Answering Question around COVID-19: The Chain of Transmission Model

Fundamental to understanding how pathogenic microorganisms can cause disease in humans is to understand how infection occurs. A time tested model used by the Centers for Disease Control and Prevention and Health Canada is the “chain of transmission” model.1,2

The Chain of Transmission, or chain of infection model, outlines 6 critical factors that are required for infection to occur. The microorganism must be capable of causing disease in people and must move to a susceptible host and enter their body for infection to occur. The six links in the model are: the infectious agent, reservoir, portal of exit, mode of transmission, portal of entry and susceptible host. The best visual representation of this model are 6 links in a chain, with the goal being to break one or more of the links, to prevent transmission or infection. A key part of the usefulness of this model is understanding that you can interrupt the chain at any link and prevent infection, but some links in the chain are much easier to interrupt than others.

SARS-CoV-2, as a novel virus, is generating many questions around the globe: questions from both healthcare workers and the public, on how to stay healthy, what and when to clean, and other issues to stop transmission. Typical COVID-19 (the disease caused by SARS-CoV-2) signs and symptoms include fever, cough, and shortness of breath. Potential atypical symptoms assessed included sore throat, chills, increased confusion, runny nose or congestion, muscle aches, dizziness, tired, headache, nausea, and diarrhea.3

In some cases rather outrageous or impractical things are being promoted in social media as a certainty in stopping infection. Infection Preventionists should always follow the established science, which is to apply the chain of infection model to prevent transmission, especially when posed with a question or a scenario, and asked for their advice. This paper will review what is currently known about this novel virus, and offer practical ways to break a ‘link’ or to prevent someone from getting exposed to, or infected with this virus. This will allow thoughtful answers of questions posed by the public and by healthcare workers.

The Infectious Agent
SARS-CoV-2 is a Coronavirus. Coronaviruses are enveloped viruses.4 All enveloped viruses (e.g., Hepatitis B, HIV, Influenza, etc.), are very susceptible to chemical disinfecting agents,4 and on a hierarchy of ‘easy to kill’ to ‘hard to kill’, enveloped viruses are the easiest microorganism to kill, with bacterial spores being the hardest.5 SARS-CoV-2 is genetically related to SARS CoV from 2002/2003 and is now the seventh coronavirus known to cause disease in humans.6 This virus is present, and established as our infectious agent.

Reservoir
The human is a reservoir, with the virus being present in respiratory secretions such as saliva and respiratory mucous. There is some evidence that the virus is excreted in stool, but no documented cases of fecal-oral spread have been conclusively presented.7 Animals are now known to be the original reservoir, with bats a likely host,6 but animals have not been found to be a source of current transmission of this virus. Thus the current reservoir is infected people.

Portal of Exit
If a person has the virus in their upper respiratory tract, the portal of exit is coughing, sneezing, talking, singing, yelling, or certain medical procedures generally done within healthcare. These procedures are known as aerosol-generating procedures (AGP) which can include:
• Sputum induction
• Open suctioning of airways
• Intubation and related procedures (e.g., manual ventilation, open endotracheal suctioning)
• Cardiopulmonary resuscitation (CPR)
• Bronchoscopy
• Sputum induction
• Nebulized therapy
• Non-invasive positive pressure ventilation (continuous or bi-level positive airway pressure)²,⁸

The most common portal of exit, however, is coughing, sneezing or talking, which are common daily activities for most people. Infectious particles may exit the infected person and land on hard surfaces, soft surfaces, or on the mucous membranes of the eyes, nose and mouth of other susceptible hosts.

**Mode of Transmission**
Transmission of infectious pathogens are generally classified as contact, droplet or aerosol with many pathogens capable of being transmitted via multiple modes. Contact is divided into direct and indirect. Direct contact would be kissing someone who has the virus, or sharing a straw or eating utensil, like a fork or spoon. Indirect contact is touching a surface contaminated by a cough, sneeze or someone talking, and then touching a portal of entry: eyes, nose or mouth. Droplet transmission occurs when someone who has the virus in their respiratory secretions coughs, sneezes or talks closely to someone else, contaminating the eyes, nose or mouth of the other person with the respiratory secretions. Airborne transmission is theoretical with this virus (WHO online), but would involve an AGP with these small, droplet nuclei coming in contact with the eyes, nose or mouth.

