Contribution ID: **65** Type: **Poster**

Evaluating ventilation effectiveness and exposure to airborne pathogens using computational fluid dynamics

COVID-19 pandemic has reignited the discussion on required ventilation rates for indoor spaces. More specifically, the discussion has revolved around the required ventilation rate to efficiently mitigate airborne transmissions in different types of indoor environments with various type of activities. The topic has been studied extensively, and the research has resulted in guidelines and standards on pandemic safe ventilation solutions. For example, the WHO Roadmap to improve and ensure good indoor ventilation in the context of COVID-19 (2021), Lancet COVID-19 Commission Proposed Non-infectious Air Delivery Rates (NADR) for Reducing Exposure to Airborne Respiratory Infectious Diseases (2022), REHVA Health-based target ventilation rates and design method for reducing exposure to airborne respiratory infectious diseases (2022), and ASHRAE standard 241 (2023), have proposed ventilation rates for different types of indoor spaces. In addition to ventilation rates, many of these standards and guidelines also consider accounting for air cleaning and disinfection strategies such as air filtration or exploiting UVC air cleaning solutions. However, most of them focus on the ventilation rates and few account for air distribution in the space, namely, how efficiently clean air is provided into the breathing zone and how efficiently the contaminants are removed from the space. Dispersion of infectious aerosols in an indoor space can be analysed using either experimental or modelling approach. Modelling offers a relatively straight-forward approach for experimenting with different air distribution strategies and ventilation rates. Therefore, this paper aims to provide new insights beyond well-mixed assumption evaluating various ventilation rates and air distribution strategies for mitigating airborne transmissions using computational fluid dynamics (CFD) assessing both ventilation effectiveness and infection probability.

Modelling ventilation air distribution and resulting dispersion of airborne pathogens in the space necessitates venturing beyond well-mixed assumption and resolving the physical phenomena with adequate spatial and temporal resolution. Therefore, to tackle this challenge, this paper presents a simulation approach exploiting computational fluid dynamics, detached eddy simulations (DES) turbulence modelling, Lagrangian particles to evaluate dispersion of and exposure to airborne pathogens. The concentrations of airborne infectious aerosol are analysed both in the space in general and in the vicinity of the occupants'breathing zone, and respective infection probability as well as and ventilation effectiveness are evaluated under different ventilation rates and air distribution strategies to identify the most efficient solutions to mitigate airborne transmission in indoor spaces.

The results show that both ventilation rate and air distribution have significant impact on reducing the exposure to infectious aerosols and consequently the infection probability of the occupants. Hence, to mitigate airborne transmission in an indoor environment, ventilation rate and ventilation effectiveness should be simultaneously considered. Therefore, future ventilation guidelines and standards addressing the mitigation of airborne transmission should account for ventilation effectiveness in addition to ventilation airflow rate itself. However, having reliable data to support standards and guidelines necessitates additional efforts using both computational and experimental approaches to establish typical ranges for ventilation effectiveness in relation to various types of indoor spaces under different ventilation configurations.

Primary author: SIILIN, Niko (VTT Technical Research Centre of Finland Ltd.)

Presenter: SIILIN, Niko (VTT Technical Research Centre of Finland Ltd.)