SARS-CoV-2 Modes of Transmission and Related IPC Measures

Tuesday, April 28, 2020

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Territorial Acknowledgement

Source: https://www.ucalgary.ca/indigenous
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• Medical Director for IPC, Alberta Health Services – Calgary and Area

• Appointed as a member of the Order of Canada in 2018 for pioneering contributions in IPC, antimicrobial resistance and healthcare innovations.
• Financial disclosure affiliations
  • Honoraria: None
  • Speakers' Bureaux, advisory boards: Received funding to attend a meeting on HAI from the CDC and bioMerieux
  • Grants/Clinical Trials: Local PI for the STRIVE S. aureus vaccine trial spinal surgery (Pfizer) and holds grants from CIHR, AI-HS, PHAC, AH, AHS, EDT.
  • Patents, royalties: None
  • Investments in health organizations: None
  • Other influential affiliations: Member of committees with PHAC, WHO and CIHR

• Acknowledgements
  • Dr J Gill/ G van Marle for permission to use some of their slides
Sorting the Message

- Mainstream media and social media in **total overdrive**
- First major pandemic in the “modern age” of **instant social messaging**
- Lots of “papers” now published online before even reviewed
- “Science” may be correct but may jump to premature or incorrect conclusions or be incomprehensible; some will never be published
- Even in top quality peer-viewed journals the articles may be premature / over interpreted / incomplete and without necessary limitations
- Many letters and short reports
- Authors, reviewers and journals are under immense pressure to be fast and first in publishing

- **Be careful and use your critical appraisal skills and common sense**
Basic Viral Facts

• The SARS-CoV-2 causes COVID-19 infection.
• Single strand RNA virus in coronavirus family named from morphology
• It is a respiratory virus (contact droplet not airborne transmission)
• Only a few coronaviruses cause human illness (mostly respiratory such as colds but also serious respiratory infections SARS and MERS)
• Uses human ACE 2 receptor (Angiotensin converting enzyme 2)
• **VERY high affinity** for receptor vs. SARS (i.e. readily latches onto respiratory cells ? few viruses needed for infection)
SARS-CoV-2

• SARS-CoV-2 likely originated from Asian bats into intermediary animal host (the pangolin) and then to humans
• Virus not mutating significantly. So vaccine more possible but virus less likely to “flame out” or become less pathogenic
• Variation is, however, enough for phylogenetic studies https://nextstrain.org/narratives/ncov/sit-rep/2020-03-27
• IgG and IgM Antibody tests are close: Will be very useful for determining natural history and possible health care staffing
• No one is immune
Natural History in Humans

• Proportion of asymptomatic infections unknown and critical for understanding possible transmission and HCW immunity.
• Estimates range 0-6% but models higher
• Incubation period after exposure likely 2-14 days (median ~5 days)
• 97.5% develop symptoms within 11 days
• Of those diagnosed
  • 80% have self-limited mainly respiratory illness probably of ~14 days duration
  • 15% have more severe illness requiring medical care +/- hospitalization
  • 5% go to intensive care +/- ventilation
• Risk in hospitalized is mainly respiratory then multi organ failure requiring ventilation and high risk of death ~ 70% ventilated patients
• Progression risk and rate down pathway below is unclear
# Diagnostic Clinical Challenges

## Influenza-like-illness (ILI)

- New or changed cough
- AND one or more of the following:
  - **Fever** (or history of fever in the last 24 hours)
  - Muscle aches
  - Severe exhaustion/weakness
  - Sore throat
  - Joint pain

## COVID-19

- Fever (98%)
- Cough (76%)
- Myalgia or fatigue (44%)
- Sore throat
- Sputum production (28%)
- Headache (8%)
- Mild Diarrhea (? 3%)
- Hemoptysis (5%)
- Additional symptoms – skin lesions, strokes
COVID-19 and SARS-CoV-2
Infection Prevention and Control

According to WHO
The disease caused by Novel Coronavirus, SARS-CoV-2 is now officially called COVID-19

SARS-CoV-2

CO - Corona
VI - Virus
D - Disease

World Health Organization

www.microbesplus.com
Transmission Routes

Transmission Routes

• Droplet and airborne routes create most debate

• Continuum of droplet and airborne routes an important concept

• Particles of a variety of sizes are expelled from the human airway during coughing, sneezing, talking and medical procedures

• Size of these particles and the distance propelled is complex
  • particle sizes variable
  • distance they will be propelled is dependent on the force generated by the individual or the procedure
  • particles may or may not contain the infectious agent
  • infectious agent may or may not be viable
  • concentration of particles affected by many factors: the relative humidity, evaporation level, settling velocity, direction of air flow, the number of air changes per hour, temperature, crowding and other environmental factors

