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Commentary

Sustainability of SARS-CoV-2 in aerosols: should we worry about airborne transmission?

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SARS-CoV-2 is predominantly transmitted by respiratory droplets and contact with contaminated surfaces, but the role of aerosol is debated. The usual personal protective equipment (PPE) recommended for healthcare workers (HCWs) includes gown or apron, gloves, protective goggles, head cover and face mask. For the latter, the World Health Organization recommends the wearing of an anti-projection or surgical mask when caring for COVID-19 patients, and a respirator (filtering facepiece particles (FFP) or N95 mask) only in case of aerosol-generating procedures (AGPs) (https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2eng.pdf). This is based on previous knowledge [1] and the convictions that: a patient positive for SARS-CoV-2 is contagious by respiratory secretions (>10 μm in size) that disseminate only over a short distance (<1 m); SARS-CoV-2 carried on large droplets settles on to local surfaces and is not stable in the air; SARS-CoV-2 aerosol dispersion is possible during AGPs which extensively expose HCWs and therefore HCWs need to wear a respirator for greater respiratory protection during AGPs. However, an experimental study by van Doremalen *et al.* [2] assessed the sustainability of SARS-CoV-2 in aerosols (<5 μm at 65% of hygrometry (expressed in %RH for relative humidity)) performed using a high-powered machine that does not reflect normal cough conditions (https://www.who.int/publications-detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations). They showed that SARS-CoV-2 remained viable and infective for at least 3 h in aerosols, which opened the debate on SARS-CoV-2 transmission through long-distance aerosols (>1 m), and questioned the appropriateness of respiratory protection for HCWs.

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An individual who is well, emits $10-10^4$ particles per litre of expired air, including 95% of <1-μm-sized particles [3]. When speaking, the rate of emitted particles can reach 5000 particles per minute, with a size up to 60 μm. A cough generates 10^3-10^4 particles of size between 0.5 and 30 μm (with a predominance of <2-μm particles size) [3], while a sneeze produces around 10^6 particles between 0.5 and 16 μm in size (https://www.anses.fr/fr/system/files/AIR2006et0003Ra.pdf). However, the particle size evolves based on temperature and humidity. Large-sized particles can rapidly desiccate at high temperature and low humidity, subsequently remaining suspended in the air [4]. Models assessing viral infectivity in aerosols and droplets, focused mainly on influenza virus, showed that respiratory droplets, usually between 10 and 100 μm in size at their emission, can rapidly shrink even more when poorly concentrated in organic substances, depending on humidity [5]. Droplets containing mixtures mimicking respiratory mucus decrease from 10 μm to 1.9 μm under 64 RH%, which significantly extended their time to settle from a height of 1.5m, from 8min to 216min [5]. Converseley, even if the humidity appears as an important parameter to consider in the potential distance and time of droplets dissemination, it may not modulate the stability of respiratory viruses in aerosols in the presence of organic material. A study comparing infectivity of both fine aerosols and stationary droplets containing pandemic influenza A (H1N1) according to seven different conditions of humidity at 25°C showed no significant differences of infectivity for both aerosols and droplets containing respiratory-like secretions [6]. Furthermore, even if influenza is considered as a droplet-mediated disease, a study showed that 43% of viral RNA emitted from patients was carried on particles of <1 μm in diameter, suggesting the potential for airborne transmission [7].

Under real-life conditions in healthcare settings, a study assessed the extended SARS-CoV-2 dispersion within the hospital environment, by sampling air and surfaces in the rooms of three COVID-19 patients, before routine cleaning for one of them (Patient 3) [8]. All environmental samples collected after cleaning the rooms of Patients 1 and 2 were negative, while SARS-CoV-2 was retrieved from 61% of surfaces sampled in the room of Patient 3. The authors were not able to identify SARS-CoV-2 in air but detected it on air exhaust outlets, suggesting that the virus in droplets was displaced by airflows and reached the vents [8]. Aerodynamic analysis of SARS-CoV-2 in two hospitals caring for COVID-19 patients in Wuhan showed that SARS-CoV-2 was present in air (including small-sized particles) especially in confined spaces [9]. But the important limitation of these two studies is that the authors did not demonstrate that SARS-CoV-2 was viable and infectious [8,9]. Another study of the indoor air in healthcare settings caring for COVID-19 patients in Iran did not detecte SARS-CoV-2 in air samples collected 2–5 m from the patients' beds with confirmed COVID-19 in ventilated rooms [10]. However, these results are not transposable to poorly ventilated environments, and airborne transmission may occur in confined spaces in the absence of respiratory protection.

The important issues of clinical relevance that remain to be addressed are: what is the infective dose to contaminate a person by inhalation? What is the impact of air ventilation on indoor contamination during patient hospitalization? The viral load detected by reverse transcription polymerase chain reaction in respiratory specimens can be highly variable between patients [11] and the relationship between viral load in the respiratory tract and emitted droplets from a patient, along with the viability of SARS-CoV-2 in patient-generated aerosols remains to be demonstrated. Furthermore, the increased infective risk for HCWs seems limited to when AGPs are performed compared with normal ward based care, provided the HCW is wearing a mask [12].

Taking all these elements into consideration, potential airborne transmission of SARS-CoV-2 can not be excluded, especially in confined spaces, and needs further investigation. This was already the conclusion of Roy and Milton in 2004 [13] for SARS-CoV-1, who led the Center for Disease Control and Prevention to propose in their guidelines of 2007 to stop compartmenting droplet from airborne transmissions and consider modes of transmission as follows: obligate (transmission of the agent occurs only through inhalation of small particle aerosols, Mycobacterium tuberculosis as an example); preferential (transmission results of multiple routes, but small particle aerosols are the predominant route, as for measles or varicella); or opportunistic (agents naturally cause disease through other routes, but under special circumstances may be transmitted via fine-particle aerosols) (http://www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf). The transmission of both SARS and influenza should be considered as droplet transmission preferentially even if airborne transmission under rare specific circumstances has been described [14].

To date, implementing both droplet and contact precautions for HCWs seems adequate in significantly reducing the risk of infection by SARS-Cov-2 during clinical care, as previously demonstrated for SARS-CoV-1 [1]. To efficiently prevent contamination, wearing a face mask must be combined with other PPE [1,15]. The growing anxiety regarding the availability of PPE, especially face masks, urges researchers to rationalize their indications. In order to prevent a supply shortage, the requirement for face masks must be argued on the level of required effectiveness. Respirator (FFP or N95) masks must be only reserved for HCWs performing AGPs [15]. A precise list of AGPs should be compiled in order to strictly address the indications of respiratory masks.

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