Transmission of SARS-CoV-2: implications for infection prevention precautions

Scientific brief

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Modes of transmission

This section briefly describes possible modes of transmission for SARS-CoV-2, including contact, droplet, airborne, fomite, fecal-oral, bloodborne, mother-to-child, and animal-to-human transmission. Infection with SARS-CoV-2 primarily causes respiratory illness ranging from mild disease to severe disease and death, and some people infected with the virus never develop symptoms.

Contact and droplet transmission

Transmission of SARS-CoV-2 can occur through direct, indirect, or close contact with infected people through infected secretions such as saliva and respiratory secretions or their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks or sings.(2-10) Respiratory droplets are >5-10 μm in diameter whereas droplets <5μm in diameter are referred to as droplet nuclei or aerosols.(11) Respiratory droplet transmission can occur when a person is in close contact (within 1 metre) with an infected person who has respiratory symptoms (e.g. coughing or sneezing) or who is talking or singing; in these circumstances, respiratory droplets that include virus can reach the mouth, nose or eyes of a susceptible person and can result in infection. Indirect contact transmission involving contact of a susceptible host with a contaminated object or surface (fomite transmission) may also be possible (see below).

Airborne transmission

Airborne transmission is defined as the spread of an infectious agent caused by the dissemination of droplet nuclei (aerosols) that remain infectious when suspended in air over long distances and time.(11) Airborne transmission of SARS-CoV-2 can occur during medical procedures that generate aerosols ("aerosol generating procedures").(12) WHO, together with the scientific community, has been actively discussing and evaluating whether SARS-CoV-2 may also spread through aerosols in the absence of aerosol generating procedures, particularly in indoor settings with poor ventilation.

The physics of exhaled air and flow physics have generated hypotheses about possible mechanisms of SARS-CoV-2 transmission through aerosols.(13-16) These theories suggest that 1) a number of respiratory droplets generate microscopic aerosols (<5 μm) by evaporating, and 2) normal breathing and talking results in exhaled aerosols. Thus, a susceptible person could inhale aerosols, and could become infected if the aerosols contain the virus in sufficient quantity to cause infection within the recipient. However, the proportion of exhaled droplet nuclei or of respiratory droplets that evaporate to generate aerosols, and the infectious dose of viable SARS-CoV-2 required to cause infection in another person are not known, but it has been studied for other respiratory viruses.(17)

One experimental study quantified the amount of droplets of various sizes that remain airborne during normal speech. However, the authors acknowledge that this relies on the independent action hypothesis, which has not been validated for humans and SARS-CoV-2.(18) Another recent experimental model found that healthy individuals can produce aerosols through coughing and talking (19), and another model suggested high variability between individuals in terms of particle emission rates during speech, with increased rates correlated with increased amplitude of vocalization.(20) To date, transmission of SARS-CoV-2 by this type of aerosol route has not been demonstrated; much more research is needed given the possible implications of such route of transmission.

Experimental studies have generated aerosols of infectious samples using high-powered jet nebulizers under controlled laboratory conditions. These studies found SARS-CoV-2 virus RNA in air samples within aerosols for up to 3 hours in one study (21) and 16 hours in another, which also found viable replication-competent virus.(22) These findings were from experimentally induced aerosols that do not reflect normal human cough conditions.

Some studies conducted in health care settings where symptomatic COVID-19 patients were cared for, but where aerosol generating procedures were not performed, reported the presence of SARS-CoV-2 RNA in air samples (23-28), while other similar investigations in both health care and non-health care settings found no presence of SARS-CoV-2 RNA; no studies have found viable virus in air samples.(29-36) Within samples where SARS-CoV-2 RNA was found, the quantity of RNA detected was in extremely low numbers in large volumes of air and one study that found SARS-CoV-2 RNA in air samples reported inability to identify viable virus. (25) The detection of RNA using reverse transcription polymerase chain reaction (RT-PCR)-based assays is not necessarily indicative of replication- and infection-competent (viable) virus that could be transmissible and capable of causing infection.(37)

Recent clinical reports of health workers exposed to COVID-19 index cases, not in the presence of aerosol-generating procedures, found no nosocomial transmission when contact and droplet precautions were appropriately used, including the wearing of medical masks as a component of the personal protective equipment (PPE). (38, 39) These observations suggest that aerosol transmission did not occur in this context. Further studies are needed to determine whether it is possible to detect viable SARS-CoV-2 in air samples from settings where no procedures that generate aerosols are performed and what role aerosols might play in transmission.

