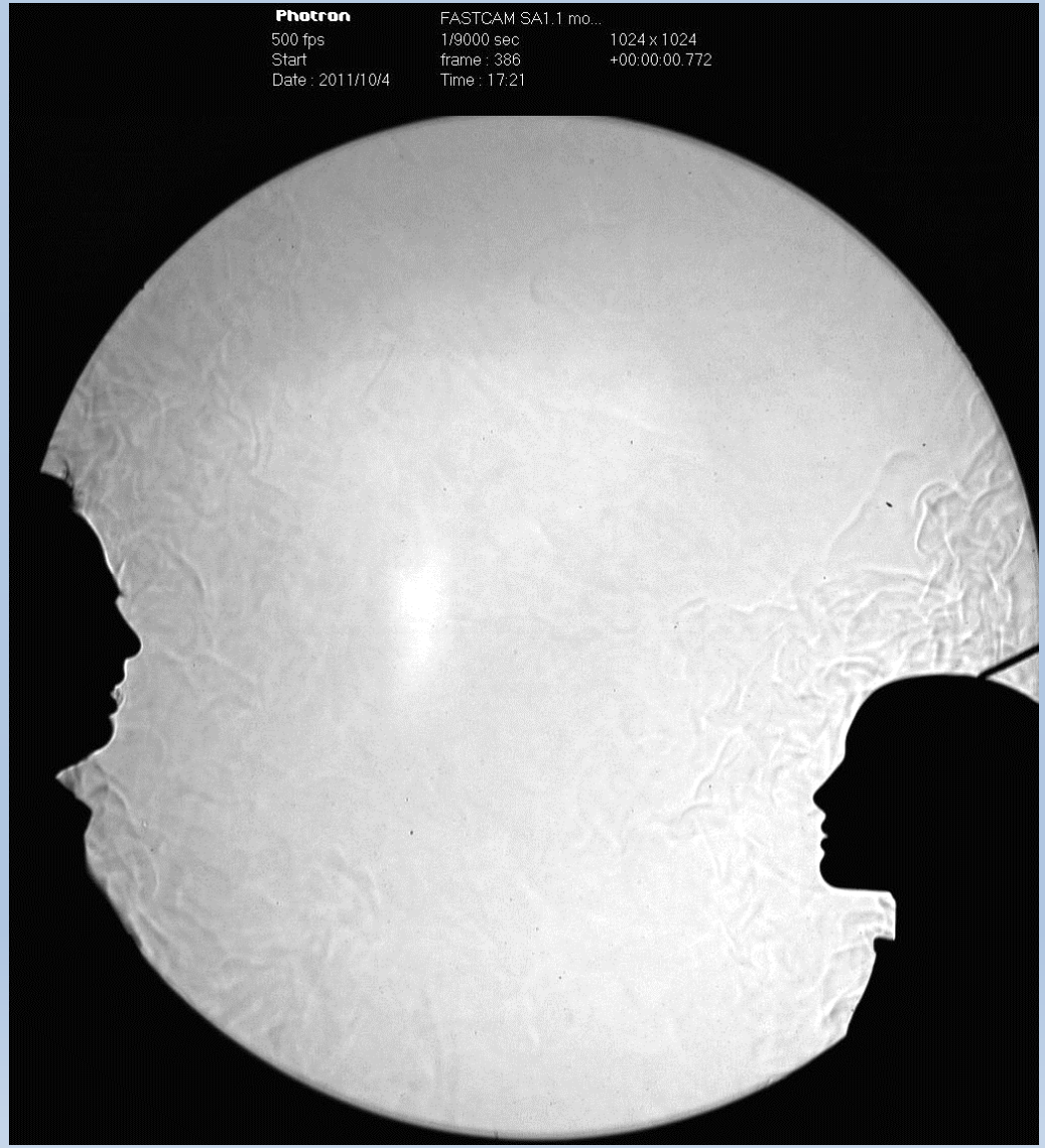
Mouth breathing – exhalation flows – during conversation…

