Review

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Coronavirus's (SARS-CoV-2) airborne transmission

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Abstract

This scientific review of mode of transmission of COVID-19 is to aid scientific community in generating hypothesis. The inadequate evidence on SARS-CoV-2 transmission has hindered the development of effective prevention strategy and resulted in continues pandemic of the COVID-19. Therefore, in this review, existing evidence is discussed, hypothesis is generated regarding COVID-19 mode of transmission, and recommendations are forwarded based on existing body of knowledge. Thus, two meters (2 m) physical distance is not completely safe even for large droplets and wearing a face mask is a key in the prevention of SARS-CoV-2 in public areas and confined space and public need to be vaccinated.

Keywords

COVID-19, SARS-CoV-2, droplets, airborne

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Introduction to Droplet and airborne transmission

Droplet

A virus-filled particle of breath or spittle that comes out of the nose or mouth of an infected individual when they breathe, speak, cough, or sneeze. Droplets fall to the ground within a few feet of the person who expels them. According to an atmospheric chemist at the Scripps Institution of Oceanography Aerosol has defined droplets as "A microscopic virus-packed particle that has also expelled from an infected person's mouth when breathing, speaking, coughing, or sneezing. Unlike a droplet, smaller aerosol particles can remain suspended in the air and continue to float and follow the air streams in a room."[1]

There are variations in the literature in cut point determination of the diameter of particles either droplet or airborne route of transmission of infectious diseases. Although there is some agreement that particle with diameters $<5\,\mu m$ (5 micrometer) is airborne particles, there is still a significant variation in the literature. Some considered $100\,\mu m$ as the cutoff limit for the droplet route.[2] Others considered a cut of a particle's diameter of more than $10\,\mu m$ to more than $100\,\mu m$.[3–5]

The World Health Organization (WHO) uses a cutoff limit of $5\,\mu m$ to differentiate between aerosols ($\leqslant 5\,\mu m$) and droplet ($>5\,\mu m$) transmission routes.[6] Particles with a diameter of more than $10\,\mu m$ can remain airborne long enough to not fall under the framework of classification of droplet route.[7] Experimentally generated aerosol particles of SARS-CoV-2 were found to have a viable virus in cell culture for 3 hours of aerosol-testing.[8]

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. Airborne transmission is different from the droplet transmission as it refers to the presence of microbes within droplet nuclei, which are considered as particles $<5\,\mu m$ in diameter, can remain in the air for long periods of time and be transmitted to others over distances greater than 1 m.[9]

Droplets exhaled when breathing, speaking, laughing, coughing, sneezing and in another procedure[9] and the size of the droplet determines whether the disease considered

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droplet or aerosol. Droplets greater than 5 μm in diameter are referred to as droplets, and those less than or equal 5 μm (5 micrometer) are referred to as aerosols,[10–12] although even these terms might be defined by other sizes in some literature. The droplet size distinction is a determining factor; the smaller the droplet, the longer and farther it may travel in the air because the buoyant force overcomes the gravity force to not fall near distance to droplet source.[11,13–15]

Body of the review

According to the reports of Center for Disease control and Prevention (CDC), Encyclopedia Britannica and review of studies in China show that the average diameter of SARS-CoV-2 is approximately 120 nm (one hundred twenty nanometer).[16–18] This average diameter of SARS-CoV-2 is much smaller than 5 μm.[6] According to WHO cut point, this makes SARS-CoV-2 aerosols and airborne transmission. Therefore, particles having a diameter of <5 μm overcome force of gravity and could stay on air for a long time and can go long distances.

