Covid Epidemiology & Infection Control Update

Infectious Disease Association of California
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Disclosures

- Grant funding
  - Centers for Disease Control and Prevention
  - Massachusetts Department of Public Health
  - Agency for Healthcare Research and Quality
- Royalties
  - UpToDate Inc.

Large New Surges in Europe and South America

New Surges in Upper Midwest and Northeast

Increase in Cases and Hospitalizations

California

Cases

Hospitalizations
Rise in Cases Fueled by B.1.1.7

USA: ~55% of Cases
Michigan: ~75%
California: ~45%

Primer on Variants

<table>
<thead>
<tr>
<th>Variant</th>
<th>Transmission</th>
<th>Morbidity</th>
<th>Vaccine Protective?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1.1.7 (U.K.)</td>
<td>↑ 50-70%</td>
<td>↑ 60%</td>
<td>Yes</td>
</tr>
<tr>
<td>B.1.351 (South Africa)</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Maybe diminished</td>
</tr>
<tr>
<td>P.1 (Brazil)</td>
<td>↑ Unclear</td>
<td>Unclear</td>
<td>Maybe protective</td>
</tr>
<tr>
<td>B.1.427/429 (USA)</td>
<td>↑ Unclear</td>
<td>Unclear</td>
<td>Maybe protective</td>
</tr>
</tbody>
</table>

Vaccine Uptake

<table>
<thead>
<tr>
<th>Population</th>
<th>USA March 19</th>
<th>CA March 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Age ≥18</td>
<td>84%</td>
<td>84%</td>
</tr>
<tr>
<td>Age ≥65</td>
<td>43%</td>
<td>43%</td>
</tr>
</tbody>
</table>

Impact of Vaccine on Healthcare Worker Infections

Impact of Vaccine in Israel

Uptake of Vaccine – Israel vs USA

Impact of Vaccine in Israel
Can Vaccinated People Spread SARS-CoV-2?

Impact of Vaccination on Viral Load

- **Day 1-11 Post-Vaccine**
  - No difference in viral loads

- **Day 12-37 Post-Vaccine**
  - Vaccinated people have higher Ct's overall, but some vaccinated people with very low Ct's

**Epicurve**

By date of symptom onset or test date (whichever is earlier)

- Patients (5-6)
  - 3 of 28
**Interventions**

- All patient with confirmed disease moved to Covid-care unit
- Enhanced respiratory isolation for all medicine patients and all affected units
- Contact tracing to identify possible transmission pathways
- Serial testing (Q3 days) of all staff working in affected units or with possible exposure to infected patients, regardless of PPE
- Serial testing (Q3 days) of all inpatients
- Ventilation measurement of affected units
- Deep cleaning of affected units
- Audit and further redesign of breakrooms and workrooms
- Education on importance of patient masking and staff eye protection
- Establishment of high volume AN testing site open to all employees
- Whole genome sequencing
- Case-control study to elucidate factors associated with infection

**Whole Genome Sequencing**

Confirmed most cases related

5 cases likely unrelated
One Patient May Have Infected Many Others

- 71 yo woman with history of COPD and bronchiectasis admitted from rehab for elective ileostomy reversal
- Tachycardic and tachypneic on arrival. Surgery cancelled, admitted for stabilization.
- Covid negative x 2 by NP PCR, precautions stopped.
- Diagnosed with bronchiectasis flare, treated with antibiotics, near continuous nebulizers
- Palatal defect made her speech difficult to understand
- Frequent coughing, rarely wore mask
- Was infecting people for at least a week before diagnosed

