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Modelling buccopharyngeal droplet dispersion in an intensive care unit for Covid patients

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Faced with the first Covid-19 epidemic wave in France, the hospital sector has been forced to considerably increase the number of intensive care beds. To meet this crucial need, some hospital structures have been adapted. This is the case with one of the intensive care sectors of the Burn Treatment Center (CTB) at Saint-Louis Hospital, which has intensive care rooms dedicated to treat burn patients. Beyond the provision and adaptation of these care structures to Covid patients, the hospital has currently an imperative need to progress on the understanding of the dispersion of buccopharyngeal droplets which constitute one of the risk vectors of airborne transmission and as a corollary of manual transmission.

As part of a partnership between CTB and the EDF Foundation, a CEREA research team provided the hospital with its aeraulics expertise which mainly relies on the digital modelling tool (CFD) code_saturne developed for more than 20 years by EDF-Research and Development. Numerical modelling in fluid mechanics makes it possible to accurately reproduce an architectural ensemble, to describe the air flows and what they carry, and thus to better understand where the risks of airborne contamination lie.

The objective of the study is to understand the dispersion of the buccopharyngeal droplets in the resuscitation room according to their sizes, identify the areas at risk of deposit, adapt the treatment protocols and optimise the level and the frequency of systematic bio-cleaning of surfaces exposed to deposit of oral-pharyngeal droplets. It should be noted that we are not directly dealing with the spread of the covid-19 virus but with one of the potential vehicles of oral-pharyngeal droplets.

The methodology consist of a parametric study of poly-dispersion of classes of particles. Each class correspond to a droplet diameter and contains one million of independent droplets for which a Generalized Langevin Model is solved to calculate the instantaneous fluid velocity seen from the particle, the particle velocity and its position. These particles are carried by a turbulent flow using the Reynolds Averaged Navier-Stokes approach, calculating only moments. The specific characteristics of this model allow dealing with poly-dispersed two-phase flow even for particles with very small diameters. The studied parameters are the angle of droplet ejection, the volume of humid air ejected and the time duration of this event and the air flowing activation of the room.

Expected conclusions are found: the largest particles sediment the fastest and close to the source, the finest droplets follow the streamlines to the air vents. In addition, non-intuitive areas of potential deposit are observed and a major impact of air conditioning on residence time is demonstrated.