https://www.youtube.com/watch?v=IHUMdhBGt1c



Laughing – exhalation flows – the joke may be on you…

https://www.youtube.com/watch?v=Eue9f73SB6E

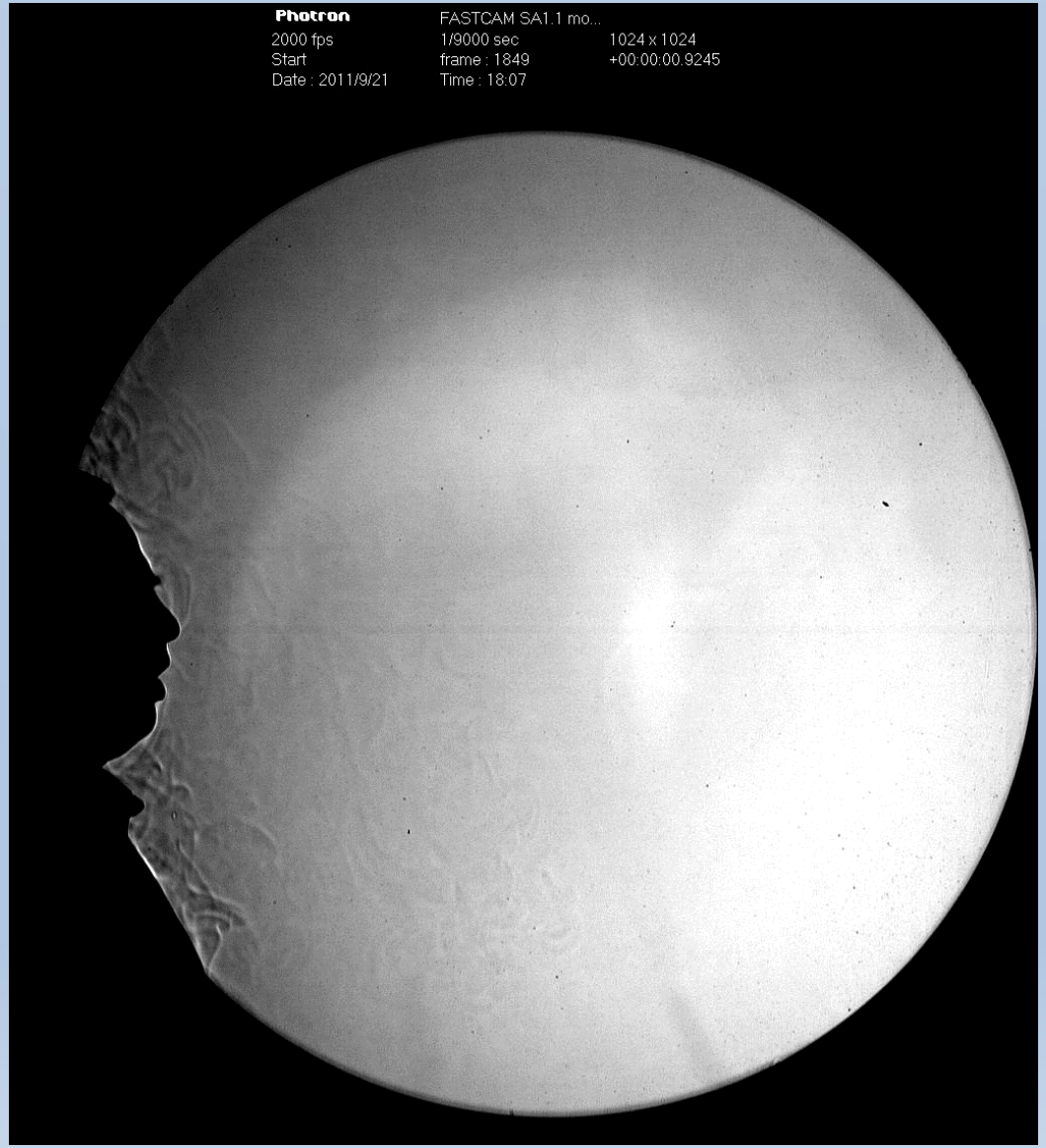


Singing (Happy Birthday) – possibly enhanced exhalation flows…

https://www.youtube.com/watch?v=suN_GAE03fk

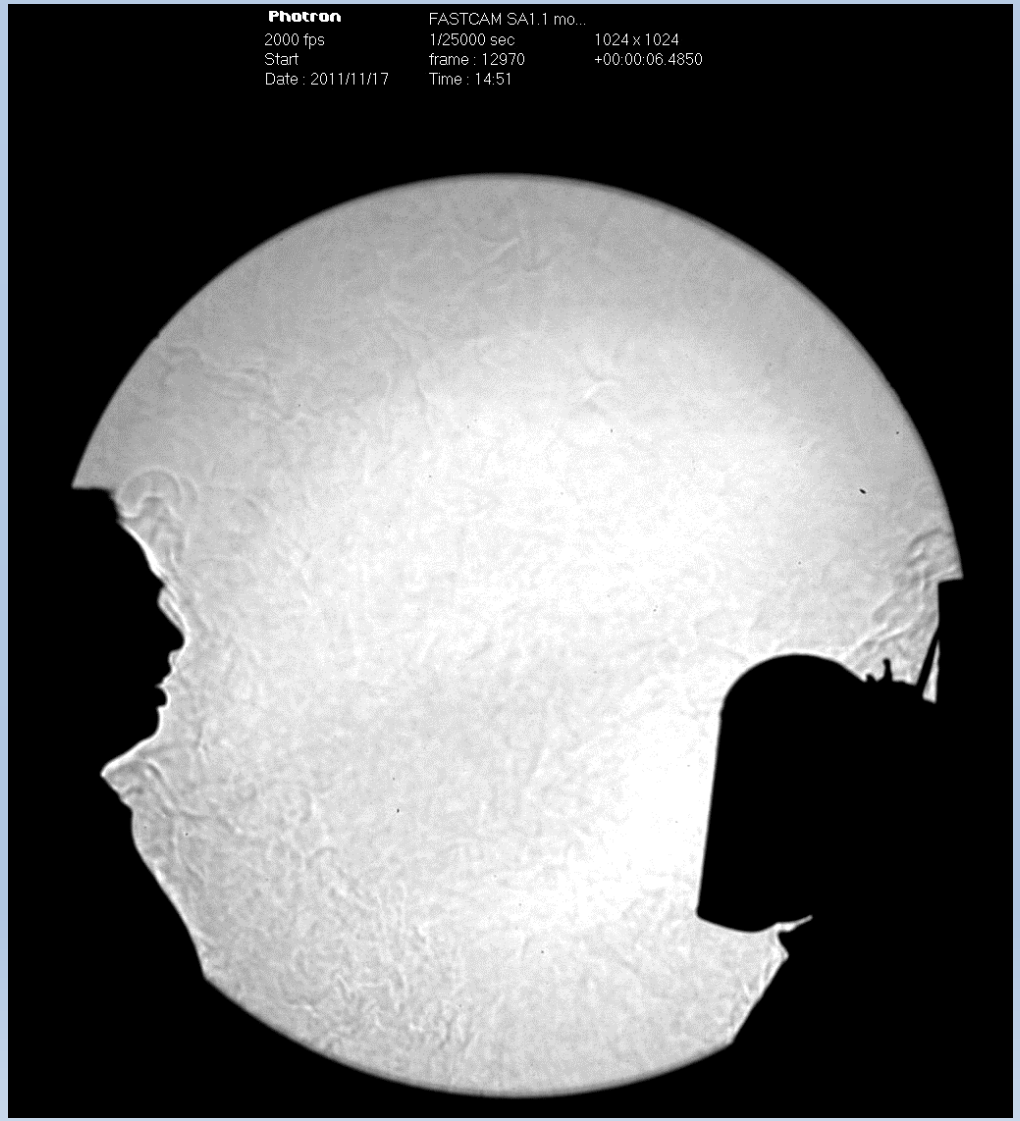
