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

Summary of evidence for different modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Droplets</th>
<th>Familial</th>
<th>Aerosols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoors &lt;&lt; indoors</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Similar viruses demonstrated</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Animal models</td>
<td>?</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Superspreading events</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Superspreading patterns similar to known aerosol diseases</td>
<td>n/a</td>
<td>n/a</td>
<td>✓</td>
</tr>
<tr>
<td>Importance of close proximity</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Consistency of close prox. &amp; room-level</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Physical plausibility (cough, sneeze)</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Impact of reduced ventilation</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>SARS-CoV-2 infectivity demonstrated in real world</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>SARS-CoV-2 infectivity demonstrated in lab</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>“Droplet” PPE works reasonably well</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Transmission by airway/symptoms (no cough)</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Infection through eyes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Transmission risk models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>

○ 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
      o Claimed that to prove air infection, need extraordinary evidence
      o Became a paradigm and then a dogma, all the way until WHO today
    • In 1930’s, Wells Riley and others fight fierce resistance
      o Finally demonstrated in measles, chickenpox, TB, but only because so contagious
      o 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
      o Chapin’s error is finally becoming obvious!
      o This has huge implications, but is still getting major resistance
      o It is extremely important to collaborate across disciplines!

• How can we protect ourselves against the infection?
  o List can be found at [https://tinyurl.com/FAQ-aerosols](https://tinyurl.com/FAQ-aerosols)
  o We need layers of protection – no magic bullet!
  o Think about trying to not breathe smoke
  o 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.
  o 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