**Portal of Entry**
How does the infectious agent get into the susceptible host? Current thinking is that the virus comes into contact with the mucous membranes of the respiratory tract: eyes, nose or mouth. There is no evidence of foodborne transmission within the CDC, Health Canada or WHO documents.⁸,⁹,¹⁰

**Susceptible Host**
Currently most people are susceptible to this virus, in varying degrees: from asymptomatic carriage, to severe respiratory collapse leading to death. >80% of cases are asymptomatic to mild. Other factors that lead to a more severe illness include:

• People aged 65 years and older
• People who live in a nursing home or long-term care facility
• People with chronic lung disease or moderate to severe asthma
• People who have serious heart conditions
• People who are immunocompromised including cancer treatment
• People of any age with severe obesity (body mass index [BMI] ≥40) or certain underlying medical conditions, particularly if not well controlled, such as those with diabetes, renal failure, or liver disease might also be at risk.³,¹¹

There is ongoing research into the immune response to this novel virus.¹²

**Breaking the Link(s) or Answering Questions**
Some links cannot be ‘broken’ or eliminated at this point in the pandemic. We are all susceptible hosts to one degree or another, and if we are currently infected, we have an infectious agent within
a well-recognized reservoir. Most questions, when posed, need to be assessed via the other links described. The three most efficient ways of stopping virus transmission are discussed below.

**Breaking the Portal of Exit**
We can limit virus leaving the mucous membranes by covering coughs and sneezes with a tissue, clothing or using your elbow (proper respiratory etiquette). Within the healthcare setting the use of a mask is recommended if tolerated. Also, social distancing or self-isolation (staying away from other people) will limit the spread of respiratory droplets. After sneezing or coughing, and after covering the portal of exit with a mask, we need to wash or sanitize our hands. CDC is now recommending the use of homemade masks for use by the public to stop transmission when asymptomatic or pre-symptomatic.13

**Breaking the Mode of Transmission**

- **Direct Contact**
  If someone has symptoms of COVID-19, do not kiss them or share straws or eating utensils.

- **Indirect Contact**
  If you have touched something that may have virus on it, either wash your hands with soap and water (using a good 20 seconds of lathering and rubbing), or if hands are visibly clean, use alcohol based hand rub (hand sanitizer). If there is a surface that may have virus on it, wipe with a disinfectant, or a store-bought sanitizer, or a good detergent with friction. This virus is not hard to inactivate on surfaces.

- **Droplet**
  Anyone who is actively coughing or sneezing should wear a mask if within a healthcare setting. If in public, they should cover their cough or sneeze. Keeping 6 feet or 2 meters from each other (social distancing, self-isolation) will also limit contact with respiratory droplets shed when sneezing, coughing or talking. Healthcare workers will wear face protection when working with a person under investigation for the illness. Also, not being face to face will limit droplet spread, healthcare providers can work beside a patient, or if caring for an ill person, avoid that face to face position.

- **Aerosol**
  Healthcare workers performing AGP will wear face protection, covering their eyes, nose and mouth with goggles, face shields, masks or respirators, depending on availability. This is still considered a theoretical mode of transmission.8 A case report in Singapore did indicate that masks were protective, with no statistical difference between wearing a surgical mask compared to a respirator during AGP.14

**Breaking the Portal of Entry**
The virus cannot enter our body unless it comes into contact with our eyes, nose or mouth. Regardless of the viral load on our hands from the environment, if we do not put the virus into our eyes, nose or mouth, we do not get sick. Thus the best defense against SARS-CoV-2 is frequent hand hygiene and social distancing.

At this time, it has been found that the virus can survive on surfaces for 3 days.15 This could include shopping cart handles, door knobs, gas pump handles, medical equipment, etc. If those surfaces cannot be disinfected prior to use, keep hands away from the portal of entry and perform hand hygiene with the method that is most readily available as soon as possible after contact. Thus, cleaning and disinfection are also helpful in preventing disease transmission.

Being vigilant to interrupt the chain of infection may not provide 100% protection because mistakes or gaps in adherence are likely. However the more practices we follow consistently, the higher the
probability that we can prevent infection. There are numerous suggestions online or in social media for protecting ourselves from this novel virus, and many do not factor in issues with these links. Careful analysis of the six links can help to clarify issues when answering questions.

References