Turbulent Gas Clouds and Respiratory Pathogen Emissions

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Summary

- Classification systems of routes of respiratory disease transmission adopted by major public health agencies including WHO and CDC (USA) use dichotomous classification of droplets based on arbitrary diameter cut-offs into droplet (>5 μ) or aerosol (<5 μ) routes of transmission.
- This dichotomous model of transmission which forms the basis of many public health recommendations and containment strategies is flawed in the light of current evidence from laboratory experiments.
- Recent fluid mechanics studies on respiratory ejecta using high frame rate (2000fps) show that human sneezes, coughs and exhalations not only consist of mucosalivary droplets following short-range semiballistic emission trajectories but are made of a multiphase turbulent gas (a puff) cloud
- This turbulent gas cloud traps and carries within it, clusters of droplets with a continuum of droplet sizes, with no such arbitrary demarcation.
- The moist and warm environment within the gas cloud could delay evaporation of contained droplets for a much longer time in comparison to isolated droplets extending the life time of the droplet by a factor of up to 1000
- Also, owing to forward momentum of the gas cloud, pathogen-bearing droplets are propelled much farther than if they were emitted in isolation as envisaged earlier.
- Considering various combinations of an individual patient's physiology and environmental humidity and temperature, the gas cloud and its payload of pathogen-bearing droplets can travel 23 to 27 feet (7-8 m) as experimentally measured in laboratory conditions
- Observations from China reporting detection of SARS-CoV-2 virus particles in ventilation systems are more consistent with the gas cloud hypothesis than the dichotomous model of droplet transmission as the former explains how viral particles can travel such long distances
- The article raises alarm based on the new model that current recommendations for separations of 3 to 6 feet (1-2 m) as safe distance to be maintained from Covid-19 patients may underestimate the distance, timescale, and persistence over which the cloud and its pathogenic payload may travel, thus considerably underestimating the risk of exposure, especially to health care workers
- Masks worn by patients intended for source control should be tested for their ability to withstand high-momentum multiphase turbulent gas clouds

Conclusion

- 'Turbulent gas cloud dynamic model' of respiratory pathogen emission should be used instead of older dichotomous droplet transmission model as the basis of public health recommendations in the context of Covid-19

Appraisal

- Strength: Proposes a new experimentally verified biophysical model for host-to-host transmission of respiratory infections which has direct implications on infection containment strategies, preventive and protective measures to be adopted by health care workers
- Limitation: Since no studies have directly evaluated the biophysics of droplets and gas cloud formation for patients infected with the SARS-CoV-2 virus, external validity of the predictions based on the model needs experimental confirmation.

Opinion

- Article proposes experimentally verified 'Turbulent gas cloud dynamic model' as a new biophysical model to explainhost-to-host transmission of respiratory infections and raises concerns over the inadequacy of current public health recommendations, infection containment strategies and guidelines pertaining to preventive and personal protective measures to be adopted by healthcare workers.

Appraisers

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