COVID-19
Transmission and Risk to Healthcare Workers

Covid-19 Symposium: From Prevention to Control
Hong Kong Hospital Authority & Centre for Health Protection
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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.
Over 68 Million Cases and 1.5 Million Deaths
New Cases Per Day

Source: Our World in Data
Transmission
Incubation Period

Mean Incubation Period: 5.8 days
95\textsuperscript{th} Percentile Interval: 11.7 days

McAloon, *BMJ Open* 2020;10:e039652
How long are people contagious before they develop symptoms?
Quantifying the Infectious Period

First Patient

- Incubation period
- Symptoms →

Second Patient

- Incubation period
- Symptoms →

Serial Interval

Presymptomatic Transmission

He 2020, Nature Medicine, doi.org/10.1038/s41591-020-0869-5
Distribution of Infectivity

Is Covid spread by droplets or aerosols?
Respiratory Emissions Vary by Volume and by Person

Louder speech → more particles

Asadi, Scientific Reports 2019;9:2348
Respiratory Emissions Vary by Volume and by Person

Some people emit much more than others

Asadi, Scientific Reports 2019;9:2348
How far does a cough travel?

No Mask: Cough travels 1-2 meters

With Mask: Cough travels 0.5-1 meters

Simha, Physics of Fluids 2020;32:081905
Transmission Risk is Affected by Proximity

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

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<thead>
<tr>
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Hu, Clin Infect Dis 2020; 10.1093/cid/ciaa1057
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

Hu, Clin Infect Dis 2020; 10.1093/cid/ciaa1057
Skagit Valley Choir Outbreak

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

**Investigation**

- One member with flu-like symptoms 3 days before practice, later found to be positive for SARS-CoV-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
Restaurant Cluster Associated with Air Conditioning, Guangzhou, China

- Well documented cluster in a restaurant in Guangzhou
- One pre-symptomatic diner infected 9 other diners (4 at own table, 5 at other tables)
- Some of the infected diners up to 4 meters (12 feet) away from the index case
- Air conditioner and lack of ventilation potentially contributory

Lu, *Emerging Infectious Dis* 2020;26:1628-31
All infected diners were in one area of the restaurant underneath an air conditioner (attack rate 9/20, 45%).

None of the 68 diners in other areas were infected (attack rate 0/68). None of the 8 waiters infected.

Air conditioner was recirculating “old” air rather than fresh (exhaust vents were closed).

Tracer gas studies confirmed VERY poor ventilation in the affected area of the restaurant (0.7 air changes/hour; hospital standard is ≥6 air changes/hour).

Take home: aerosol transmission possible but under conditions of very poor ventilation.

Cluster of Infections on Poorly Ventilated Bus

- Cluster of 31 infections amongst 300 people who attended an outdoor Buddhist ceremony and lunch in Eastern China. Traced to one pre-symptomatic attendee.
- Two groups traveled to the ceremony by bus. Others travelled via private transport
- 100 mins travel time. 150 mins ceremony time. Ceremony Outdoors.

**Bus #1 (indoor exposure)**
- Pre-symptomatic patient onboard
- 24/68 people on bus infected
- 35% infected

**Bus #2 (outdoor exposure)**
- 0/60 infected despite attending the same ceremony as passengers on Bus #1
- 0% infected

**Private transport**
- 7/172 infected.
- All 7 had close contact with the index patient at ceremony
- 4% infected

What is an aerosol generating procedure?
Tracheal Intubation Associated with Increased Risk of SARS

Risk of SARS-CoV-1 in HCWs Exposed to Tracheal Intubation

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>Exposed n/N</th>
<th>Unexposed n/N</th>
<th>OR (random) 95% CI</th>
<th>Weight %</th>
<th>OR (random) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scales (2003)</td>
<td>3/5</td>
<td>3/14</td>
<td>16.86</td>
<td>5.50</td>
<td>5.50 [0.61, 49.54]</td>
</tr>
<tr>
<td>Raboud (2010)</td>
<td>12/144</td>
<td>14/480</td>
<td>46.10</td>
<td>3.03</td>
<td>3.03 [1.37, 6.70]</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>167</td>
<td>584</td>
<td>100.00</td>
<td>6.56</td>
<td>6.56 [2.28, 18.89]</td>
</tr>
</tbody>
</table>

Total events: 24 (Exposed), 24 (Unexposed)
Test for heterogeneity: $\chi^2 = 4.97, df = 3 (P = 0.17), I^2 = 39.6\%$
Test for overall effect: $Z = 3.49 (P = 0.0005)$

Tracheal intubation associated with a 6-fold increase in SARS-CoV-1!

