VIRAL TRANSMISSION

CanCOVID State of the Science Report: Volume 3

COVID Science evolves rapidly. This information is up to date as of July 6, 2020.

01 Science Backgrounder

06 Strategic Considerations for Policy-Makers & Critical Research Directions

10 About CanCOVID
SARS-CoV-2’s main transmission route is through the air from person to person. Transmission by first touching a surface and then touching one’s mouth, nose or eyes (or fomite transmission) appears to be less common. The risk of spread from animals to humans is low, though there have been some reports of dogs and cats possibly getting the virus from people. How SARS-CoV-2 is transmitted through the air is a hot topic of debate. Two routes of SARS-CoV-2 transmission that are frequently discussed are droplet mediated transmission and airborne transmission.

Droplet and aerosol transmission are considered by many authorities to represent the extremes of a spectrum. There may be some overlap between these two routes of transmission.

**Airborne transmission** (also called aerosol transmission) differs from droplet transmission because infectious particles are much smaller (<5 micrometers) and can remain suspended in the air for a longer period of time. These smaller particles spread further than droplets. Airborne transmission is not considered to be a common mode of household or community transmission. It can occur following medical or dental procedures such as airway intubation, ventilation and some dental procedures that create aerosols. Airborne transmission can also occur in confined environments where fans or air conditioners create accelerated airflows and move droplets farther than they would naturally travel.
The following factors govern efficiency of viral transmission during exposure and should be considered when developing transmission prevention strategies:

1. The number of infectious virus particles present during the exposure. This represents the number of intact particles exhaled by an infected person at any given time (aka infectious viral shedding), or potentially found on surfaces.

2. The duration of exposure.

Newly infected persons shed infectious viral material when they exhale. Over 50% of infected people spread the virus without realizing they are infectious because they do not yet – or may never - have symptoms. The time period between exposure and becoming infectious (the latent period) for SARS-Cov-2 appears to be shorter than the time between being exposed and showing symptoms (the incubation period) leaving a window of time when a person can spread the disease without being obviously sick.
The average incubation period is 5 days, but infectious viral shedding starts 1-3 days prior to symptom development and peaks prior to the first 1-2 days of symptoms. People who never develop symptoms (asymptomatic) are thought to shed the virus in an infectious form for a couple of days before their immune system wipes the virus out.

According to studies, **asymptomatic and symptomatic individuals spread similar levels of intact virus**. This means that infected people who are asymptomatic (sometimes called silent spreaders) are just as likely to spread the virus as people with symptoms. Among people who develop symptoms, infectious transmission rapidly decreases once fever or cough occur, falling to near zero within 8 days of the start of symptoms.
Having a positive COVID test is not the same thing as being able to transmit the virus to other people. Some infected individuals receive persistently positive COVID tests because viral RNA can be detected for much longer than 8 days. However, this RNA is not infectious. It is no longer viable or contagious because it is “leftover” from dead cells.

The gold standard test for detecting infectious virus is a viral culture, which involves waiting to see if the virus grows or replicates in a test tube. It is unknown whether viral particles found on fomite surfaces are a robust source of infection to humans. Lab experiments have projected intact SARS-CoV-2 particles onto different surfaces such as plastic, stainless steel, cardboard and copper and then measured viral viability over the next 3 days. Experiments revealed that viral decay occurs rapidly on all surfaces, especially copper, where no remaining infectious virus particles remained after 4 hours.

However, it is unclear whether fomite transmission can cause significant infection in humans. The number of viral particles transmitted from touching infected surfaces and then touching the mouth, also called the dose of exposure, may simply not be high enough. Contaminated surfaces might only have a minor role - if any - in transmitting the virus within households where one person has the virus.

Distance and duration of exposure

A person is more likely to become infected the longer they are exposed to intact virus particles in the air and the more particles they inhale. In closed quarters, such as indoor restaurants, offices, hospitals or household rooms with poor ventilation, viral particles will accumulate and remain suspended in the air until they settle. **Overall exposure can be reduced by ensuring good ventilation in indoor spaces, which reduces the concentration of viral particles in the air.** Spaces with open windows or doors, or high air exchange rates, will move viral particles along more quickly, reducing exposure. Outdoor windy spaces whisk away and disperse viral particles most rapidly.
Exhaled viral particles hover in a three-dimensional cloud close to the mouth and nose before dispersing; **close facial contact between two people increases exposure**. Viral particles travel faster and farther away from the mouth and nose during a cough, laugh or sneeze. Talking, yelling and singing - vocal activities that require more forceful breathing - will eject more viral particles over longer distances. Imagine a smoker blowing out smoke after a long drag on a cigarette. The smoke would get more and more concentrated in a closed room with each breath, or travel in the direction of wind currents when sitting outside.

