Respiratory activities correspond to a droplet velocity of 1 m/s for normal breathing, 5 m/s for talking, 10 m/s for coughing and 20-50 m/s for sneezing. Expelled droplets evaporate and desiccate in the air so that the final droplet nuclei shrink to roughly a half or one-third of the initial diameter[xi]. Droplets with initial diameter smaller than 60 µm do not reach the ground before they desiccate entirely and may be carried further than 1.5 m by airflows.

2. Long-range airborne transmission applies beyond 1.5 m distance for droplets <60 µm. Droplet desiccation is a fast process; for instance, 50 µm droplets desiccate in about two seconds and 10 µm droplets in 0.1 s to droplet nuclei with roughly a half of the initial diameter[3]. Droplet nuclei <10 µm may be carried by airflows for long distances since the settling speeds for 10 µm, and 5 µm particles (equilibrium diameter of droplet nuclei) are only 0.3 cm/s and 0.08 cm/s, so it takes about 8.3 and 33 minutes respectively to fall 1.5 m. Because of instant desiccation, the term "droplet" is often used for desiccated droplet nuclei which still include some fluid explaining why viruses can survive. Droplet nuclei form a suspension of particles in the air, i.e. an aerosol. With effective mixing ventilation, the aerosol concentration is almost constant from 1-1.5 m distance onward. This concentration is most dominantly affected by air change rates in adequately ventilated rooms but is also reduced by deposition and decay of virus-laden particles.

The distance of 1.5 m for large droplets to fall, shown in Figure 2, left, applies if there is no air movement in the room. Usually, air distribution of ventilation and convection air flows of heat gains cause air velocities between 0.05 - 0.2 m/s in typical rooms with human occupancy. Using these velocities as lower and upper bounds together with particle settling velocities allows an estimate of how far droplets can travel before falling 1.5 m under the influence of gravity. These estimates illustrate that even larger than 30 µm droplets can travel much more than 1-2 meters.

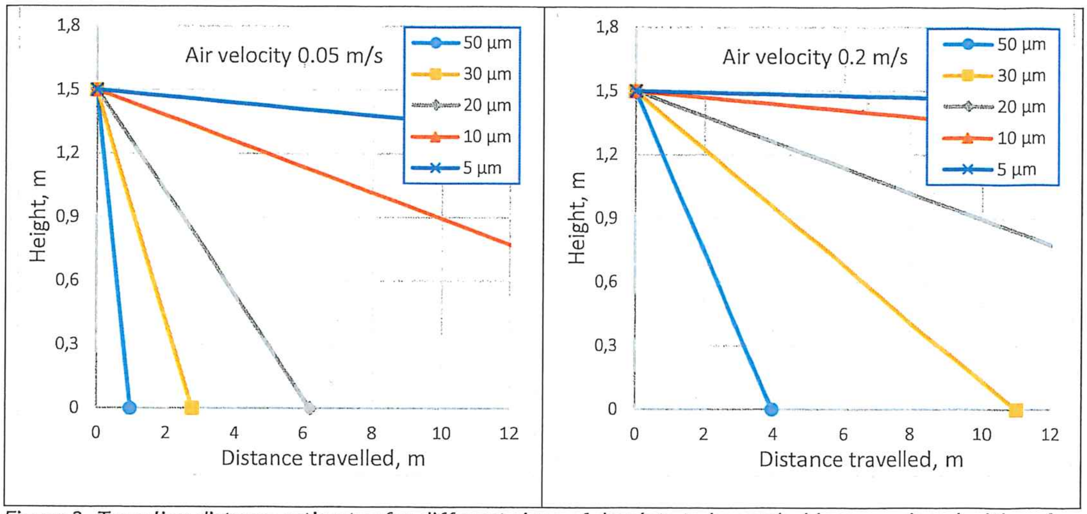

Figure 2. Traveling distance estimates for different sizes of droplets to be carried by room air velocities of 0.05 and 0.2 m/s before settling 1.5 m under the influence of gravity. The travelled distance accounts for movement after the initial jet has relaxed and is calculated with the equilibrium diameter of completely desiccated respiratory droplets (µm values in the figure refer to equilibrium diameters). With turbulence distance travelled is less, but settling time is longer.

More important than how far different size droplets travel, is the distance from the source or infected person at which a low, an almost constant aerosol concentration will be reached. As shown in Figure

[3] Physics of suspended respiratory droplets in air shows that a droplet with initial diameter of 20 µm will evaporate within 0.24 seconds in room air with 50% RH shrinking at the same time to a droplet nuclei with equilibrium diameter of about 10 µm. For this droplet nuclei of 10 µm, including still some fluid, it takes 8.3 minutes to fall down 1.5 m in still air.

2020年12月2日　衆議院厚生労働委員会　提出資料④　日本共産党　宮本徹
出典：REHVA COVID-19 guidance document., 17 November 2020., Belgium: Federation of European Heating, Ventilation and Air Conditioning Associations.