Coughing – enhanced exhalation flows…

https://www.youtube.com/watch?v=KOkE4jjsXWY

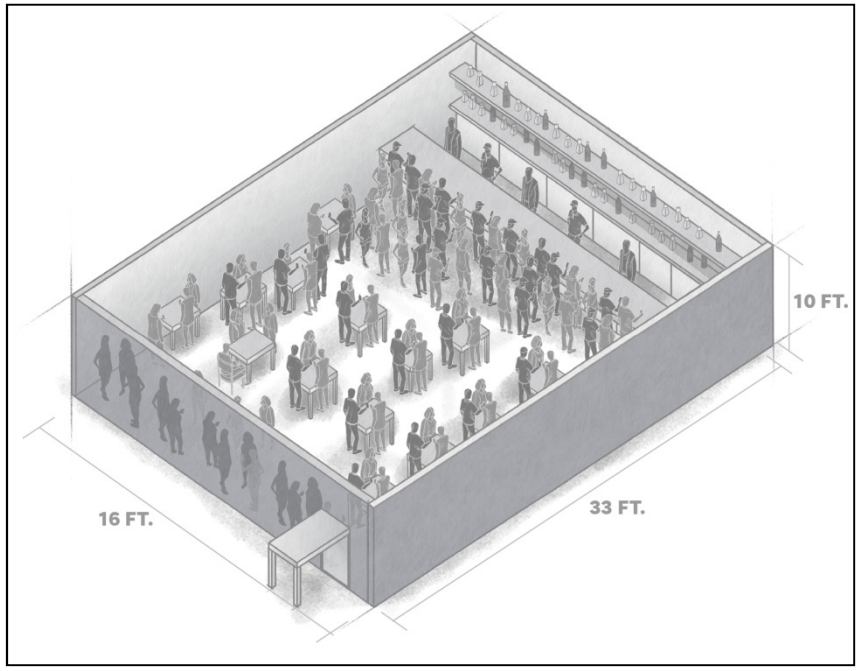


Sneezing – enhanced exhalation flows…

https://www.youtube.com/watch?v=ZDiLsu8hipI



Long-range aerosol transmission – not determined by droplet size – but by circumstance:

