

APS COVID Webinar: December 2, 2020

The modes of transmission of SARS-CoV-2, and how to protect ourselves: What we know now

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- **What do we know about the modes of transmission?**
 - 3 ways:
 - Surfaces – infect by touching surface, then touching eyes, mouth, etc
 - Droplets – ballistic projectiles; infect by impact on eyes, nostrils, mouth
 - Aerosols – float in the air; infect by inhalation
 - Big question = which is most important?
 - Surfaces are not very important – well agreed
 - *Science* article that there is overwhelming evidence that inhalation is a major transmission route
 - *Clinical Infectious Diseases* article says short range aerosol transmission is important
 - This has been surprising
 - CDS knows that aerosols are the main transmission route
 - Only aerosols can be inhaled
 - But they call them small droplets to favor droplet precautions
 - Quite confusing
 - WHO original messaging says that covid-19 is **not** airborne
 - Clear messaging, calls aerosol messaging misinformation
 - WHO latest brief says there could be aerosol transmission, but not really known
 - They say ventilation is very important, but don't say why
 - But only aerosols would care about ventilation! Confusing, conflicting
 - Substantial support for aerosol transmission is dominant and droplet transmission was likely overestimated
 - Easily transmitted in close proximity
 - WHO claims this suggests that it is a droplet transmission – logical error!
 - Alternative explanation is aerosols
 - Breath moves out and then up away from people (why distance helps and ventilation is important)
 - Observation that social distance works alone does not prove droplets or aerosols
 - Is there infection when sharing room air then?
 - If droplets: safe with distance
 - If aerosols: not safe, with low-ventilation, transmission can happen
 - Studies suggest transmission is much less likely in outdoor spaces
 - If droplets: would expect similar transmission indoor vs outdoor
 - If aerosols: virus rises and is removed more quickly outdoor, expect less transmission
 - WHO says COVID is different than accepted airborne diseases (ie measles, TB)
 - Convincing example superspreading event: Skagit choir
 - No one is social outside of rehearsal
 - 2.5 hr rehearsal, minimal socializing

- Infected person only touched bathroom surfaces – can't be surfaces
 - No one 3m in front of the infected person, only talked to 2-3 people in break – can't be droplets
 - Low ventilation, room well mixed, long time, no masks – suggest aerosol trans
- Often not very contagious
 - Many don't transmission to anyone
 - Attack rate in households not very high
 - WHO claims this is evidence for droplets
 - WHO made similar mistakes interpreting measles originally!
 - WHO mental model: constant and high aero emission by all infected (if not consistent with some observations, conclude disease never on aero)
 - COVID study in chia found that 27% of infected exhaled viruses, but 73% did not – disease is very variable between people
 - So superspreading can only happen if wrong time, wrong place, right type of person (high variability in viral loads)
 - Box model of room-level transmission
 - Infective emits virus particles, mix in the room
 - Same as modeling radon (ODE, solved analytically)
 - Used to plot attack rate as a function of risk parameter (ventilation, time, masks, vocalization, intense breathing)
 - Tuberculosis requires high risk parameters to spread
 - Measles requires much lower risk parameters; very highly transmissible
 - COVID falls in between COVID and measles
 - Low risk = low attack rate, high = high
 - Remarkably consistent across COVID outbreaks
 - Very consistent with airborne transmission
- Droplets are larger, therefore have more virus – so must be the cause according to WHO
 - WHO study shows that there are 50 times more aerosols than droplets, but argue that droplets are larger and have more disease
 - But CDC aerosols 101 says that for droplets to fall in seconds, would have to be 100 um! (COVID is ~5um). So this is a huge error
 - So analyzing the same data suggests that since there are 1000 aerosols for each large droplet
 - float a long time with many chances to be inhaled
 - whereas droplets have to hit small targets in order to cause infection
 - So the physics favors aerosols by a huge amount
 - Study about dose:
 - Aero volume does is 100-2000 times larger than for droplets when talking
 - Droplets only ½ on direct hit from cough/sneeze
 - For all diseases where measured, pathogens are more concentrated in smaller particles – favors aerosol theory even more
 - Reviewing lit on large droplet transmission, one can find no direct evidence for large droplets as the route of transmission for any disease!
 - Why did we assume this so quickly for COVID?!
- Aerosol-generating procedures

- Extubation generates more detectable aero than intubation (especially when patient coughed) but falls below current criterion for designation as a high-risk aero-generating procedure
- Summary of evidence: Aerosols are much more likely to be the cause of transmission



Key:
 ✓: evidence
 ✓✓: very strong ev.
 X: no evidence
 X: evidence against
 n/a: not applicable
 (v1.47, 18-Sep-2020)