Other procedures that have been associated with increased risk of HCW infections include non-invasive ventilation, manual ventilation before intubation, tracheotomy, cardiac resuscitation.

...but how much 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

Most “Aerosol Generating Procedures” Generate Very Few Aerosols

Li, Open Forum Infect Dis 2017;4(Suppl 1):S34
O’Neil, Clin Infect Dis 2017;65:1342-1348
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)
  - Symptoms (tachypnea, heavy breathing, coughing)
  - Profound proximity to the respiratory tract
  - Sustained exposure

Klompas, *JAMA Surgery* 2020; in press
How contagious is Covid?
How Contagious Is Covid?

- **Intensive contact tracing, Ningbo City, China**
  - Amongst 2,147 close contacts of 147 cases
  - 6.2% became infected

- **Secondary attack rates**
  - Household members – 18% developed infection
  - Eating together – 7% developed infection
  - Relatives – 5% developed infection
  - Supermarket – 0.6% developed infection
How Contagious is Covid?

Intensive contact tracing, Guangzhou, China
- 3410 close contacts of 391 Covid patients
- Close contacts identified by interview and cell phone tracing
- 127/3410 contacts infected (3.7%)

Secondary attack rates varied by setting:
- Household (10.3%)
- Entertainment venues or workplace (1.3%)
- Health care settings (1.0%)
- Public transport (0.1%)

Luo, Ann Intern Med 2020; doi.org/10.7326/M20-2671
Secondary Attack Rates by Severity of Illness

Secondary attack rates amongst 3410 close contacts of 391 Covid patients, Guangzhou, China

Asymptomatic (n=305)
Mild (n=576)
Moderate (n=1469)
Severe (n=260)

Luo, Ann Intern Med 2020; doi.org/10.7326/M20-2671
Contagiousness ($R_0$)

- Covid-19
- Influenza
- SARS
- Varicella
- Pertussis
- Measles

Influenza Cases – Southern Hemisphere

World Health Organization (who.int/flunet)
Rhinovirus Conquers All?

Respiratory multiplex testing on symptomatic patients, St. Vincent’s Hospital, Australia (N=21,808)

Lockdown imposed → Rhinovirus

→ Lockdown lifted

Marriott, Clin Infect Dis 2020;ePub
Risk Factors for Covid outside the Home

Case-Control study, symptomatic outpatients without known Covid exposures, 10 U.S. states, N=225

- Shopping
- Restaurant
- Office
- Salon
- Gym
- Public transport
- Bar/Coffee Shop
- Church

Odds Ratio for Covid

Fisher, MMWR 2020;69(36):1258-1264
How long are people contagious?
Duration of Infectiousness

Infection rates amongst 2,761 close contacts of 100 patients with confirmed Covid-19 in Taiwan

Days from Symptom Onset

Secondary Attack Rate

Probability of Viral Viability After Symptom Onset

Association between Cycle Threshold and Culture

How reliable is a post-exposure test to rule out Covid transmission?
Household Transmission Rates

- CDC study of 191 household contacts of 101 Covid patients
- Household contacts tested daily following exposure

53% of household contacts ultimately tested positive
- 53% if index patient age <12
- 38% if index patient age 12-17

75% of transmissions detected by day 5 following the index patient’s start of illness

Grijalva, MMWR 2020;69 (early release)
What is the risk to healthcare workers?
First Coronavirus Case of Unknown Origin Being Treated at UC Davis
Risk of SARS-CoV-2 Transmission for Healthcare Workers

- CDC analysis of the first U.S. case of locally acquired COVID19 (Solano, CA)
  - Patient with unsuspected COVID19
    - 121 providers had contact with the patient, no precautions
    - 3 developed COVID-19 (2.5%)
  - Risk factors:
    - aerosol generating procedures (2 HCWs)
    - prolonged contact (>2 hours, 1 HCW)

Heinzerling, MMWR 2020;69:472-476
Healthcare Worker Infection Rates Parallel Community Rates


Total Covid-19 patients in Barts Health NHS Trust

Percent of asymptomatic HCWs positive for SARS-CoV-2 by PCR

Treibel, Lancet 2020;395(10237):1608-1610
Healthcare Worker Infection Rates Parallel Community Rates