Patient Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Infected Staff (N=32)</th>
<th>Uninfected Staff (N=128)</th>
<th>Prev Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cared for patient who was short of breath</td>
<td>65%</td>
<td>28%</td>
<td>2.11 (1.14-3.74)</td>
</tr>
<tr>
<td>Interacted with shouting</td>
<td>30%</td>
<td>16%</td>
<td>1.65 (0.68-4.01)</td>
</tr>
<tr>
<td>Care for patient who was coughing</td>
<td>83%</td>
<td>59%</td>
<td>1.90 (1.24-2.89)</td>
</tr>
<tr>
<td>Provider examined patient’s oropharynx</td>
<td>35%</td>
<td>16%</td>
<td>2.08 (0.97-4.98)</td>
</tr>
<tr>
<td>Provider helped to roll patient</td>
<td>57%</td>
<td>43%</td>
<td>1.30 (0.59-1.86)</td>
</tr>
</tbody>
</table>

Personal Protective Equipment

<table>
<thead>
<tr>
<th></th>
<th>Infected Staff (N=32)</th>
<th>Uninfected Staff (N=128)</th>
<th>Prev Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wore surgical mask during all encounters</td>
<td>100%</td>
<td>94%</td>
<td>1.09 (0.99-1.2)</td>
</tr>
<tr>
<td>Wore N95</td>
<td>0%</td>
<td>5.9%</td>
<td>NA</td>
</tr>
<tr>
<td>Patients wore masks during all encounters</td>
<td>4.4%</td>
<td>25%</td>
<td>0.16 (0.01-1.80)</td>
</tr>
<tr>
<td>Wore eye protection during all encounters?</td>
<td>30%</td>
<td>67%</td>
<td>0.44 (0.18-1.08)</td>
</tr>
</tbody>
</table>

Ventilation Assessment

- Air changes were measured in all rooms
- All had a minimum of 6 air changes
- Room of the index patient may have been overpressurized
  - 11 air changes per hour
  - Tracer gas study with sulfur hexafluoride
  - Demonstrated flow of air from the patient’s room to the nursing station
    - 31pm in patient room, 11pm in nursing station (~30%)
  - Minimal flow to the rooms of the other infected patients
Many Roommates Infected
- 8 of the infected patients were roommates
  - 3 potentially exposed to patient getting nebulizers
  - 5 infected in absence of aerosol-generating procedures
- 8/9 roommates of potentially contagious patients infected
  - Median duration together 30 hours (range 20-54 hours)
- No known positive staff intermediaries for 3
- Patient beds 7 feet apart (midline to midline) with curtain between

Infections Despite Mask + Eye Protection
- Speech language pathologist & CT technicians infected with the cluster strain, confirmed by whole genome sequencing
  - Both saw patient 1 outside of the inpatient unit
    - No exposure to nebulizers or other aerosol-generating procedures
    - No contact with doctors & nurses working on cluster units
    - No breakroom/workroom exposures
  - Both wore surgical mask and eye protection
    - CT tech noted patient was masked, 10min exposure time
    - SLP tech noted patient was not masked x 10-15 minutes

Serial Testing Identified Additional Cases
- Multiple cases where patients or employees tested negative initially but positive when retested a few days later
- 7/52 (13%) of Covid-positive patients & employees initially had a negative test
  - Some tested negative 2-3x before testing positive

Many patients & staff had very high viral loads
- 50% of cluster staff and patients had cycle thresholds <20
- High viral loads may have been a factor in facilitating transmission
### Breakrooms / Workrooms

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<th>Infected Staff (N=32)</th>
<th>Uninfected Staff (N=128)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used breakrooms/workrooms</td>
<td>71%</td>
<td>82%</td>
<td>.21</td>
</tr>
<tr>
<td>Wore mask in breakrooms/workrooms all times</td>
<td>32%</td>
<td>39%</td>
<td>.63</td>
</tr>
<tr>
<td>Ate with others present</td>
<td>73%</td>
<td>72%</td>
<td>.99</td>
</tr>
<tr>
<td>Self or others ate within 6 feet</td>
<td>69%</td>
<td>57%</td>
<td>.42</td>
</tr>
<tr>
<td>Spent &gt;60mins/day in breakrooms/workrooms</td>
<td>23%</td>
<td>24%</td>
<td>.99</td>
</tr>
</tbody>
</table>