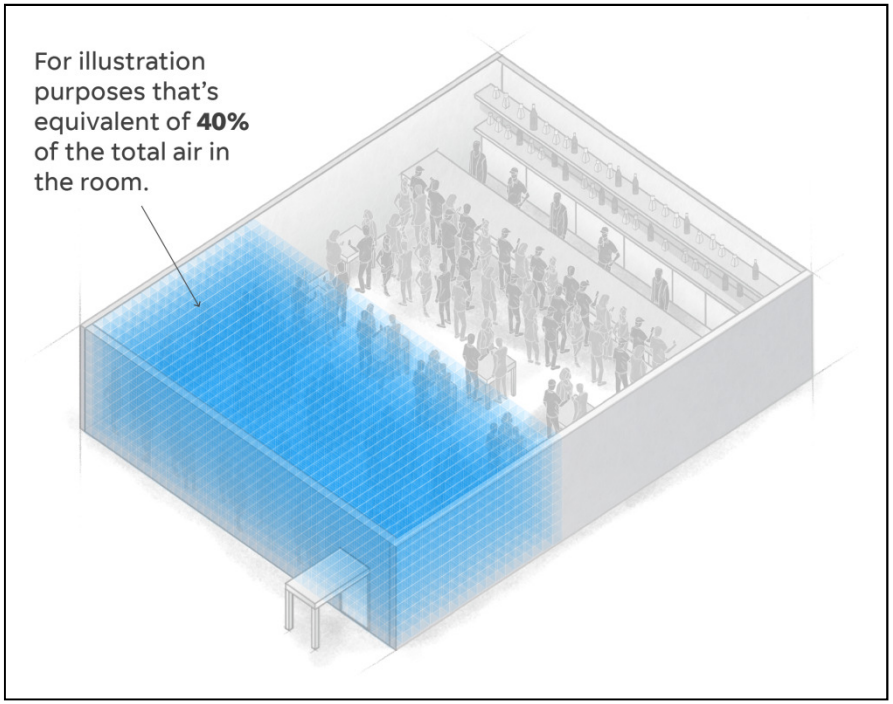


In crowded, indoor, poorly ventilated areas like bars, cinemas, pubs, restaurants – with perhaps 10-20% of people being unknowingly infected

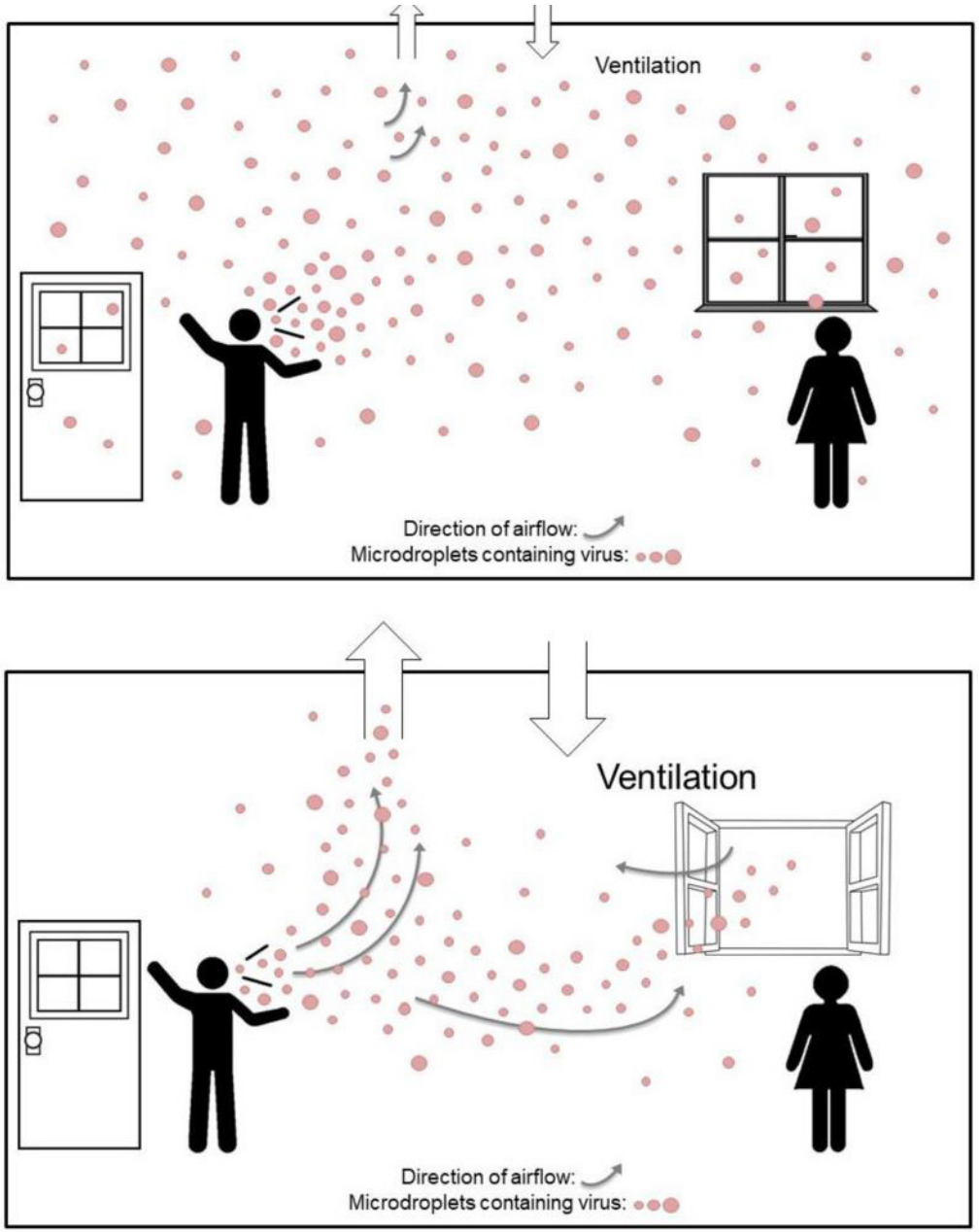
- the virus can spread via talking and breathing (over short-distances) to those immediately nearby, and also into the air around them.

