Airborne transmission of SARS-CoV-2: The world should face the reality

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\section*{A R T I C L E   I N F O}

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\section*{A B S T R A C T}

Hand washing and maintaining social distance are the main measures recommended by the World Health Organization (WHO) to avoid contracting COVID-19. Unfortunately, these measures do not prevent infection by inhalation of small droplets exhaled by an infected person that can travel distance of meters or tens of meters in the air and carry their viral content. Science explains the mechanisms of such transport and there is evidence that this is a significant route of infection in indoor environments. Despite this, no countries or authorities consider airborne spread of COVID-19 in their regulations to prevent infections transmission indoors. It is therefore extremely important, that the national authorities acknowledge the reality that the virus spreads through air, and recommend that adequate control measures be implemented to prevent further spread of the SARS-CoV-2 virus, in particular removal of the virus-laden droplets from indoor air by ventilation.

The entire world is anxiously watching as COVID-19, a disease caused by the SARS-CoV-2 virus, spreads from country to country, following modern travel routes. It was first reported to the WHO Country Office in China on 31 December 2019 (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen). After that, it inevitably crossed the country’s boundaries, and has become a global pandemic (WHO 2020b).

It could be said that compared with previous global epidemics or pandemics, humanity is much better equipped to control the new epidemic. The virus's gene sequence was identified and made public and a vaccine (Yan et al. 2020). In addition, testing methods measuring the infection (using RT-PCR) and measuring the antibodies formed after infection (using immunoassays) (Elfaitouri et al. 2005; Souf 2016). Real-time statistics on all aspects of the virus’s transmission are available online (Worldometers 2020). Countries have enacted emergency response procedures, and travel bans have been put in place (Tian et al. 2020), and lockdown procedures which limit the movement of people inside the administrative zones.

Unfortunately, the truth is that we have only a rudimentary knowledge of several aspects of infection spread, including on one critical aspect of the SARS-CoV-2 virus: how THIS virus transmits (Bourouiba 2020; Brosseau 2020). In general it is considered that viral respiratory infections spread by direct contact, such as touching an infected person or the surfaces and fomites that the person has either touched, or on which large virus-containing droplets expired by the person have landed (Morawska 2006), and there the virus can remain stable for days (van Doremalen et al. 2020). The droplets can also be deposited directly on a person in close proximity to the infected person. Therefore, frequent hand-washing and maintaining a distance of at least one meter (arm’s length) are considered the main precautions against contracting the infection (WHO 2020a). One transmission route that is mentioned only in passing, or not at all, is the transport of virus-laden particles in the air. Immediately after droplets are expired, the liquid content starts to evaporate, and some droplets become so small that transport by air current affects them more than gravitation. Such small droplets are free to travel in the air and carry their viral content meters and tens of meters from where they originated (e.g. Morawska et al. 2009), as graphically presented in Fig. 1.

Is it likely that the SARS-CoV-2 virus spreads by air? Its predecessor, SARS-CoV-1, did spread in the air. This was reported in several studies and retrospectively explained the pathway of transmission in Hong Kong’s Prince of Wales Hospital (Li et al. 2005; Xiao et al. 2017; Yu et al. 2005), as well as in health care facilities in Toronto, Canada (Booth et al. 2005), and in aircraft (Olsen et al. 2003). These studies concluded that airborne transmission was the main transmission route in the indoor cases studied. Other examples of airborne transmission of viral infections include the spread of Norwalk-like virus between school children (Marks et al. 2003), and the transmission of influenza A/H5N1 virus.
It is difficult to explain why public health authorities marginalize the significance of airborne transmission of influenza or coronaviruses, but a possible reason is that it is difficult to directly detect the viruses traveling in the air. Immediately after expiration, the plume carrying the expired viral content is diluted, and as it travels in the air carried by the air flow. In the process, the concentration of the virus does not increase uniformly in the interior environment of the enclosed space, but it is elevated only in the flow (if there is adequate ventilation, which is normally the case in medical facilities or on aircraft) (Morawska 2006). Therefore, sampling for the presence of the virus requires knowledge of the air flow from the infected person, and a sufficiently long sampling period to collect enough copies of the viruses. Both these requirements present major challenges: microbiologists collecting viral samples are not normally experts in building flow dynamics, and practicality prevents long sampling times that would be adequate for the sensitivity of existing viral detection methods (Booth et al. 2005). The fact that there are no simple methods for detecting the virus in the air does not mean that the viruses do not travel in the air. The above-mentioned retrospective modeling studies explained the transmission of SARS-CoV-1 in 2003 (Booth et al. 2005; Li et al. 2005; Olsen et al. 2003; Xiao et al. 2017; Yu et al. 2005). While we do not yet have all the required data in hand, including for example data on the patterns of infections, or specific indoor characteristics where the infections occurred, analysis of the initial pattern of COVID-19 spread in China reveals multiple cases of non-contact transmission, especially in areas outside Wuhan, such as those in Hunan and Tianjin. On numerous cruise ships where thousands of people onboard were infected, many of the infections occurred after the imposition of isolation that confined passengers for the majority of time to their cabins, and limited direct contact, and with hand hygiene carefully obeyed. Was it therefore the ventilation system that spread the airborne virus between the cabins one of the reasons for the infections? There are also hypothesis, that airborne transmission was at least partially responsible for a larger number of infections during a choir, where 45 out of 60 choir members were infected (Read 2020).

Despite the evidence and strong hypotheses, the world appears to be locked in the old way of thinking that only direct contact matters in
viral infection spread. It is disconcerting that with all the experience and evidence currently available, when faced with a new viral outbreak of COVID-19, the authorities still fail to acknowledge the airborne pathway of transmission, although many experts in China and other countries have had experience with dealing with SARS.

We predict that this failure to immediately recognize and acknowledge the importance of airborne transmission and to take adequate actions against it will result in additional cases of infection in the coming weeks and months, which would not occur if these actions were taken. The air transmission issue should be taken seriously now, during the course of the epidemic. When the epidemic is over and retrospective data demonstrates the importance of airborne transmission it will be too late. Further, the lessons learnt now will prepare us better for when the next epidemic strikes.

To summarize, based on the trend in the increase of infections, and understanding the basic science of viral infection spread, we strongly believe that the virus is likely to be spreading through the air. If this is the case, it will take at least several months for this to be confirmed by science. This is valuable time lost that could be used to properly control the epidemic by the measures outlined above and prevent more infections and loss of life. Therefore, we plead that the international and national authorities acknowledge the reality that the virus spreads through air, and recommend that adequate control measures, as discussed above, be implemented to prevent further spread of the SARS-CoV-2 virus.

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