### Case-Control Multivariable Analysis

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
</tr>
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<tbody>
<tr>
<td>Cared for patients with shortness of breath</td>
<td>6.8</td>
</tr>
<tr>
<td>(95% CI 1.7-34.9)</td>
<td></td>
</tr>
<tr>
<td>Present during nebulization</td>
<td>4.4</td>
</tr>
<tr>
<td>(95% CI 1.2-18.8)</td>
<td></td>
</tr>
<tr>
<td>Use of eye protection</td>
<td>0.1</td>
</tr>
<tr>
<td>(95% CI 0.01-0.3)</td>
<td></td>
</tr>
</tbody>
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### Summary of Some Key Lessons

- Acutely infected staff and patients are highly contagious
- Transmission can take place despite masks & eye protection
- Very high rate of roommate-to-roommate transmission
- A single test 3 days after exposure will miss some positives
- Risk factors for transmission
  - Early infection
  - Shortness of breath and cough
  - Nebulizers
  - Lack of eye protection
- Good ventilation alone will not prevent face-to-face transmission
### Incubation Period

Mean Incubation Period: 5.8 days  
95th Percentile Interval: 11.7 days

### Most Infections Are Spread by People without Symptoms

- **Never symptomatic:** 24%
- **Pre-symptomatic:** 35%
- **Symptomatic:** 41%

### Distribution of Infectivity

- Days after symptom onset
- Density (%)

### Viral Load Relative to Symptom Onset

- Days Since Symptom Onset
- Days Since Inoculation

### Severe Illness Associated with More Transmission

- Secondary attack rates amongst 2410 close contacts of 291 Covid-19 patients, Guangzhou, China

### Viral Load Determines Infectiousness

- Secondary infection rates amongst 753 contacts of 314 adults with mild Covid-19

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8
Is Covid spread by droplets or aerosols?

People Produce Respiratory Particles in a Range of Sizes

Transmission via Aerosols

Variation in Respiratory Emissions by Voice Volume
Variation in Respiratory Emissions by Activity

Variation in Respiratory Emissions by Person

Dilution of Respiratory Emissions by Distance

Transmission Risk is Affected by Distance

Variation in Respiratory Emissions by Person

Dilution of Respiratory Emissions by Distance

Transmission Risk is Affected by Distance
Transmission Risk is Affected by Duration

Temporal analysis of 2,334 Covid patients and 72,093 close contacts who rode high-speed trains in China

Secondary Attack Rate (% Travelers Infected)

<table>
<thead>
<tr>
<th>Duration of Train Trip (Hours)</th>
<th>2h</th>
<th>4h</th>
<th>6h</th>
<th>8h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Attack Rate (1/6h)</td>
<td>0.5</td>
<td>0.7</td>
<td>1.0</td>
<td>1.3</td>
</tr>
</tbody>
</table>


Skagit Valley Choir Outbreak

- 61 members of the choir attended practice together March 10
- 53 developed Covid-19 (87% attack rate)
- 3 hospitalized, 2 died

Investigation
- One member had flu-like symptoms 3 days before practice, later tested positive for SARSCoV-2
- 2.5 hour practice; no masking
- Participants sat in chairs 6-10 inches apart
- Cases broadly spread throughout the room, no clustering by seating location
- Air change rate estimated to have been 0.7 changes per hour

Hamner, MMWR 2020;69:606-610
Miller, medRxiv 2020; doi: 10.1101/2020.06.15.20132027

So, what about masks?
Medical Masks are Good! ... But Not Perfect

Transmission study using Golden Syrian Hamsters in adjacent cages with and without tightly fixed surgical masks between cages.

<table>
<thead>
<tr>
<th>No Mask</th>
<th>Mask on Source</th>
<th>Mask on Exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>Air box</td>
<td>Naive</td>
</tr>
<tr>
<td>67%</td>
<td>(10/15) Infected</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td>Air box</td>
<td>Naive</td>
</tr>
<tr>
<td>17%</td>
<td>(2/12) Infected</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td>Air box</td>
<td>Naive</td>
</tr>
<tr>
<td>33%</td>
<td>(4/12) Infected</td>
<td></td>
</tr>
</tbody>
</table>

Chan, Clin Infect Dis 2020;71:2139-2149

Test End

Can this lead to infections?