• Airborne may be obligate or preferential or opportunistic and refers to particles that stay aloft for minutes or hours (less than 5-10 µm in diameter) and can be carried by air currents over a measurable distance

• Droplet spread refers to large droplets ( >5-10µm) that fall within 1 metre
Exposure, Transmission and Invasive Infection

• Exposure to microorganisms
• Not all exposures lead to transmission and invasive infection.
• Exposure occurs when a host comes into contact with an infected source or contaminated environment (e.g., inanimate/animate object or particles in the air)
• Probability of transmission followed by invasive infection →many factors
  • host susceptibility
  • presence of host receptors
  • receptivity of host receptors
  • inoculum
  • viability
  • virulence
  • effectiveness of the hierarchy of controls
Droplet and contact – multiple studies demonstrated compliance with gloves, gowns and medical masks or N95s were adequate to prevent transmission for SARS

Major risks exposure of eye and mucous membranes to respiratory secretions and AGMPs, ie intubation (opportunistic airborne); no association with contact with urine/stool

HCW spread - associated with inconsistent or improper PPE use for SARS/MERS-CoV outbreaks; Infections in HCWs: 22% and 25% for SARS and MERS, respectively

Risk factors for nosocomial spread of MERS-CoV in two large outbreaks in Saudi Arabia and South Korea found ER/Ward overcrowding and sub-optimal control of visitors were major factors

Transmission of MERS-CoV was not documented in one investigation of mostly asymptomatic and pauci-symptomatic cases and their household contacts

Asymptomatic cases reported but uncommon – one study of MERS cases found 80% of “asymptomatic” persons actually had symptoms on close questioning

SARS-CoV-2 Detection

Patient specimens

- **BAL** samples (Zhu NEJM) + viral isolation
- **Nasopharyngeal/oropharyngeal** (NP/OP) swabs
  - multiple reports of detection of 2019-nCoV RNA in NP/OP swabs; sensitivity varies 71-100% and depends on operator, timing and site of specimen; specificity near 100%
  - shedding over time varies but recent studies elucidating
  - viable virus does not correlate well with RT-PCR depending on time

- **Serum**
  - Chan (Lancet 2020) also showed + RT-PCR of serum in one patient

- **Stool**
  - Investigators in Shenzhen and Washington State have detected 2019-nCoV RNA in the stool of infected patients (Holshue NEJM 2020)
<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Virus</th>
<th>Strain / Isolate</th>
<th>Inoculum (viral titer)</th>
<th>Temperature</th>
<th>Persistence</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>Steel</td>
<td>MERS-CoV</td>
<td>Isolate HCoV-EMC/2012</td>
<td>$10^3$</td>
<td>20°C</td>
<td>48 h</td>
<td>[21]</td>
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<tr>
<td></td>
<td>TGEV</td>
<td>Unknown</td>
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<td>4°C</td>
<td>≥ 28 d</td>
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<tr>
<td></td>
<td>MHV</td>
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<tr>
<td>Aluminium</td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>21°C</td>
<td>5 d</td>
<td>[23]</td>
</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strains 229E and OC43</td>
<td>$5 \times 10^3$</td>
<td>21°C</td>
<td>2–8 h</td>
<td>[24]</td>
</tr>
<tr>
<td>Metal</td>
<td>SARS-CoV</td>
<td>Strain P9</td>
<td>$10^3$</td>
<td>RT</td>
<td>3 h</td>
<td>[25]</td>
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<tr>
<td></td>
<td>SARS-CoV</td>
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<td>$10^3$</td>
<td>RT</td>
<td>&lt; 5 min</td>
<td></td>
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<tr>
<td>Wood</td>
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<td>$10^3$</td>
<td>RT</td>
<td>4–5 d</td>
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<td>RT</td>
<td>24 h</td>
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</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain GVU6109</td>
<td>$10^3$</td>
<td>RT</td>
<td>3 h</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain 229E</td>
<td>$10^4$</td>
<td>RT</td>
<td>5 d</td>
<td>[26]</td>
</tr>
<tr>
<td>Glass</td>
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<td>RT</td>
<td>4 d</td>
<td>[25]</td>
</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>21°C</td>
<td>5 d</td>
<td>[23]</td>
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<tr>
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<td>Strain HKU39849</td>
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<td>≤ 5 d</td>
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<tr>
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<td>$10^3$</td>
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<td>48 h</td>
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<td>3 h</td>
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<tr>
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<td>SARS-CoV</td>
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<tr>
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<td>HCoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>RT</td>
<td>2–6 d</td>
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</tr>
<tr>
<td></td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>RT</td>
<td>5 d</td>
<td>[23]</td>
</tr>
<tr>
<td>PVC</td>
<td>HCoV</td>
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<td>$10^3$</td>
<td>21°C</td>
<td>1 h</td>
<td>[23]</td>
</tr>
<tr>
<td>Silicon rubber</td>
<td>HCoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>21°C</td>
<td>1 h</td>
<td>[23]</td>
</tr>
<tr>
<td>Surgical glove (latex)</td>
<td>HCoV</td>
<td>Strains 229E and OC43</td>
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<td>Disposable gown</td>
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<td>Strain GVU6109</td>
<td>$10^4$</td>
<td>RT</td>
<td>2 d</td>
<td>[26]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain 229E</td>
<td>$10^3$</td>
<td>RT</td>
<td>24 h</td>
<td>[23]</td>
</tr>
<tr>
<td></td>
<td>SARS-CoV</td>
<td>Strain 229E</td>
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<td>RT</td>
<td>1 h</td>
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<td>Ceramic</td>
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</tr>
</tbody>
</table>