Breathing exhales ~10 L/min ~ 600 L/hr into the surrounding air - increasing the airborne concentration over time.

Any airborne virus can then be carried over greater distances to other people further away (long-range aerosols) – which is why ventilation is important.



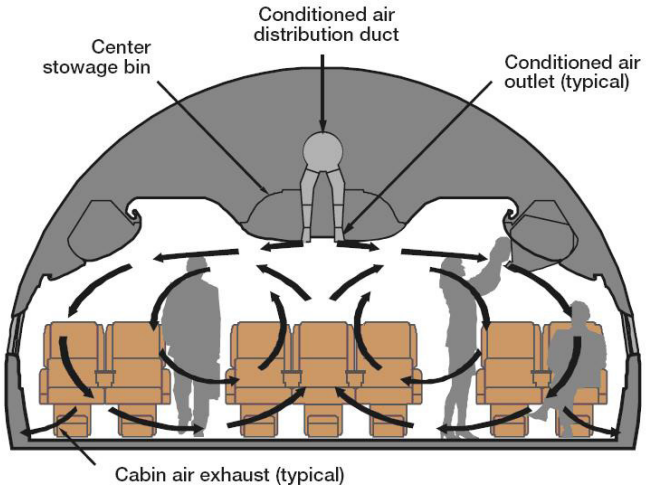
https://amp.usatoday.com/in-depth/graphics/2020/07/16/why-bars-hotspots-covid-19-transmission/5389988002/ (with permission from Ramon Padilla, reporter)



Enhanced ventilation acts to dilute and remove any airborne virus using fresh air/ filtered-recirculated air – to reduce the airborne concentration and therefore the exposure/ transmission risk

Figure 1. Distribution of respiratory microdroplets in an indoor environment with (a) inadequate ventilation and (b) adequate ventilation.

https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciaa939/5867798

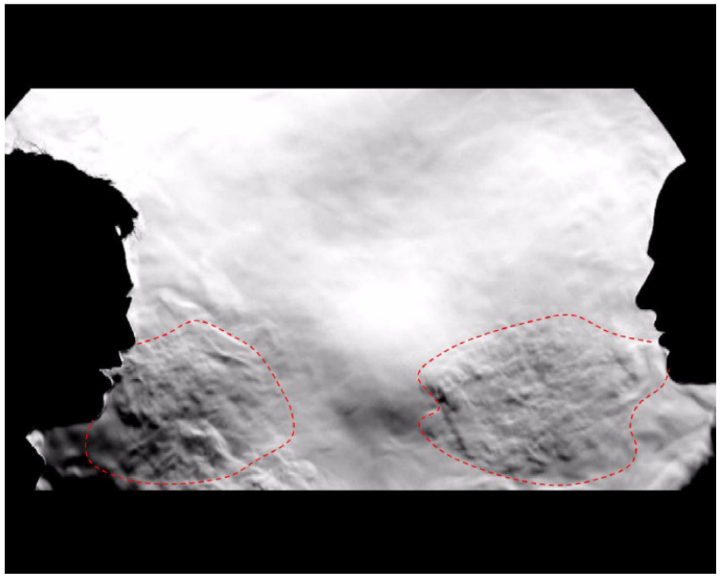


https://aviation.stackexchange.com/questions/26105/where-does-the-air-enter-the-passenger-cabin

Plane ventilation systems will not prevent short-range aerosol transmission during conversational situations with nearest neighbors

– but will reduce the build-up of airborne virus in the passenger cabin to reduce/prevent longer-range airborne transmission

