Numerical Investigation on Airborne Transmission of Expiratory Droplets between Two Standing Manikins

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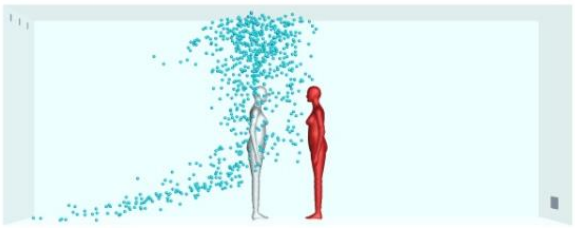
Considerable uncertainties remain about the relative importance of airborne, large droplet and contact transmission of respiratory viruses. Occurrence of infection close to the proximity for influenza and other respiratory diseases is often cited as evidence for large droplet and/or close contact transmission.

Using computational fluid dynamics simulations, we explore the interpersonal exposure of exhaled droplets and droplet nuclei of two standing people as affected by distance, humidity, and ventilation and breathing mode.

We find a substantial increase of airborne exposure to droplet nuclei exhaled by the source patient when a susceptible person is close to the source patient within 1.5 m, which is referred to as the proximity effect. The threshold distance of about 1.5 m distinguishes the two basic transmission processes of droplets and droplet nuclei, i.e. short-range modes and long range airborne route. The short range modes include both the conventional large droplet and the new short range airborne transmission. The droplet dispersion also varies with humidity, thus impact on the interpersonal transmission. With the same initial size, droplets could form droplet nuclei sufficiently fine enough to be suspended in air for a substantial length of time for the relatively dry air (e.g. relative humidity 35% and 23 ℃ as studied here), while droplets could also evaporate 10 times slower and settles down rapidly in the humid air (e.g. at relative humidity 95% and 23 ℃). We thus reveal that transmission occurring in close proximity to the index patient includes both droplet-borne (large droplet) and short-range airborne routes, in addition to the direct deposition of large droplets on other body surfaces which may lead to indirect contact transmission.

20 seconds



30 seconds

100 seconds
(a)

The mechanisms of droplet-borne and short-range airborne routes are different; and their effective control methods are also different. Both the existing droplet precaution and dilution ventilation does not prevent short-range airborne transmission, and new control methods are needed.

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