Outside of medical facilities, some outbreak reports related to indoor crowded spaces (40) have suggested the possibility of aerosol transmission, combined with droplet transmission, for example, during choir practice (7), in restaurants (41) or in fitness classes.(42) In these events, short-range aerosol transmission, particularly in specific indoor locations, such as crowded and inadequately ventilated spaces over a prolonged period of time with infected persons cannot be ruled out. However, the detailed investigations of these clusters suggest that droplet and fomite transmission could also explain human-to-human transmission within these clusters. Further, the close contact environments of these clusters may have facilitated transmission from a small number of cases to many other people (e.g., superspreading event), especially if hand hygiene was not performed and masks were not used when physical distancing was not maintained.(43)

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Direct
Druppelinfectie: transmissie via grote druppels uit hoesten en niezen binnen een afstand van 1,5 meter. Via Medische procedures die een infectieus aerosolgenereren (WHO 2020a). De Federatie Medisch Specialisten heeft een overzicht van deze medische procedures gepubliceerd.

De rol van verspreiding via fecaal-oraal contact is nog onduidelijk. Virus is gedetecteerd en gekweekt uit feces (Wang W 2020, Xu 2020, Zhang 2020). Dit zal naar verwachting weinig bijdragen aan de overall transmissie.

Indirect
Er zijn aanwijzingen dat indirecte overdracht mogelijk is wanneer een persoon met de handen besmette oppervlakten en voorwerpen heeft aangeraakt waarop voldoende infectieus virus aanwezig is en daarna de mond, ogen of neus aanraakt (WHO 2020 transmission, ECDC Q&A4, Van Doremalen 2020). Er is geen bewijs waaruit blijkt dat indirecte overdracht in de publieke ruimte, waaronder openbaar vervoer en winkels, heeft plaatsgevonden. De kans op overdracht via oppervlakken en voorwerpen nabij een bevestigde COVID-19-patiënt lijkt groter dan in de publieke ruimte, maar het is nog onduidelijk of dit een belangrijke of prominente rol speelt in de verspreiding (Guo 2020, Yung 2020, Ong 2020).

Aerogeen
Het is op dit moment onduidelijk of aerogene verspreiding (via zwevende deeltjes in de lucht) een relevante rol speelt bij de verspreiding van het virus. Een uitzondering vormen aerosolvormende handelingen in de zorg, waar aanvullende maatregelen worden geadviseerd (WHO 2020a). De Federatie Medisch Specialisten heeft een overzicht van deze medische procedures gepubliceerd. Zie voor achtergrondinformatie en literatuurreferenties de bijlage Inhoudelijke onderbouwing van de mogelijke rol van aerogene verspreiding van SARS-CoV-2 bij mens-tot-mens transmissie en de bijdrage van ventilatiesystemen en Ventilatie en COVID-19.

ECDC
https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-public-transport-29-April-2020.pdf

Personal protective measures on public transport in the context of COVID-19
Public transport is an essential service. In the context of the COVID-19 pandemic there are two types of risks related to public transport. First, crowding in public transport and their use by large numbers of people can contribute to direct transmission of COVID-19 through respiratory droplets and indirect transmission through contaminated surfaces; second, public transport staff are at increased risk of infection. The following measures are recommended to mitigate these risks and maintain public transport services: * Inform the passengers about the signs and symptoms of COVID-19 and advise that they should not use public transport if showing COVID-19 compatible symptoms (cough, sore throat, general weakness and fatigue, and muscular pain) [9]; * Ensure physical distancing for service staff at booths, ideally behind glass or plastic panels; * Consider using protective barriers for the driver, when the driving compartment is not physically separated from the travellers [10]; * Disseminate information infographics for display in waiting areas, platforms and docks, explaining the importance of physical distancing, hand hygiene, respiratory etiquette, and the appropriate use of face masks if advised by health authorities [11]; * Facilitate physical distancing on public transport: * Prevent crowding in public transport and in the waiting areas through the provision of sufficient vehicles and consider enhancing the service during rush hour times. * Encourage physical distancing in the waiting areas only and allow the use of every other seat when on the vehicle/wagon/boat. * Consider reducing the maximum number of passengers per vehicle/wagon/boat to avoid crowding and ensure physical distancing of at least one metre. If the distance is less than two metres, the use of face masks may be considered. * In buses, introduce boarding from the rear doors to ensure physical distancing from the driver if the driving compartment is not physically separated from the travellers. * Ensure the availability of face masks to staff [10] who are not physically separated from travellers when working; * Ensure proper ventilation in the vehicle/wagon/boat at all times. Avoid recirculating air and encourage the use of windows, skylight panels and fans to increase replacement with fresh air. Such measures should be adapted based on local conditions, needs and type of vehicles and other equipment in use; * Remind the public about proper hand hygiene before boarding and after disembarking the vehicle/wagon/boat. Consider making alcohol based hand-rub solutions available on the vehicles and at transport hubs [10]; * Consider the use of face masks (medical or non-medical) for passengers on public transport, particularly if physical distancing cannot be guaranteed, paying attention to proper mask use