SARS-CoV-2 seroprevalence amongst 3,248 healthcare workers from 13 different hospitals

Self, MMWR 2020;69:1221-1226.
# Risk Factors for Healthcare Worker Infections

Hospital-wide seroprevalence survey, Hospital East-Limburg, Belgium, *N*=3,056

<table>
<thead>
<tr>
<th>Exposure Present</th>
<th>Exposure Absent</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient contact</td>
<td>114/1864 (6.1)</td>
<td>67/1000 (6.7)</td>
</tr>
<tr>
<td>Worked during lockdown</td>
<td>188/2902 (6.5)</td>
<td>8/142 (5.6)</td>
</tr>
<tr>
<td>COVID-19+ patient contact</td>
<td>73/1092 (6.7)</td>
<td>120/1921 (6.2)</td>
</tr>
<tr>
<td>COVID-19+ coworker contact</td>
<td>95/1434 (6.6)</td>
<td>100/1548 (6.5)</td>
</tr>
<tr>
<td>Suspected COVID-19+ household</td>
<td>81/593 (13.7)</td>
<td>116/2435 (4.8)</td>
</tr>
</tbody>
</table>

Steensels, *JAMA* 2020;324:195-197
SARS-CoV-2 seroprevalence by Job Type & Setting

Antibody testing amongst 1699 employees of St Francis Hospital, Roslyn, NY

PPE for Patients with Suspected or Confirmed Covid-19

**Preferred PPE – Use N95 or Higher Respirator**

- Face shield or goggles
- N95 or higher respirator
- When respirators are not available, use the best available alternative, like a facemask.
- One pair of clean, non-sterile gloves
- Isolation gown

**Acceptable Alternative PPE – Use Facemask**

- Face shield or goggles
- Facemask
- N95 or higher respirators are preferred but facemasks are an acceptable alternative.
- One pair of clean, non-sterile gloves
- Isolation gown

[cdc.gov/covid19]
What is the risk to patients?
We identified 226 patients at Brigham & Women’s Hospital exposed to healthcare workers who were subsequently diagnosed with Covid.

Followed each patient for 14 days for symptom & tests.

Identified 1 patient infection potentially attributable to their healthcare exposure.

Baker, Clin Infect Dis 2020;ePub
Nosocomial Transmission Rare

• From Mar 7- May 30 we admitted almost 700 patients with Covid & 8000 patients without Covid

• We reviewed all patients who tested positive on hospital day ≥3

• Only 2 cases of hospital-acquired COVID detected:
  • 1 in March who likely acquired Covid from visiting wife
  • 1 in April who developed Covid shortly after long hospitalization – no clear exposures inside or outside hospital

Rhee, JAMA Network Open 2020;3(9):e2020498
Brigham and Women’s COVID-19 cluster illustrates challenges in controlling infection

Experts say leadership, vigilance, and culture change are needed, along with more space to gather and eat at safe distances

By Felice J. Freyer Globe Staff, Updated September 26, 2020, 1:16 p.m.
Our Hospital Cluster

- 14 patients, 38 staff (confirmed by whole genome sequencing)

- Likely source: patient admitted during incubation period (negative by NP x 2 on admission) but contagious by day 3

- High rate of transmission amongst patients sharing rooms

- Factors that may have facilitated transmission: early infections, symptomatic patient, variable use of eye protection by providers, inconsistent masking of patients
Mitigation and Lessons Learned

- Pre-emptive precautions for all patients on cluster units & services
- Serial testing of all patients and staff associated with cluster units (every 3 days)
- Confirmation of adequate ventilation
- Messaging about eye protection & masking patients
- Structural changes to breakrooms/workrooms to decrease density

- New measures instituted post-cluster
  - Retest all patients 3 days after admission
  - Serial testing of all patients getting aerosol generating procedures
Protective Measures to Prevent Covid

Case-Control study, asymptomatic contacts of people with confirmed Covid, Thailand, 211 cases & 839 controls

Distance
- Direct contact
  - <1 meter
  - >1 meter

Duration of Contact
- >60mins
- 15-60mins
- <15mins

Handwashing
- Never
- Sometimes
- Often

Type of Mask
- None
- Cloth mask
- Medical mask

Mask Frequency
- Never
- Sometimes
- Always

Odds Ratio for Covid

Doung-ngern, *EID* 2020;26:2607-16
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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