Predicting SARS-CoV-2 transmission probabilities through expiratory aerosol modeling

Alison Robey, Environmental Studies & Mathematics, Williams College, Williamstown, MA 01267
Laura Fierce, Environmental & Climate Science, Brookhaven National Laboratory, Upton, NY 11773
Catherine Hamilton, Environmental, Indiana University of Pennsylvania, Indiana, PA 15709

Abstract
Efforts to halt the COVID-19 pandemic are divided between understanding its transmission and producing an effective vaccine. The former pursuit has largely been viewed as a set of temporary measures to maximize while waiting for the vaccine’s ‘silver bullet’ solution. This perspective has detrimental public health consequences, since the vaccine will be less effective the more severe the pandemic is during implementation. Minimizing airborne transmission of the SARS-CoV-2 virus through studying expiratory aerosol behavior thus remains imperative. Utilizing the aerosol expertise and quadrature-based modeling methods already well-developed within the Environmental & Climate Sciences Department at Brookhaven National Laboratory, combined with continued development of jet plume and evaporative process modeling, we predict the risk of infection based on the length and proximity of encounters between infected and susceptible individuals. We further estimate the risk reductions of different mitigation strategies to inform the behaviors essential to reducing the severity of the COVID-19 pandemic.

Introduction
Human expirations create aerosols (<5 μm) and droplets (>5 μm) which may carry viral RNA that can spread viruses like SARS-CoV-2. Particulate creation, behavior, and deposition is variable and size dependent. Environmental conditions and mask wearing alter particle behavior and thus infection risk.

Hypothesis
Airborne transmission is an important component of coronavirus spread. Mask wearing, social distancing, ventilation each reduce the risk of initial infection. Accurate modeling of particulate behavior will provide the best possible estimates of the probability of infection.

Methods
Literature review of expiratory distributions, mask efficacy, particulate behavior, respiratory deposition, particle evaporation, viral loading, and infection

Results
The final model predicts the probability of infection in a given scenario, either with a specific set of assumptions or over the probability space spanned by our assumptions. Its best use is predicting the difference in risk between different scenarios.

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References

Next Steps
How can we use our understanding of infection probability and risks to a) inform individual and collective actions aimed at minimizing the number of sick individuals and b) contribute to the growing body of epidemiological models of SARS-CoV-2 by refining (reproductive rate) values to reflect the different infection risks possible under different mitigation scenarios?

Conclusions
Understanding aerosolized transmission of COVID-19 is key to protecting the lives and health of as many people as possible, particularly during the wait for and implementation of coronavirus vaccines, which will be more effective the lower the current spread rate of SARS-CoV-2 is. We add that effort research on the effect of evaporative modeling and risk predictions based on the combination of quadrature-based aerosol and near-field dispersion models.