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Letter to the Editor

A Letter about the Airborne Transmission of SARS-CoV-2 Based on the Current Evidence

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ABSTRACT

World Health Organization has suggested that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is transmitted through person-to-person transmission and contact with contaminated surfaces. However, rapid spread of the coronavirus disease 2019 (COVID-19) suggests other routes such as airborne transmission may be involved. A few research studies have been conducted to evaluate the potential transmission of this virus through air. Although some studies have found no evidence of airborne transmission, other more recent work is proving the presence of SARS-CoV-2 even in public places. Also, the past experiences and knowledge about the mechanisms of similar viruses such as SARS-CoV support this hypothesis. It seems that the best decision at the moment is to follow a conservative approach, and accept the hypothesis that SARS-CoV-2 is able to be transmitted through air. By this, control measures could be employed to prevent further COVID-19 infection.

Keywords: SARS-CoV-2; COVID-19; Airborne transmission; Aerosolization.

MAIN TEXT

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that was firstly introduced in December 2019 in Wuhan, China, is now causing a pandemic of coronavirus disease 2019 (COVID-19), infecting about 2.9 million people and death toll of more than 203,000 people worldwide (https://www.worldometers.info/coronavirus/#countries).The symptoms of this disease may include but not limited to fever, shortness of breath, and cough (Sohrabi *et al.*, 2020). Due to the rapid spread of the disease, the transmission routes of SARS-CoV-2 have been subject of much debate. From the early beginning, the evidence suggested that this virus can be transmitted by respiratory droplets and contact with contaminated surfaces (Public Health England, 2020). Even though, the transmissibility of SARS-CoV-2 through airborne routes has been proposed, especially in case of aerosol generating procedure such as endotracheal intubation, bronchoscopy, open suctioning, administration of nebulized treatment, etc. in hospitals and health centers (WHO, 2020a). Airborne transmission has been defined by the World Health Organization (WHO) as the spread of an infectious agent caused by the dissemination of droplet nuclei that remain infectious when suspended in air over long distances and time (WHO, 2014).

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In China, epidemiological assessment of more than 75,000 patients of COVID-19 reported that airborne particles cannot be a route for transmission (WHO, 2020b). In a study in Iran, 10 patient rooms were sampled using standard midget impingers, and no SARS-CoV-2 was detected from 2–5 m distance from the patients' beds. However, the volume of sampled air was low as 90 L (Faridi *et al.*, 2020). In another study in 2019, 8 air samples (by passing 1000 L air) were taken using an air sampler and culture plate containing viral transport medium (VTM) from a distance of 10 cm from the patients at different conditions (normal breathing, deep breathing, speaking continuously, and coughing continuously with or without surgical mask). All of the samples were negative in case of the novel corona virus (Cheng *et al.*, 2020b). In addition, no evidence for the airborne transmission of SARS-CoV-2 was found in a study of three patients' rooms in Singapore (Ong *et al.*, 2020).

Despite the mentioned studies, other reports, which mainly are more recent, have found the presence of SARS-CoV-2 in air and declared the possibility of airborne transmission. A study in two hospitals in Wuhan, some ICU, CCU, general patient rooms, and the hallway had undetectable or low concentrations of airborne SARS-CoV-2, but medical staff rooms in both hospitals and patients toilet in one hospital had positive airborne samples. More important results were the finding of positive samples of airborne SARS-CoV-2 in public areas, possibly due to the presence of asymptomatic carriers. Researchers found that reducing the number of people (patients or general people) reduced the concentrations of the virus (Liu *et al.*, 2020). In another study, air samples from the isolation rooms of the COVID-19 patients showed evidence of SARS-CoV-2 contamination even in hallways, indicating that this virus can be released to the surrounding environment as expired particles, during toileting and through contact with fomites (Santarpia *et al.*, 2020). Resuspension of deposited viruses can be another pathway for airborne transmission (Liu *et al.*, 2020). In another study, viable SARS-CoV-2 were found in the nebulized aerosols after three hours (van Doremalen *et al.*, 2020).

The mechanisms of production and size distribution of human-expired aerosols should be discussed when evaluating the transmission of viruses. Johnson *et al.* (2011) found three modes for aerosol production (from deep in lower respiratory tract, larynx, and oral cavity) during speech and voluntary coughing, leading to three size distribution with count median diameters of 1.6, 2.5 and 145 μm for speech and 1.6, 1.7 and 123 μm for coughing. Using sneezing tests by human participants, two distributions including unimodal (aerosol geometric mean: 360.1 μm) and bimodal (aerosol geometric mean: 74.4 μm) distributions have been observed for sneezing (Han *et al.*, 2013). In another study, more small size particles were generated during coughing (minimum diameter of about 4 μm) in comparison to speaking (minimum diameter of about 10 μm) (Xie *et al.*, 2009). Some of the studies of human generated droplets use instruments that are limited to droplets less than ~20 μm. Other studies designed to look at larger sized droplets such as Xie *et al.* (2009) found that the bulk of the droplet mass were in droplets were in the 50 to 100 μm. However, coughing and sneezing are not the only mechanisms for producing respiratory aerosols. Normal speech can produce 1–50 particles second^{-1} (0.06–3 particles cm^{-3}) for low to high amplitudes with a geometric mean particle diameter of 1 μm (Asadi *et al.*, 2019). In addition, different types of breathing generate particles at a lower rate and smaller diameters comparing to the speech. The lowest rate of particle production was observed in case of nose breathing (Asadi *et al.*, 2019). Finally, speech generated droplets were observed in modes near 3.5 μm and 5 μm. These modes were most pronounced during continuous vocalization (Morawska *et al.*, 2009).

In addition to this direct scientific evidence, we should also consider the past experiences and knowledge about the mechanisms of similar viruses such as SARS-CoV. Aerosol transmission has been known to be responsible for half of the influenza A transmission (Cowling *et al.*, 2013). People with influenza produce a significantly greater volume of aerosols during coughing with 63% of the cough droplets in the respirable size fraction (Lindsley *et al.*, 2012). Morawska and Cao (2020) have recently criticized the current approach of health authorities in prevention of COVID-19. Because of the increasing infection trends, and a better understanding of the basic science of viral infection spread, they concluded that the virus is probably spreading through the air (Morawska and Cao, 2020). Bourouiba (2020) reports that emissions from talking, coughing, and sneezing are more complex than simple expulsion of large droplets. In indoor air in temperate or cold climates, relative humidity values are low, and the droplets will evaporate rapidly to much smaller sizes, thereby staying airborne longer and be transported further than their initial size would suggest (Bourouiba, 2020). Airborne transmission is a function of particle size. Depending on how sampling is performed, capturing of fine particles affects the virus detection in samples and may bias conclusions in research studies (Nicas *et al.*, 2005). Also, the limited sensitivity of the polymerase chain reaction (PCR) tests can favor negative results (Cheng *et al.*, 2020a).

In conclusion, while we are observing the rapid spread of SARS-CoV-2 in the world, limited research studies have been conducted to investigate the potential airborne transmission of this virus. The more recent studies favor a role for airborne transmission. However, the results may not be completely conclusive at the moment. Given that the main recommendations by the health care sector and especially WHO in concentrating on person-to-person transmission and extended contact with infected persons or contaminated surfaces, it would be a better decision to take the conservative approach, and accept the hypothesis that SARS-CoV-2 is transmitted through air. On this basis, simple to implement control measures such as better ventilation, disinfection of air (e.g., using ultraviolet radiation) in public places, and changes in personal behavior such as wearing masks could be employed to prevent further COVID-19 infection.

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