The Miasma theory is back – at least for respiratory viruses

Aerosols are the main culprit for the spread of Covid-19

The miasma theory explained the dissemination of diseases by bad air from the old Greek healers up to the second half of the 19th century. The 'germ' theory questioned the concept. Girolamo Fracastoro hypothesized in 1546 that "diseases are caused by transferable seed-like entities (seminaria morbi) that transmit infection by direct or indirect contact, or even without contact over long distances". But the miasma theory remained because vector-borne diseases, such as malaria, were so much more apparent linked to "bad air" that the "germ" theory had to wait for some more centuries before it was proven true.

Why the Covid-19 calamity reminds us of the miasma theory?

We are supposed to wear a mask, keep a distance from others, and even be advised not to speak, such as when riding on a BTS train in Bangkok. Does the inhibition of freedom, even wearing a mask and keeping social distancing, doesn't go too far together with the advice to shut our mouth? The air in a heavily airconditioned BTS couch certainly is cold but not "bad". However, more recent insight into respiratory virus transmission justifies the hint to avoid speaking while on our way above the Bangkok traffic in the BTS trains. Maybe the BTS management also should consider increasing the temperature in the heavily air-conditioned trains. Epidemiological observations and animal studies revealed that low temperature favors virus infection (1, 2). It has been shown that SARS-CoV and other viruses are more stable in lower temperatures (3).

Droplets and aerosols

Besides air-borne infections, we are also very much concerned about surface transmission of the SARS-CoV-2. We are conscious about "droplet-contaminated surfaces", generally called "fomites". Droplets, defined as >100µm, exhaled from someone at best travel for 2 meters and fall to the ground after less than 5 seconds. That's why the continuous advice to keep a distance from others. Yet, what could be inhaled from a contaminated person are not droplets, but aerosols or "droplet nuclei" often of a size <5µm, which travel much further than one or two meters and might remain in the air "for hours" (4). The virus particle will travel with the droplet-nuclei and be taken up from another host into the respiratory tract.

In the past, aerosol transmission was regarded to happen infrequently. But the airborne transmission was established for several respiratory viruses, including SARS-CoV-2 (5). Similar transmissions were found for measles virus, influence virus, respiratory syncytial virus (RSV), human rhinovirus (hRV), adenovirus, enterovirus, Middle East respiratory syndrome coronavirus (MERS-CoV), and SARS-CoV (4).

The role of aerosols in the course of infection

Aerosols are expired by breathing and talking and by singing, shouting, and sneezing (6). Aerosol SARS-CoV-2 had a half-life of about 1 to 3 hours (7). They are infectious on short and long ranges, as WHO and CDC claim. Numerous factors influencing infection should be considered, such as temperature, humidity, airflow, and ventilation. Superspreading events of Covid-19 are best explained as indoor activities in crowded facilities, such as boxing stadiums or entertainment facilities, and religious places such as temples and churches. The long-range airborne transmission even happened in hotels serving as quarantines in New Zealand at a time when the country proudly claimed to be free of the virus (8). While super spreading episodes are relatively seldom, slums and dormitories, and workshops proved to be major driving forces for the spread of Covid-19 in Thailand.

The virus within the aerosols

The probability of infection depends on environmental factors and the viral load, from the stability of the virus within the aerosols and the likelihood of infection. The often-cited R_0 value expresses the latter one. The number is supposed to indicate how many persons will be further infected by someone contaminated with the virus already. The R_0 value can vary over a wide range (9). A study in India found a probability of spread of infection of 4.7 to 10.7% (10). The size of the aerosols also plays an important role. The size might vary from 0.1 µm to 5.0 µm. The small aerosols reach the tracheobronchial and alveolar regions while larger sizes settle in the nasopharyngeal area. The larger size with 145 µm originated from talking and 123 µm from coughing and derived from the oral cavity and the lips (11). Most aerosols exhaled are <5 µm and even smaller <1 µm and originate from breathing, talking, and coughing (12, 13). More dangerous are the smaller aerosols in that they are more enriched in virus particles (14). Multiple layer masks, worn correctly, might block 90% of particles between 0.5 and 10 µm (15).

Conclusion

Droplets and aerosols can transmit SARS-CoV-2. Aerosols not only over a long distance but also within a short one. It is still meaningful to be aware of surface contamination, but the more effective way to travel from host to host is through aerosols for the virus. Masks wearing doesn't protect to 100% from the infection, but it helps significantly reduce the spread of the virus.

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