MERS = Middle East Respiratory Syndrome; HCoV = human coronavirus; TGEV = transmissible gastroenteritis virus; MHV = mouse hepatitis virus; SARS = Severe Acute Respiratory Syndrome; RT = room temperature.
Survival SARS-CoV-2
- Virus was readily isolated during the first week of symptoms from a considerable fraction of samples (16.66% in swabs, 83.33% in sputum samples)

- No isolates of virus obtained from samples taken after day 8 in spite of ongoing high viral loads by RT-PCR

Wolffel et al Nature. 2020 Apr 1. doi: 10.1038/s41586-020-2196-x. [Epub ahead of print]
How SARS-CoV-2 spread compares to other viruses

Basic reproductive number ($R_0$) - the average number of individuals infected by a case over the infectious period, in a fully susceptible population.

Most major studies suggest it is falling into range of 2.20 - 2.68.

Korea and Italy of 2.60 (based on initial case growth).


Mode Transmission SARS-CoV-2

• Droplet - contact considered predominant route
  • Consistent with SARS-CoV-1, MERS-CoV

• Consistent with $R_0$ of other droplet-contact respiratory viruses

• WHO-China Joint Mission on COVID-19 in China with 75,465 cases supported person-to-person droplet and fomite transmission
  • 78-85% of the investigated infection clusters occurred within families, with an intra-household $2^0$ attack rate of 3-10%, not consistent with airborne transmission

References: WHO- China Joint Mission Report 2020
Reports against/for Airborne Transmission for CoVs

• 41 HCW exposure over 10 minutes within 2 meters to a COVID-19 patient during multiple AGMPs, 85% surgical masks and no transmission events

• COVID-19 + who was nursed in an open cubicle of a general ward before the diagnosis was made and 76 tests 52 contacts, some without PPE and no transmissions

• No evidence of COVID-19 transmission to passengers seated around a COVID+ passenger long flight

• No transmission events in 5544 continuous person hours HCW exposure to 132 inpatient COVID+ pts using medical masks as part of PPE routine care

• Amoy Garden outbreak Sars-CoV-1 > 300 residents possible aerosol event vs rats

• Report of a bus transmission 4.5 meters distance in Chinese report (translated)

• Outbreak in air-conditioned (AC) restaurant China with 10 persons with 1 meter distance between tables along flow of air from the AC

• Experimental study with 3-jet Collison nebulizer creating aerosol of viable SARS-CoV-2

• Systematic review of droplet dispersion but mainly modelling studies; no clinical settings or epidemiologic data

Reports against/for Airborne Transmission for CoVs

- SARS-CoV-2 (RT-PCR) in 1/13 (7.7%) environmental samples but 0/8 air samples collected 10 cm from the patient's chin in Hong Kong
- SARS-CoV-2 (RT-PCR) in 17/22 (77%) environmental samples but 0/5 air sample sites including beside the patient collected in Singapore
- None/10 air samples for SARS-CoV-2 (RT-PCR) with samplers with fresh DMEM 2 to 5 m away from the patient (severely ill)

- SARS-CoV-2 (RT-PCR) in 20/37 air samples at 1-113 copies/m³ highest ICU – multiple areas hospital
- SARS-CoV-2 (RT-PCR) in 126/163 samples (77.3%) collected in this study, 0 to 1.75 copies/μL and air samples 2.86 copies/L including outside pt rooms; no viable virus cultivated in any of the 163 samples
- SARS-CoV-2 (RT-PCR) high touch surface contamination was shown in 10/15 (66.7%) rooms 1840 to 3380 RNA copies per m³; viability not done