More detail & references at <http://tinyurl.com/aerosol-pros-cons>
 Preliminary, being written up for publication; feedback most welcome

	Droplets	Fomites	Aerosols
Outdoors << Indoors	X	✓	✓✓
Similar viruses demonstrated	X	✓	✓
Animal models	?	✓	✓
Superspreading events	X	X	✓✓
Supersp. Patterns similar to known aerosol diseases	n/a	n/a	✓
Importance of close proximity	✓	X	✓✓
Consistency of close prox. & room-level	X	X	✓
Physical plausibility (talking)	X	✓	✓
Physical plausibility (cough, sneeze)	✓	✓	✓
Impact of reduced ventilation	X	X	✓
SARS-CoV-2 infectivity demonstrated in real world	X	X	✓
SARS-CoV-2 infectivity demonstrated in lab	X	✓	✓
"Droplet" PPE works reasonably well	✓	✓	✓
Transmission by a/pre-symptomatics (no cough)	X	✓	✓
Infection through eyes	✓	✓	✓
Transmission risk models	✓	✓	✓

- Conclusion is the opposite of what we have been told by WHO for months!!
- Why? How we got here:
 - Based in history
 - 1910 Chapin's Sources and Modes of Infection
 - Claimed that to prove air infection, need extraordinary evidence
 - Became a paradigm and then a dogma, all the way until WHO today
 - In 1930's, Wells Riley and others fight fierce resistance
 - Finally demonstrated in measles, chickenpox, TB, but only because so contagious
 - But great process against diseases with vaccines, antibiotics, etc. – so has been a non-issue until now
 - Now: they are confusing of artifact of history with law of nature
 - Aerosols have never been considered important for disease transmission, so WHO doesn't have any aerosol experts and it hasn't been studied well by medical professionals
- Chapin's error is finally becoming obvious!
- This has huge implications, but is still getting major resistance
- It is extremely important to collaborate across disciplines!
- **How can we protect ourselves against the infection?**
 - List can be found at <https://tinyurl.com/FAQ-aerosols>
 - We need layers of protection – no magic bullet!
 - Think about trying to not breathe smoke
 - Some people still think that if they wear a mask and keep 6 ft, they are totally safe - this is false! Because of dilution of the aerosols around the room
 - Important that you share the air with the person for > 15 min, low-ventilation, etc.
 - Ventilation is important - stopped a TB outbreak in 2011
 - The problem is cold weather! But there is a trick!

- We can use CO₂ as an indicator of ventilation
- Simple CO₂ detector can tell:
 - Outside = ~400 ppm
 - Car = ~4600 ppm
 - Car with outside air circulation = ~800 ppm
- We should install CO₂ detectors in all places where many people share air

QUESTIONS:

- So do people still need masks and goggles outside??
 - There is an index of risk – check time, proximity, masks, ventilation, etc.
 - Definitely wear a mask! Goggles maybe only in high risk situations
 - More important thing is to fit your mask well – minimal surface area of gaps around your mask
- Is smoke a good analogy?
 - The smoke analogy is a little too strong – COVID cannot be transmitted at the same distances as you can smell smoke
- Why do you think WHO is denying the evidence? Ignorance or trying to avoid scaring people too much?
 - ¾ they really don't believe it because of their tradition and historical paradigm
 - So it's hard to convince them that aerosols are important
 - Scaring people does play a smaller fraction, maybe a growing fraction
- How would you rank the relative risk of aerosol fomites to droplets? Study in WuHan showed surfaces able to re-aerosolize the virus
 - Plausible, but unlikely
 - Quantitatively the virus that falls to the ground has a much lower chance of spread
 - Also the virus doesn't survive for very long
 - Even if it is a factor, we would protect against this in the same ways as aerosol spread
- Where does the 5-6 air changes per hour recommendation come from?
 - It's a balance of what is feasible with what can provide good protection
 - Same issue with ppm of CO₂ – he recommends less than 700, others 800 ppm
- Do we know the CO₂ levels in an airplane?
 - On 2 hour trip in Europe...
 - Terminal = 500, boarding = >1000, flight = 700-800, outside = 400, train = 650
 - Relatively safe on the actual plane, but airlines need to turn on the ventilation during boarding
- How long does the pathogen survive in aerosols, droplets, etc?
 - There are many measurements now, suggest virus maintains its activity for 1-2 hours
 - Cold helps it maintain activity, heat kills it faster
 - Humidity retains activity at very low or very high humidity – loses activity at mid-range
- Are quantitative aerosol studies challenging? Why so few?
 - Many have been done, but difficult because they are hard to detect in the air, even in large enough quantities to infect
 - No one has ever taken infected air and shown the presence of enough virus to infect people
 - Never done for measles or TB – but for some reason expected for COVID