Day 2 breakout session, Chair: Lydia Bourouiba

Can we quantify, understand and predict, the importance of multiscale and multiphase flow physics in modelling respiratory emissions and their spatio-temporal evolution?

- To build multiscale models, one approach is to homogenize scales. Implication of that? How to assess validity? Limitations in insights gained?
- DNS or more detailed simulations that capture more underlying physics than CFD and so can provide further important insights, but trade-off between details and ability to use for rapid decision making is a challenge.
- Averaged modeling vs. details in general is a challenge. There are important limitations with average models and inaccuracies. But they are rapid to obtain. Is speed more important than insight? It depends on the question, how such models are used, the care taken by those making them and those communicating their results, and those using such communication to make decisions and their ability to handle this tradeoff. Importance of understanding and acknowledging limitations and great uncertainties and not overclaiming.

What are the challenges and perspectives on measurements of respiratory emissions and their modelling? How do these depend upon different environments (e.g., a school room/lecture theatre, a concert hall, a dense crowd etc.)?

- Relying on particle size distributions that others produced is a challenge for modelers in an interdisciplinary settings. Important variation in quality of data and how it was collected and processed. Highly heterogeneous reporting of parameters and conditions of data collection hiding underlying physics of the process. Key to develop a gold-standard or just a minimum standard for the publication and reporting of these datasets, so studies can be compared.
- One effort discussed was the need to have a call to action paper to call for such standards in the field.
- Key to have these details to model the underlying physics and inform experiments and measurements.
- Importance of synergies to communicate and discuss how measurements are done and to collaborate to clarify these from the start – team building early and not during a time of pandemic but also in between epidemics and pandemics, so team are already in place and with a history of doing this work for true prevention and preparation.
- Bimodal or multimodal distributions have been mentioned many times, yet there are many experimental challenges and approaches that could be leading to these modalities as artifacts of measurements. Not enough information to support these features in the distribution as true and very few studies and protocols enable to compare distributions between events (speaking, coughing, etc) due to the lack of homogeneous measurement approaches. Great caution is needed when using these in models of respiratory emissions or multiscale models, and sensitivity analysis is a must.
- Importance to consider worst-case scenario, and not average scenario due to such high heterogeneity.

Day 2 breakout session, Chair: Oleksiy Klymenko

1. When can the fomite transmission pathway carry a significant risk?
   - There is a lack of experimental measurements and evidence of fomite transmission leading to infection.
   - However, Infection risk increases when shared objects acquire high viral loads through touching and/or deposition of large droplets over extended periods of time.
2. What can we tell about the survival of the virus in the environment and relevant mitigation strategies?
   - While SARS-CoV-2 has been shown to survive for hours or days on surfaces and in air in lab experiments, there is a lack of data on its survival in real situations.
   - The survival on a particular surface also strongly depends on the (changing) environmental conditions.
   - Cleaning of smooth surfaces is effective while half-life of viable virus is lower on porous surfaces. Transfer from the latter to hand is also less effective.
3. What are the challenges and perspectives on measurements of respiratory emissions and their modelling? How do these depend upon different environments (e.g., a school room/lecture theatre, a concert hall, a dense crowd etc.)?
   - It is challenging to trace infections back to sources in large settings with high occupancy.
   - CFD simulations for specific conditions may not be general enough.
   - On the other hand, an individual's risk depends on the specific flow pattern and viral concentration/plumes/jets.
   - Statistical CFD approaches are needed for average risk estimation in an environment.
   - The use of CO2 as a proxy for aerosols may not be fully justified.
4. What processes determine the timescales for purging a space or determining the frequency of cleaning and which environmental conditions affect these?
   - The nature of ventilation: mechanical or natural, and the exact flow pattern including any dead zones in a given space.
   - Shared objects should ideally be cleaned after each user.
5. Can we quantify, understand and predict, the importance of multiscale and multiphase flow physics in modelling respiratory emissions and their spatio-temporal evolution?
   - The evolution of flow structures at different scales arising as a result of small and fast intermittent jets (coughs and sneezes) interacting with larger-scale flow structures requires further study. Non-resolved spatio-temporal scales and turbulence in current numerical simulations should not be ignored.
   - The assumption of rapid homogenisation of aerosol concentrations may need to be revisited.

Day 2 breakout session topics, Chair: Marco-Filipe King

1. What are the challenges and perspectives on measurements of respiratory emissions and their modelling? How do these depend upon different environments (e.g., a school room/lecture theatre, a concert hall, a dense crowd etc.)?

- The location of sensors for measurement is very important, especially in environments with large spatial variability.
- There is a lot of variability in the time spent in different environments, e.g., office or school versus a shop.
- There is a lot of variability in seemingly comparable environments, e.g., a modern concert hall with excellent ventilation versus a medieval concert hall.
- Lots of existing studies focus on specific environments, e.g., public transport, schools, shops etc. Perhaps a typology of indoor environments - understanding and categorising rooms depending on size, length and density of occupancy, type of activity (e.g., talking, singing, coughing), ventilation etc. – would be more generalisable.

2. What can we tell about the survival of the virus in the environment and relevant mitigation strategies?

- Survival of the virus is dependent on many factors.
- Soap and water is typically good enough to disrupt its protein.
- Alcohol gels are effective.
- Contamination on hands.
- It’s important not to touch your face!
- TB is predominantly transmitted in droplet form, so inhalation is the overriding factor. For COVID-19, what are the different response levels to whether the virus is transferred via the mouth, nose, eyes, or ears?
- UV light is important, does the strength of the sun matter? In the warmer months, opening windows and taking advantage of the sunlight can be helpful mitigation strategies, however this is more difficult in winter.