– so masking on planes is important still

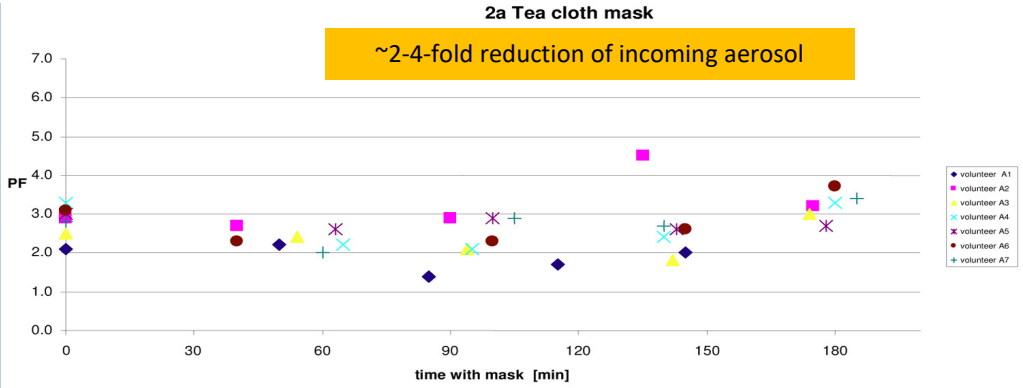


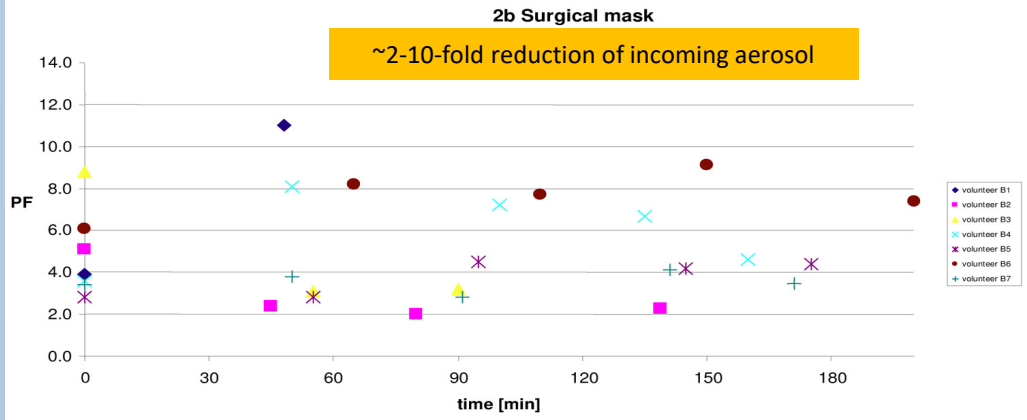
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0021392

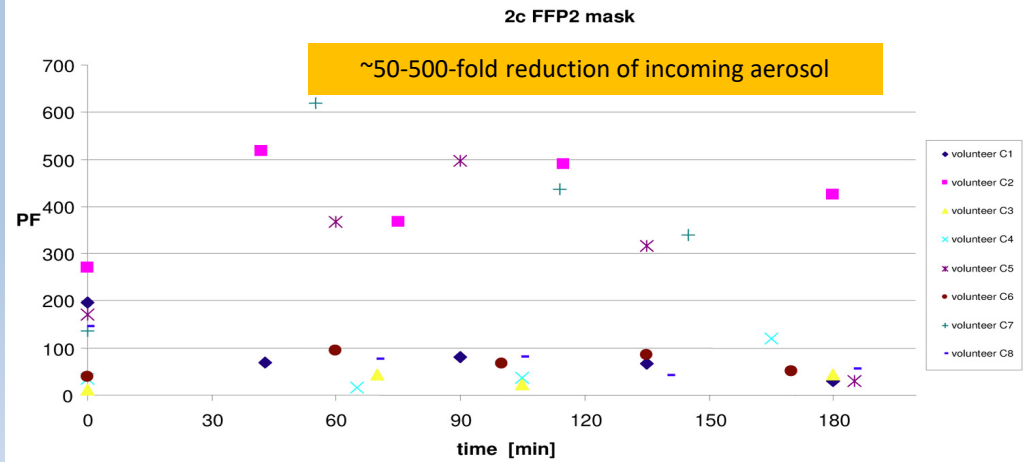
https://www.techbyn.com/researchers-conduct-a-reassuring-study-on-coronavirus-transmission-risks-involved-on-planes/

<u>Home-made cloth masks</u> (made out of ?1-layer tea cloth in this study) can reduce the exposure from incoming aerosols (produced by lighted candles) by up to 2-4-fold (i.e. ~50-75%) though this will depend on how the mask is made, what it is made from, and the nature of the aerosols to which it is exposed. (2008)

