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Computational fluid dynamics modelling of the infectiousness of airborne droplets.

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Airborne transmitted diseases are a public health concern [1]. They are ubiquitous in human's life and include large variety of diseases such as the common cold, chicken pox, mumps and more serious ones like COVID-19 and tuberculosis. These diseases are transmitted through saliva droplets emitted in the environing air [2]. While being airborne, droplets are affected by multiple environmental factors mainly air flow, humidity, and temperature. Furthermore, droplets are interacting with the surrounding air, exchanging mass and momentum. Droplets are also released under specific conditions defined by parameters like injection speed, the height from where they are emitted, their size distribution, and temperature. The physical processes involved in droplets'evolution over time have influence on how they are spread and likely to transmit pathogens. Computational Fluid Dynamics (CFD) can be used to model droplet transport, and interaction with surrounding air, considering environmental parameters to get the spatial and temporal distribution of the expelled droplets [3]. In this study, the CFD model is augmented with an infectiousness tracker, to evaluate the likelihood of each droplet to transmit diseases. Infectiousness corresponds to the amount of pathogen the droplet is carrying and is decreasing with the droplet size. The two-way coupling approach was applied to compute momentum and mass exchange between droplets and its environment. Interactions between particles were also considered with the stochastic collision model including droplet breakup and coalescence. The Rosin-Rammler distribution was used for the size distribution of droplets with a range varying from 1 to 200 microns. An exponential decay was used to model the infectiousness variation as a function of the droplet size. When increasing the speed at which droplets are ejected, particles are occupying a wider range of position, more spread and reaching farther distance. Increasing injection velocity is equivalent to considering different respiratory events from which particles are generated. In fact, speaking has a lower injection speed than coughing which injection velocity is lower than that of sneezing. Therefore, violent respiratory events are more likely to transmit diseases because droplets are more spread. Infectiousness of droplets are neutralized in a reasonable amount of time under the condition that evaporation is occurring. For the safety of public and confined spaces, it is encouraged to fulfil the conditions that trigger evaporation like aeration. Our model will be used as a guide for configuring clinical and public spaces.

References

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Abstract Category

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