https://doi.org/10.7250/CONECT.2023.018

NUMERICAL MODEL AND SYSTEM FOR PREDICTION AND REDUCTION OF INDOOR COVID-19 INFECTION RISK

Jānis VIRBULIS[1], Jevgenijs TELICKO[2], Andrejs SABANSKIS[3], Dagis Daniels VIDULEJS[4], Andris JAKOVICS[5]

[1–5] *Institute of Numerical Modelling, University of Latvia, Jelgavas iela 3, Riga, LV-1004, Latvia*

Abstract – Airborne aerosol transmission is a significant route of SARS-CoV-2 and other viruses in indoor environments. The developed numerical model assesses the risk of a COVID-19 infection in a room based on the measurements of temperature, relative humidity, CO_2 and particle concentration, as well as the number of people and occurrences of speech, coughing, and sneezing obtained through a dedicated low-cost sensor system. As the model operates faster than real-time, it can dynamically feed this information back to the measurement system or building management system, and it can activate an air purifier with filtration and UV-C disinfection when the predicted infection risk is high. This solution enhances energy efficiency as (1) lower ventilation intensity is necessary in the cold season to reach the same safety level and (2) the purifier is activated only if the predicted infection risk is above a certain threshold. The model is integral and takes into account the average values of simulated variables. However, it considers the inhomogeneous vertical distribution of concentration of droplets and aerosol particles. The droplets expelled by a potentially infectious person at a certain height through breathing, speaking, coughing, and sneezing are characterized by the total amount of expelled liquid, droplet size distribution and virus particle concentration. The rate of droplet evaporation depends on the temperature and relative humidity. Droplets are redistributed within the room vertically through turbulent diffusion and gravitational force. If the final droplet diameter is less than 5 mm, these particles are considered airborne and can leave the room only by ventilation, filtration, or by sedimentation on surfaces through Brownian diffusion. As a person in the room inhales these droplets and aerosols, the risk of infection increases as the number of absorbed virions grows, with the probability of infection being 50 % when 300 virions have been inhaled. The parameter studies using the model indicate that the coughing and sneezing events greatly increase the probability of infection in the room, therefore, the identification of these events is crucial for the applied measurement system. A method for determining the unknown ventilation intensity by measuring the number of people and the CO_2 concentration is proposed and tested.

Keywords – COVID-19; infection risk, numerical modelling

Acknowledgements

The present research has been supported by the European Regional Development Fund, Project No. 1.1.1.1/21/A/046.