Studies in Washington, China, and South Korea suggested that there is a possibility of aerosol transmission of SARS-CoV-2 combined with droplet transmission.[19–21] In Mongolia of China, COVID-19 positive case has been reported after repeatedly passing through the door of a symptomatic patient, giving evidence of the airborne transmission.[22] According to Morawska and Cao, some droplets, even large to be suspended in air, consequently become airborne. Larger droplets become smaller through evaporation so that such smaller particles are called droplet nuclei. Such aerosol particles with the encapsulation of viruses could be termed as bio-aerosols or droplet nuclei.[23] According to Duguid, breathing and exhalation originating from the nose have shed up to a few hundreds of droplets of which some were aerosols. In contrast, talking, coughing, and sneezing have produced more aerosols than droplets.[24]

According to Morawska, the physicochemical processes affecting the fate of airborne aerosols constitute evaporation, interaction with other types of particles, transport, and removal from the air by deposition on solid surfaces.[25] Particles in the air are often subjected to motion, gravity, electrostatic forces, thermal gradients, electromagnetic radiation, turbulent diffusion, and inertial forces. Of these mechanisms, the diffusion is a key mechanism of transmitting viruses.[26] Under standard atmospheric conditions, droplets smaller than 100 μm often evaporate before reaching the ground, and the evaporated droplet residues linger in the air for prolonged periods. When the droplets contain infectious bio-aerosols, such as viruses, bio-aerosols will remain in the air, even after the liquid content evaporates. However, the time interval that a virus survives in the air varies from one type of bio-aerosol to another type.[25]

According to Cox, droplets larger than 1 μm, gravity becomes more significant than the Brownian motion in deciding the fate of such particles whether droplet or airborne.[27] The average half-lives of the SARS-CoV-2 in aerosols are 1.1–1.2 hours, pointing that transmitting through the air is possible.[8] Based on 3 hours viability of SARS-CoV-2 in the air,[8] prerequisites for the disease such as exposure, inhalation, and infection could occur minutes or a few hours later near and far from an aerosol source even in a stagnant environment.[28]

Air velocity and relative humidity of the air carried away for more than 6 meters of horizontal distance.[4] Other studies have also revealed that when an infected person coughs or sneezes, pathogen-bearing droplets of different size travel even up to 7–8 meters from the point of source.[29,30]

The most important environmental factors that could impact the viability of airborne microorganisms are temperature, humidity, radiation (sunlight), and open-air.[31] Viruses in aerosols lose or gain the viability and infectivity because of environmental stresses such as temperature, relative humidity, and sunlight before they reach a susceptible host.[32]

A study published by Morawska and colleagues as a preprint found that people infected with SARS-CoV-2 exhaled 1000–100,000 per minute of viral RNA.[23] The experimental data suggest the possibility of aerosol-based transmission. The reproduction number for COVID-19 before measures were taken to mitigate its spread was estimated to be approximately 2.5, which means each person with COVID-19 infects an average of 2–3 other people. This reproduction number is small and comparable to disease transmitted by droplets and different from that of viruses that are well spread via aerosols.[33,34] This may be linked with the number of SARS-CoV-2 virus necessary to cause an infection, which is still unknown. According to the study conducted in Caribbean region, airborne mode of transmissions through aerosols and medical procedures were reported.[35]

Other modes of COVID-19 transmission

Recent studies found that SARS-CoV-2 RNA has been detected in body fluid samples, including the urine and feces of some patients and COVID-19 could be transmitted via fecal routes after they detected the live infectious agents of COVID-19 in patients' stools.[36–40] There have been no reports of feco-oral or blood-borne transmission of the COVID-19 virus to date. WHO has denounced that there was no supporting evidence on the fecal-oral transmission of the SARS-CoV-2 virus.[10]

Some other studies reported that detection of SARS-CoV-2 RNA in either plasma or serum, and the virus can replicate in blood cells. However, the role of transmission remains uncertain, and low viral titers in plasma and serum suggest that the risk of transmission through this route is low.[41]

Getting COVID-19 vaccinated could save life from COVID-19 morbidity and mortality that could cause. COVID-19 vaccines offer effective protection against serious illness, hospitalization, and death. There is also evidence that getting vaccinated makes this less plausible that you might spread the virus to others, so getting the vaccine also protects individuals around you those around you as well.