In studies examining the effectiveness of physical distancing to reduce person-to-person transmission, the risk of transmission decreases by 80% with every additional meter distance from an infected person. However, because of all the factors listed above, we can only define as higher or lower risk different distances between people, environments (such as inside or outside) and durations of exposure.

The **reproductive number or R0** (pronounced R nought) refers to how many people an infected individual transmits the virus to. The public health goal in an epidemic is to achieve an R0 of zero, meaning there is no longer any transmission. An R0 below one indicates that containment measures are working such that each infected individual transmits to less than one other person – eventually extinguishing the outbreak. R0 above one means rapid, exponential spread.
Strategic Considerations for Policy Makers

Understanding the dynamics of viral transmission can inform the most effective policy measures to reduce the spread of the virus in specific settings in a community such as hospitals, clinics, schools, public transit, work places, sports and entertainment venues, restaurants, etc.

**Barrier** techniques such as plastic screens, visors, masks or closing the door to a room interrupt the paths of exhaled viral particles. Viral particles stick to surfaces, such as the inside or outside of a mask. This removes some viral particles from the air, reducing the number of particles that can be breathed in by other people.

**Many different types of masks exist**, such as cloth masks, surgical masks or N95 masks. Each one is categorized by the density of the fibers constituting the mask: the denser the fiber, the stronger the filtration function of the mask. Some studies suggest that the use of face masks could reduce the risk of infection by up to 85%. The N95 confers the greatest protection over surgical masks or reusable cotton masks. However, most studies are imperfect so the exact results remain uncertain.

**Barrier techniques such as visors and masks also serve to reduce the number of times people touch their faces** (estimated at 15-20 times per hour). Visors, face masks and plastic screens need to be cleaned or changed once they become wet from breathing or become contaminated with the virus to decrease the risk of transmission. Only regulated and approved cleaning techniques that preserve the barrier and effectively kill the virus should be used.
**Isolation** is the only guaranteed method for completely removing exposure to the virus. The more people one is exposed to – who may have been unknowingly exposed to others who are infected - the greater the likelihood of coming into contact with someone who is exhaling viral particles asymptotically. Isolation may be imposed and supervised by others during quarantine, or self-imposed such as when a person stays alone at home.

**Physical distancing.** Protection increases as the distance lengthens. The two-meter physical distancing rule is based on studies showing that the air travel distance of viruses decreases by almost 80% over a 1 meter or more area, compared with a distance of less than 1 meter. However, most studies of physical distancing are based on experiments that do not reflect real-life settings, or on population studies where adherence to physical distancing and the number of individuals who are actually infected is hard to measure.

**Ventilation** procedures are another method to reduce viral transmission in an indoor setting. In hospital isolation rooms, negative pressure management is used to direct airflow away from the door and corridors and prevent escape of the virus into clean areas. Frequent air changes in normal rooms such as in offices or apartments, can dilute the concentration of viral particles. To efficiently remove infectious particles from enclosed spaces 6 to 12 room air changes per hour is recommended by the CDC. One way is to bring in virus-free air for ventilation, from outside of the building. Another way is to recirculate interior air that has been filtered through high efficiency particle air (HEPA) filters or actively disinfected with UV irradiation or other techniques.

**Hand-washing and surface disinfection.** Hand-washing and surface disinfecting techniques are effective methods for cleaning away viral particles on surfaces.
Closed, confined, indoor spaces where business meetings, classes or meals are usually held tend to have poor ventilation. **Even if people stay 2m apart, in a location with poor ventilation, the risk of viral transmission if an infectious person is present is higher because there can be a high concentration of viral particles.** The risk increases with the amount of time people are together because exposure to and concentration of viral particles increases. Barriers such as masks can reduce the risk of transmission in these settings.

Decisions about implementing workplace, home, school and public safety recommendations should follow the evolving science. Multifaceted interventions, such as those provided by the WHO, use a variety of methods and will be most effective.
CRITICAL RESEARCH QUESTIONS

Current methods for detecting infection use single human samples of viral RNA only, which may or may not be infectious. New methods of intact virus detection, shed in the air or by specific individuals, will be a huge break-through for controlling the pandemic.

A deeper understanding of asymptomatic transmission is required.

It would be helpful to study, compare and learn from regions or countries around the world that have implemented different levels of transmission containment interventions in public transit, hospital, school, workplace, commercial and sports settings.

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CanCOVID uses digital collaboration tools to rapidly co-create and mobilize knowledge across Canada’s diverse healthcare, research, policy, industry, and partner communities.

Our mission is to support needs-driven research and agile, evidence-based decision-making to help Canada steer quickly, safely, and compassionately through the COVID-19 pandemic.

Our members are affiliated a wide range of organizations from across Canada’s universities, hospitals, research networks, industry, public health authorities, provincial and regional governments, community non-profits, and funding agencies.

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