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0002618







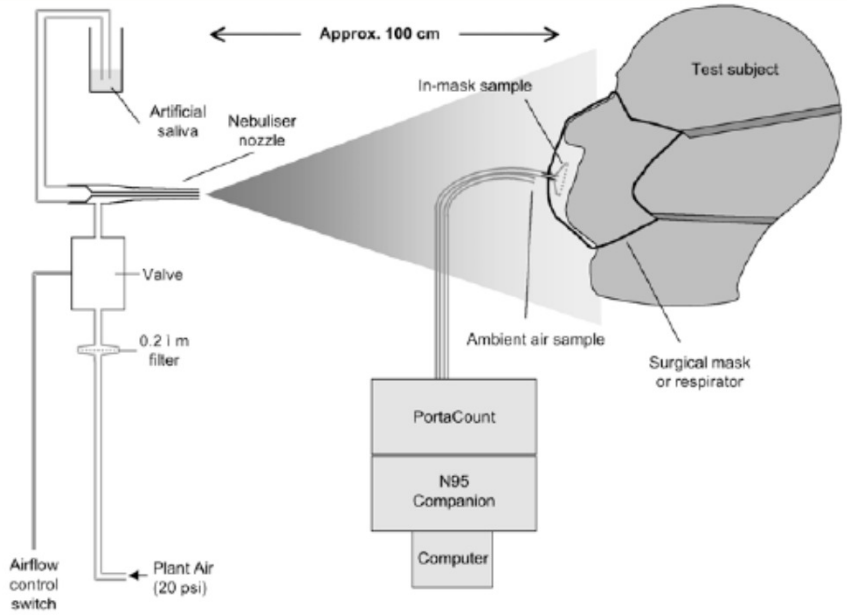


Figure 2.1. Schematic diagram of the inert aerosol test arrangement

HSE

Health and Safety Executive

Evaluating the protection afforded by surgical masks against influenza bioaerosols

Gross protection of surgical masks compared to filtering facepiece respirators

Prepared by the **Health and Safety Laboratory** for the Health and Safety Executive 2008

<u>Surgical masks</u> can also protect the wearer to some degree by reducing the exposure to incoming droplets and aerosols by up to 6-fold (i.e. ~83%), from others who are ill. (2008)

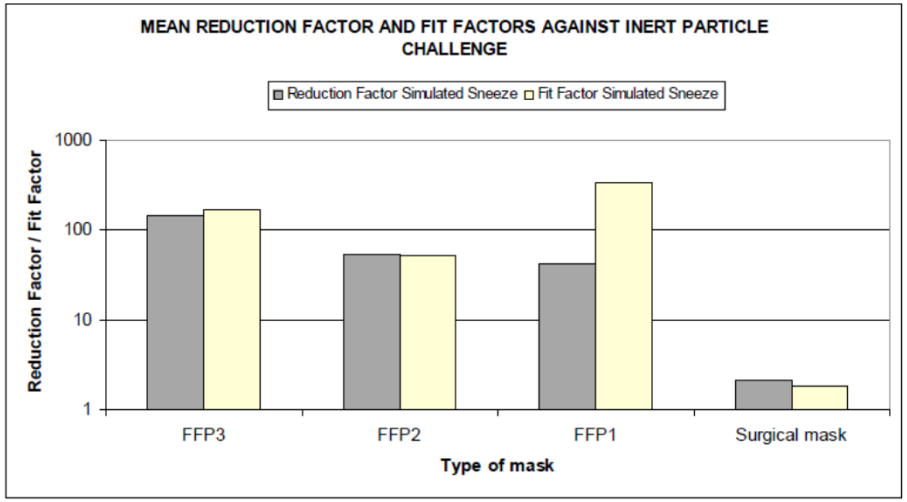
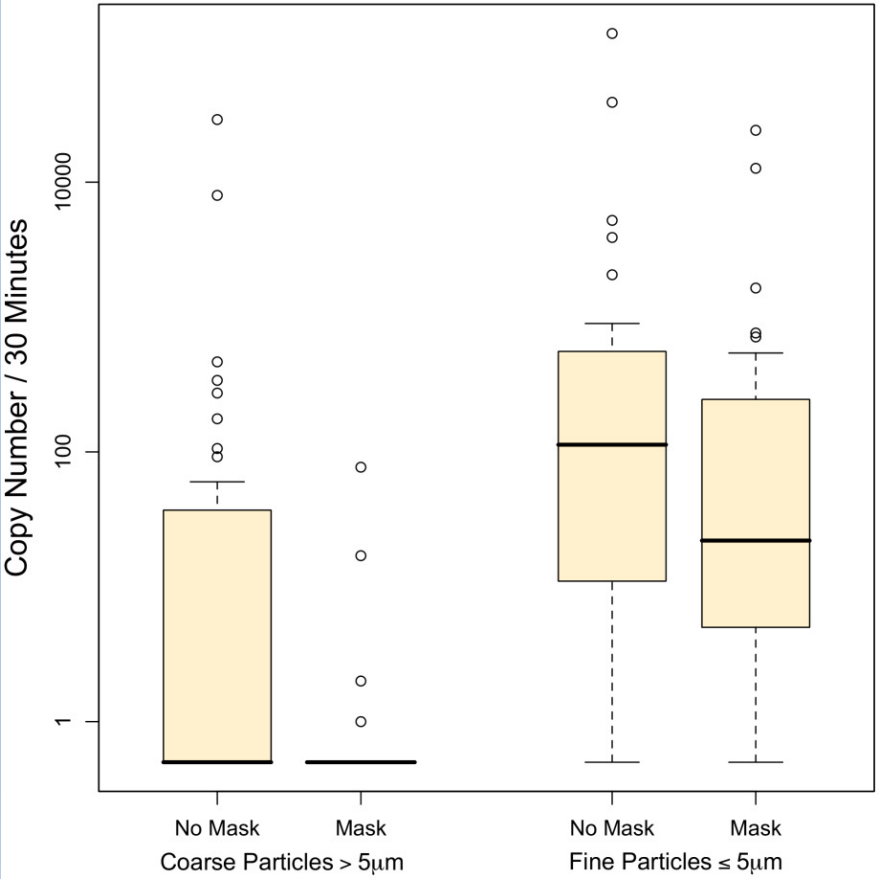