Absolutely.

Transmission To and From HCWs Despite Masks

- We have documented multiple instances of transmission to healthcare workers despite masks & eye protection
- All transmissions confirmed by whole genome sequencing (0 SNP differences)
  - Patient to OT tech (10 min interaction)
  - Patient to video swallow technician (45 mins)
  - Asymptomatic inpatient to two patient care assistants (4-8 hours)
  - Presymptomatic nurse to patient (2 shifts)
  - Presymptomatic outpatient to physician (45 mins, both parties masked)

Klompas, Ann Intern Med 2021; doi.org/10.7326/M20-7567
Klompas, Clin Infect Dis 2021; doi.org/10.1093/cid/ciab218
We Have the Solution!

N95 Respirators’ Overall Efficiency: 98%

PPE for Patients with Suspected or Confirmed Covid-19

“HCP who enter the room of a patient with suspected or confirmed SARS-CoV-2 infection should... use a NIOSH-approved N95 or equivalent or higher-level respirator, gown, gloves, and eye protection.”

Should we be using N95s for non-Covid care as well when Covid rates are high?

Most reported Covid clusters in hospitals have occurred on non-Covid units

The Sickest are Sometimes the Least Contagious

Viral load

Host inflammatory response

Benefit demonstrated

Benefit unclear

Inspired by Paul Sax MD

The Sickest are Sometimes the Least Contagious

Viral load

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Benefit unclear

Inspired by Paul Sax MD
Symptomatic vs Asymptomatic Disease

Distribution of Infectivity

Average CT counts in Known Covid+ Inpatients vs Others

Active Review of Covid Admissions

What is an aerosol generating procedure?

Tracheal Intubation Associated with Increased Risk of SARS
...but how many aerosols does intubation generate?

Continuous aerosol monitoring using an optical particle sizer in an operating room

Intubation: Mean 1.4 particles/L, N=14

Extubation: Mean 21 particles/L, N=10

Cough: Mean 732 particles/L, N=38

Brown, Anesthesia 2021;76:174-181

Most “Aerosol Generating Procedures” Generate Very Few Aerosols

Most "Aerosol Generating Procedures" Generate Very Few Aerosols

Aerosol Production with Supplementary Oxygen

Aerosol measurement with 10 healthy volunteers in a negative pressure room

Gaeckle, AJRCCM 2021;ePub

Variation in Respiratory Emissions by Activity


Impact of High Flow O2 on Respiratory Emissions


The Intubation Paradox

- It’s not the procedure, it’s the patient!
- Associations between procedures and healthcare worker infections more likely due to the circumstances surrounding procedures rather than the procedures themselves
  - Severe illness (high viral loads)
  - Significant symptoms (tachypnea, heavy breathing, coughing)
  - Profound proximity to the respiratory tract
  - Sustained exposure

Klompas, JAMA Surgery 2021;156:113-114
Beware of the Rise of the Mutants!
20-50% more transmissible = 20-50% less room for error

Summary
- SARS-CoV-2 transmitted by respiratory particles in a range of sizes including aerosols
- Risk of infection is associated with the amount of viral exposure
  - Determined by source patient’s viral load, quantity of emissions, symptoms, proximity, duration of exposure, masking, and ventilation
- Masks decrease exposure but do not eliminate it
- More transmissible variants will increase transmission risk
- Covid patients sick enough to be hospitalized may be less contagious than those with acute infection with or without symptoms. Should we be doing more to protect healthcare workers and patients in non-Covid units?
- Most “aerosol generating procedures” do not generate aerosols
- Stay humble.

Thank You!
For all the lives we touch
Clean hands protect our patients
Always perform hand hygiene and help others do the same
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