Transmission Risks of SARS-CoV-2

• Prospective cohort study of 4,950 persons who had a close contact with confirmed COVID-2019 patients (n=129;2.6% [6.2% asymptomatic/38% mild/51.9% moderate/3.9% severe])

• RT-PCR q2 days; daily temp and symptom check

• Uni- and multivariable regression analysis (SAS) were performed for risk factors for developing COVID-19

• Age (1.8-4.2% 0-17 to > 60 yrs); household and multiplicity of contacts (10.2-13%) highest risk whereas public transport and HCW lowest (1.0 and 0.1%) and severity were (0.33 % asymptomatic/3.3% mild/5.6% moderate/6.2% severe]) and sputum production and fever all significant risk factors in MV analysis

• RT-PCR sensitivity 71.9%; 93.2%; 96.9% 100% at 1,2,3 and 6 tests

Building upon key existing WHO guidance

Infection prevention and control during health care for probable or confirmed cases of Middle East respiratory syndrome coronavirus (MERS-CoV) infection
Interim guidance
Updated October 2019
WHOMERS/IPC/15.1 Rev 1

https://apps.who.int/iris/bitstream/handle/10665/174652/WHO_MERS_IPC_15.1_eng.pdf;jsessionid=718B13F93CBB3B2DD7CCAA262321BDF?sequence=1

https://www.who.int/csr/bioriskreduction/infection_control/publication/en/
Seto WH. Conly JM, Pessoa-Silva et al EMHJ 2013
2019 n-CoV: WHO guidance

Home care for patients with suspected novel coronavirus (nCoV) infection presenting with mild symptoms and management of contacts
Interim guidance
20 January 2020


Infection prevention and control during health care when novel coronavirus (nCoV) infection is suspected
Interim guidance
25 January 2020


Infection prevention and control during health care when COVID-19 is suspected
Interim guidance
19 March 2020

Principles of IPC Strategies associated with Health Care for Suspected COVID-19

1. Ensuring triage, early recognition, and source control (isolating patients with suspected COVID-19)
2. Applying standard precautions for all patients
3. Implementing empiric additional precautions (droplet and contact and, whenever applicable, airborne precautions) for suspected cases of COVID-19
4. Implementing administrative controls
5. Using environmental and engineering controls
Ensuring triage, Early Recognition, and Source Control

- Encourage HCWs to have a high level of clinical suspicion
- Establish a well-equipped triage station at the entrance to the facility, supported by trained staff
- Institute the use of screening questionnaires according to the updated case definition; refer to the Global Surveillance for human infection with coronavirus disease (COVID-19) for case definitions
- Post signs in public areas reminding symptomatic patients to alert HCWs
Applying Standard Precautions for all Patients

• Ensure that all patients cover their nose and mouth with a tissue or elbow when coughing or sneezing
• Offer a medical mask to patients with suspected COVID-19 while they are in waiting/public areas or in cohorting rooms
• Perform hand hygiene after contact with respiratory secretions
• Hand hygiene includes either cleansing hands with an alcohol-based hand rub or with soap and water
• Alcohol-based hand rubs are preferred if hands are not visibly soiled
• Wash hands with soap and water when they are visibly soiled
Implementing Empiric Additional Precautions

• Contact and droplet precautions
  • Gloves, gowns, medical masks, eye protection
  • Donning and doffing appropriately
  • Requires education for HCW populations
  • Single use or dedicated equipment
  • Limit visitors
  • Refrain touching face/mask/eyes
  • Disinfect high touch surfaces

• Airborne precautions for aerosol-generating procedures
  • Well ventilated room
  • Use a particulate respirator at level of a NIOSH-certified N95 or (EU) standard FFP2, or equivalent
Administrative Measures related to Health Care Workers

• Provision of adequate training for HCWs
• Ensuring an adequate patient-to-staff ratio
• Establishing a surveillance process for acute respiratory infections potentially caused by COVID-19 virus among HCWs
• Ensuring that HCWs and the public understand the
• Importance of promptly seeking medical care
• Monitoring HCW compliance with standard precautions and providing mechanisms for improvement
Using Environmental and Engineering Controls

• Address basic infrastructure of the health care facility and aim to ensure adequate ventilation
• Maintain adequate environmental cleaning
• Separation of at least 1 metre between all patients
• Ensure that cleaning and disinfection procedures are followed consistently and correctly
• Manage laundry, food service utensils and medical waste in accordance with safe routine procedures
References

• World Health Organization
  • http://covid19.who.int

• Questions ?