How coronavirus aerosols travel through lungs

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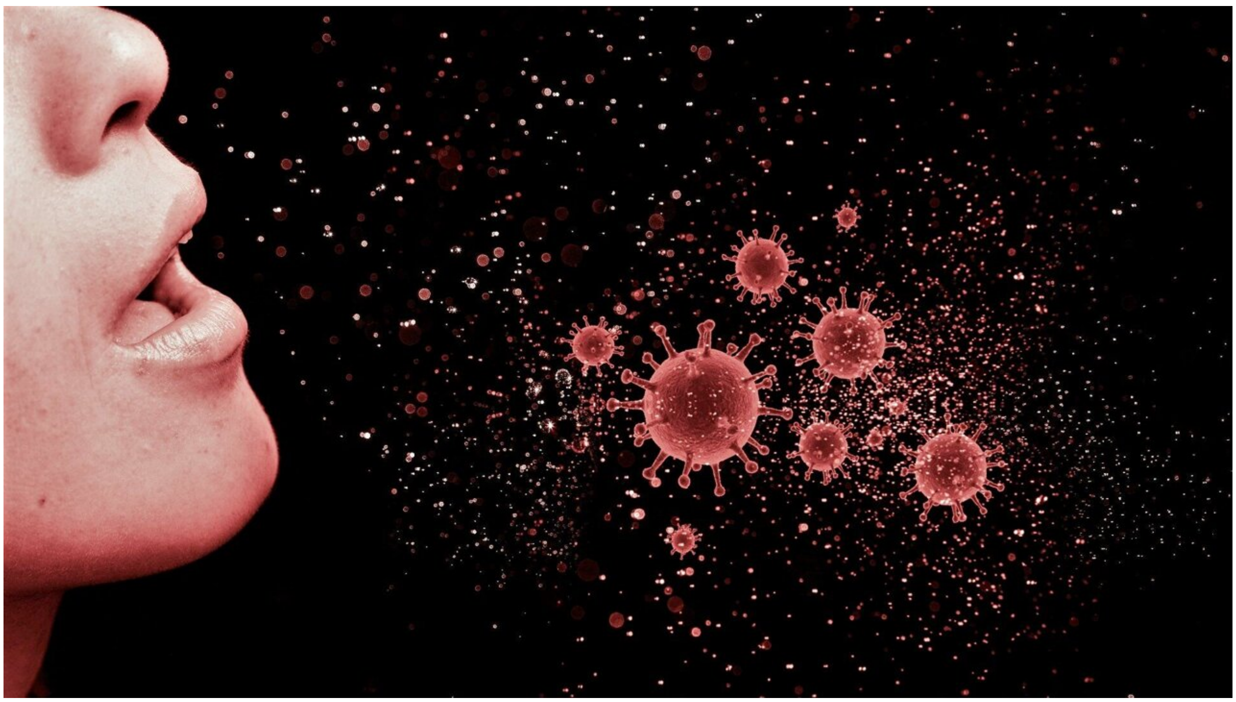

Credit: Mohamed Hassan from Pixabay

More than 65% of inhaled coronavirus particles reach the deepest region of our lungs where damage to cells can lead to low blood oxygen levels, new research has discovered, and more of these aerosols reach the right lung than the left.

Lead author of the study Dr. Saidul Islam, from the University of

Technology Sydney, said while previous research has revealed how virus aerosols travel through the upper airways including the nose, mouth and throat—this study was the first to examine how they flow through the lower lungs.

"Our lungs resemble tree branches that divide up to 23 times into smaller and smaller branches. Due to the complexity of this geometry it is difficult to develop a computer simulation, however we were able to model what happens in the first 17 generations, or branches, of the airways," said Dr. Islam.

"Depending on our breathing rate, between 32% and 35% of viral particles are deposited in these first 17 branches. This means around 65% of virus particles escape to the deepest regions of our lungs, which includes the alveoli or air sacs," he said.

The alveolar system is critical to our ability to absorb oxygen, so significant amounts of virus in this region, along with inflammation caused by our body's immune response, can cause severe damage, reducing the amount of oxygen in the blood and increasing the risk of death.

The study also revealed that more virus particles are deposited in the right lung, especially the right upper lobe and the right lower lobe, than in the left lung. This is due to the highly asymmetrical anatomical structure of the lungs and the way air flows through the different lobes.

The research is backed up by a recent study of chest CT scans of COVID-19 patients showing greater infection and disease in the regions predicted by the model.

The researchers modeled three different flow rates—7.5, 15 and 30 liters per minute. The model showed greater virus deposition at lower flow rates.

As well as improving our understanding of coronavirus transmission, the findings have implications for the development of targeted drug delivery devices that can deliver medicine to the areas of the respiratory system most affected by the virus.

"Normally when we inhale drugs from a drug delivery device most of it is deposited in the upper airways, and only a minimum amount of drugs can reach the targeted position of the lower airways. However, with diseases like COVID-19 we need to target the areas most affected," said Dr. Islam.

"We are working to develop devices that can target specific regions, and we also hope to build age and patient specific whole lung models to increase understanding of how SARS CoV-2 aerosols affect individual patients," said co-author and group leader of Computer Simulations and Modelling group, Dr. Suvash Saha, from University of Technology Sydney.

The World Health Organisation recently updated its advice about the importance of aerosol transmission, warning that because aerosols can remain suspended in the air, crowded indoor settings and areas with poor ventilation pose a significant risk for transmission of COVID-19.

"When we use an aerosol deodorant, the smallest particles of that liquid fall on us under extreme pressure in the form of gas. Similarly, when an infected person speaks, sings, sneezes or coughs, the virus is spread through the air and can infect those nearby," said Dr. Saha.

The study has further applications, with researchers using portable devices to examine air quality—including PM2.5 and PM10 concentration and gasses such as carbon dioxide, formaldehyde and sulfur dioxide—in spaces such as train carriages. The researchers can then use this data to model the impact on our lungs.

More information: Mohammad S. Islam et al, SARS CoV-2 aerosol: How far it can travel to the lower airways?, *Physics of Fluids* (2021). DOI: 10.1063/5.0053351