Figure 3.6 Mean values of the reduction factors and fit factor results for the grouped range of filtering facepieces and surgical masks tested against the inert simulated sneeze

https://www.hse.gov.uk/research/rrpdf/rr619.pdf

Surgical masks can contain and therefore reduce the dissemination of droplets and aerosols produced by a sick wearer by up to 3-4-fold (i.e. ~67-75%) to protect others. (2013)



https://journals.plos.org/plospathogens/article?id=10.1371/journal.ppat.1003205

https://sph.umd.edu/news-item/flu-may-be-spread-just-breathing-new-study-shows-coughing-and-sneezing-not-required

Problems with RCTs to demonstrate mask effectiveness

RESEARCH ARTICLE

Minimal transmission in an influenza A (H3N2) human challenge-transmission model within a controlled exposure environment

Jonathan S. Nguyen-Van-Tam[1], Ben Killingley[1¤a]*, Joanne Enstone[1], Michael Hewitt[1], Jovan Pantelic[2¤b], Michael L. Grantham[2¤c], P. Jacob Bueno de Mesquita[2], Robert Lambkin-Williams[3], Anthony Gilbert[3], Alexander Mann[3], John Forni[3¤d], Catherine J. Noakes[4], Min Z. Levine[5], LaShondra Berman[5], Stephen Lindstrom[5], Simon Cauchemez[6¤e], Werner Bischoff[7], Raymond Tellier[8], Donald K. Milton[2], for the EMIT Consortium[¶]

Failure to show any expected difference: they don't work for various reasons…lab-strain of virus, excessive ventilation, etc.

BMJ Open

A cluster randomised trial of cloth masks compared with medical masks in healthcare workers

C Raina MacIntyre,[1] Holly Seale,[1] Tham Chi Dung,[2] Nguyen Tran Hien,[2] Phan Thi Nga,[2] Abrar Ahmad Chughtai,[1] Bayzidur Rahman,[1] Dominic E Dwyer,[3] Quanyi Wang[4]

Over-interpretation: the control was not appropriate to make the statement "not to use cloth masks at all because they offer no protection" – control included routine mask use

A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers

Chandini Raina MacIntyre,[a] Quanyi Wang,[b] Simon Cauchemez,[c] Holly Seale,[a] Dominic E. Dwyer,[d] Peng Yang,[b] Weixian Shi,[b] Zhanhai Gao,[a] Xinghuo Pang,[b] Yi Zhang,[b] Xiaoli Wang,[b] Wei Duan,[b] Bayzidur Rahman,[a] Neil Ferguson[c]

Under-powered: the seasonal influenza attack rate was too low (and this is unpredictable) to definitively show the superiority one mask over the other.

Most importantly – RCTs themselves do not reflect real-life – participant recruitment is selective – even as they argue that laboratory experiments do not reflect reality….

Nor do they cover all types of patients/scenarios that may encountered in everyday practice…

For masks, MacIntyre et al. – in a followup to their 2015 RCT on cloth masks recently added this comment for COVID-19:

"Health workers are asking us if they should wear no mask at all if cloth masks are the only option. Our research does not condone health workers working unprotected. We recommend that health workers should not work during the COVID-19 pandemic without respiratory protection as a matter of work health and safety. ….. Some health workers may still choose to work in inadequate PPE. In this case, the physical barrier provided by a cloth mask may afford some protection, but likely much less than a surgical mask or a respirator."

https://bmjopen.bmj.com/content/5/4/e006577.responses#covid-19-shortages-of-masks-and-the-use-of-cloth-masks-as-a-last-resort

So something is better than nothing – right?

RCTs need to be carefully designed and interpreted to allow incremental benefits to be discussed – and possibly applied when the alternative is nothing at all
– their interpretation should not be simply binary, especially when it comes to PPE.