Even after you've been vaccinated, you should continue to take precautions to protect yourself, your family, friends, and anyone else you may come into contact with. Although COVID-19 vaccines are highly effective, some people will still become ill as a result of COVID-19 after vaccination. There is also a chance that you will spread the virus to others who have not been immunized.[42]

At the beginning of 2022, over 5.5 million deaths notified globally since the COVID-19 pandemic.[43] Regions and countries with high human development index (HDI) are affected by COVID-19 more than regions with low HDI. Regions with high HDI are affected by COVID-19 despite their high universal health coverage index (UHCI) and Global Health Security Index (GHSI). This seems to be a paradox scenario with existing body of knowledge that countries with weak health systems capacity will have worse health outcomes in that the countries with higher high UHCI and GHSI have experienced higher burdens of COVID-19. The paradox evidence can be somewhat explained by variations in testing procedures, ability for testing, and reporting of cases and deaths across different countries.[44]

Zoonotic modes of COVID-19 transmission

According to WHO report, all available evidence for COVID-19 suggests that SARS-CoV-2 has a zoonotic source. The transmission of the virus to humans happened through animal species that is more likely to be handled by humans. This intermediate animal host or zoonotic source could be a domestic animal, a wild animal, or a domesticated wild animal that is yet to be identified.[45]

Fomite mode of COVID-19 transmission

WHO reported that COVID-19 transmitted via respiratory droplets from infected individuals can also land on objects, creating fomites (contaminated surfaces). As environmental contamination has been documented and it is likely that people can also be infected by touching these surfaces and touching their eyes, nose, or mouth before cleaning their hands.

Discussion

This review suggests that infection prevention strategies to control further propagation of the disease.

Currently, droplet, fomite and zoonotic transmission of SARS-CoV-2 is an agreed route of transmission. So that hand sanitization, physical distancing, and using a face mask in public areas are being practicing in current prevention.

There is different scientific evidence on SARS-CoV-2 transmission route. Some scholars prove its transmission route is airborne but other disproves this view.[10] There is contradicting evidence on airborne route of transmission. Its transmission via stool, mother to child during pregnancy, and other body fluids such as urine and blood is still not proven. SARS-CoV-2 possibly transmits via airborne route according to the different studies and experts' opinions.[40,43,44]

Wearing face mask is a key to prevent SARS-CoV-2 in public areas, confined space like church, mosque, restaurants, hotels, health-care settings, schools, meeting halls, barber shops, shops, super markets, confined entertainment area irrespective of physical distancing and hand washing.

Two meters (2 m) physical distance is not completely safe even for large droplets. Because droplets' movement affected by wind currents and velocity, wind direction, emitting force from the source, slope gradient.

Limitation

This review based on merely published literature, experts' opinion, organizations' report, and guidelines. The whole review is narrative due to lack of quantitative findings. The dynamic innovative ideas and scientific findings on transmission and preventive and control measures may report inconsistent ideas with each other and may affect applicability of the recommendations.

Conclusion

COVID-19 transmission is via droplet, fomite, zoonotic, and aerosols. There is no adequate evidence of transmission through blood, urine, stool, and mother to child during pregnancy.

There are many hypotheses regarding transmission route of COVID-19, these hypotheses need to be tested. Wearing face mask is strongly recommended in public areas, confined space like church, mosque, restaurants, hotels, and health-care settings, schools, meeting halls, irrespective of physical distancing, hand sanitizing, stay home if unwell and get tested, and hand washing.

Two meter (2 m) physical distance is not completely safe even for large droplets. Because droplets' movement affected by wind currents and velocity, wind direction, emitting force from the source, slope gradient.

Wearing face mask in addition to physical distancing and sanitation minimizes the risk of acquiring the infection. Until the mode of transmission is understood well, covering the portal of entry and portal of exit using appropriate face mask has no harm and better strategy in the prevention of SARS-CoV-2. In addition to other prevention and control precautions, vaccination is key activity in prevention measures.

Author contributions

T.B.H. conceptualized, wrote the original draft, and synthesized. M.S.J. edited reviewed, and approved this review, S.N.H. reviewed and approved manuscript.

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