Transmission Routes of SARS-Cov-2: Literature Review as of October 21, 2020

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With COVID-19 rapidly spreading throughout the world, there is great interest in determining the main method of transmission. By knowing the main route of transmission, proper mitigation can help prevent further spread.

Currently, the CDC states that close contact with an infected individual is the common route of transmission and is believed to be due to inhalation of respiratory droplets. Recently, the CDC has also recognized that smaller particles and droplets "that can linger in the air for minutes to hours" could be playing a role under certain conditions.[1] Besides the information supporting droplet and sometimes aerosol transmission, there is evidence that suggests that SARS-Cov-2 may also be spread through fomites, but likely much less than the droplet route. Below is a brief summary of evidence for specific routes of transmission as they pertain to the current pandemic.

Droplet

Droplet transmission refers to droplets released by an infected person larger than a standard, accepted cutoff of 5μm. Droplets are generally created during high expulsion activities such as sneezing or coughing and are created simultaneously to aerosols described below.[2,3] Transmission occurs when droplets from an infectious individual enter a new host, for example, when a healthy individual inhales after an infectious individual has sneezed in close proximity. This route of transmission has received attention as other respiratory viruses such as SARS, MERS, and influenza also transmit via droplets. In addition to the CDC stating this is a major route, specific outbreak investigations provide evidence for this. For example, the Skagit county choir practice in Washington could have propagated via droplets, in addition to possible aerosol spread, from the close contact of attendees during the 2.5 hour practice.[4] And, early transmission has been shown to occur from close contacts since the beginning of the outbreak in China.[5]

Due to the larger size of droplets, gravity will pull them down before they have the chance to travel long distances. Most droplets will be removed from the air before traveling 1-2 meters.[6] Although, some studies have shown that droplets may be able to travel further distances when strong air currents are present.[7] After falling, these infectious droplets can remain on surfaces which can then become a route of transmission. Studies have shown detection of viral RNA on floors, toilets, door handles, bed railings, etc.[8–10] Most nations have implemented interventions to curb this route of transmission, namely, physical distancing by 6 feet/2 meters, wearing facemasks as source control, covering eyes, and stay at home orders.

Fomite

Fomite transmission occurs by touching an inanimate object that is contaminated with infectious material and then transferring the infectious material via touching the eyes or mouth. This is a plausible pathway as studies have found virus on numerous surfaces and their ability to survive hours and even days in some cases.[11–16] While the virus may be detectable on surfaces, the amount can rapidly decline[12] and can vary greatly depending on air temperature and relative humidity.[13] For example, a study being conducted on common materials of items from libraries has shown live SARS-Cov-2 virus to be undetectable after 1 day for common book paper or DVD cases.[17] Other materials can support live virus for longer, such as up to 4 days for glossy book paper or magazine paper, and stacking these same library materials increases the time the virus can be detected. Transmission via fomites is thought to have increased the number of infections during a business conference and amongst visitors at a church in Singapore,[18] as well as contributed to transmission of COVID-19 in a Chinese shopping mall through shared touch surfaces.[19]

To combat transmission of SARS-Cov-2 by fomites, the WHO and CDC recommend frequent handwashing, cleaning of surfaces, and avoiding touching one's face. By constantly cleaning hands and surfaces the virus will be removed or deactivated and will then be unable to infect others.

Aerosol

Aerosolization refers to small aerodynamic droplets generally accepted as being less than 5 μm in diameter. These particles are created through aerosol generating procedures such as intubation[20,21] and also through normal actions such as talking, singing, and breathing.[20] Aerosolized viruses may lead to more severe COVID-19 since the smaller particles are able to travel further into the lungs.[22] The dynamics of aerosol transmission differs from droplets. Aerosolization can be especially problematic because the virus is able to suspend in the air in these small droplets. These droplets are then subject to the airflow of a given space and therefore could travel large distances beyond the accepted physical distancing of 6 feet/2 meters and survive suspended in the air.

Over the course of the pandemic, evidence has grown to support the possibility of aerosol transmission playing a significant role under specific conditions. Several studies have detected the SARS-CoV-2 virus in air samples and on surfaces beyond the 6 feet.[10,23–26] van Doremalen et al. showed the virus was still viable in aerosols for at least 3 hours,[27] however, in one study, the amount of virus was low.[25]

Ventilation appears to play a role in reducing or eliminating the presence of the virus in air samples. While some studies have detected SARS-CoV-2 in air samples from patient rooms that usually have HEPA filtration and increased air exchange rates,[28,29] others have failed to detect the virus under similar circumstances.[25] de Man et al. described an outbreak in a nursing home where one specific ward experienced an outbreak while all others did not.[30] An epidemiologic investigation followed by an investigation of the HVAC system suggests the low mixing of fresh air in the air system coupled with recycled air provided by two air conditioning units could have contributed to the outbreak through spreading aerosolized SARS-CoV-2. Notably, the virus was detected in dust from the mesh filter from an air conditioner in addition to filters in three ventilation cabinets. Another large study of aerosol dispersion in airplanes using manikins and fluorescent tracers reported very low risk from exposure to aerosols.[31] Limitations of this study should be considered since the manikins did not move, eat, or talk and wore masks. Additionally, high rates of air exchange and filtration in the planes during the experiment likely played a positive role and may not represent true conditions during a typical flight. Experts maintain that aerosols building up in crowded rooms with poor ventilation pose an increased threat of COVID-19 infection.[32]

For SARS-Cov-1, the most known outbreak caused by aerosols occurred at the Amoy Gardens living complex, where residents living on floors above an infectious case also became infected through aerosol transport of the virus.[33] Certain outbreaks of COVID-19, such as those described in a restaurant where infected individuals did not sit together, cannot rule out transmission via aerosols.[34]

A method of combating this route of transmission is through high ventilation rates of the space, use of HEPA or high-rated MERV filters to filter out the particles, and wearing of personal protective equipment. Environments with poor ventilation can be especially dangerous as these particles will “hang” in the air for extended periods of time while still remaining infectious.[35]

Fecal

A common theme through many studies of patients with COVID-19 is that viral RNA is detectable in fecal matter well beyond when a nasopharyngeal test is negative. Many studies compare the difference in time from a negative nasopharyngeal test versus a negative test in a stool sample or anal swab. Most studies report an average difference of 10-20 days, with some exceptions that may exceed 40-50 days.[36–41] Additionally, some studies examining environmental contamination in COVID-19 patient wards have found many positive samples from bathrooms, suggesting potential fecal contamination[29,42].

With viral RNA detectable in fecal matter, the concern of transmission of SARS-Cov-2 via the fecal-oral route exists. Most studies have focused on detection of viral RNA and only a few have investigated whether the fecal-oral route is possible. Based on the literature, there is confidence that fecal matter contains viral RNA.[43] Although, only a few studies have claimed to have found live virus capable of infection in small samples of subjects.[44,45] Based on this information, there is no definitive answer on whether the fecal-oral route of transmission is viable, which suggests that handwashing should continue to be encouraged.

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