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Google Scholar, Lens et WoS

Faulkner, C.
Advanced Modeling for Sustainable HVAC Operation to Mitigate Indoor Virus Transmission in Office Buildings.
University of Colorado at Boulder, Mechanical Engineering, Colorado, United States. Thèse 2023

The COVID-19 pandemic demonstrated the challenges of operating buildings to address multiple, potentially conflicting, objectives. For example, the heating, ventilation, and air conditioning (HVAC) system operation can be adapted to improve indoor air quality (IAQ) and reduce the risk of virus transmission. However, doing so has practical downsides on the HVAC operation, such as increasing energy consumption. Furthermore, changing the long-term operation to improve IAQ can lead to significant increases in costs and CO2 emissions. Additional research is needed to address these application needs and provide practical guidance to building operators. Building system modeling is a relatively fast and cost-effective method to evaluate HVAC operation strategies to mitigate indoor virus transmission, but further modeling advances are needed to perform the necessary assessments. A modeling capability for holistically evaluating HVAC operation to mitigate indoor virus that incorporates models for the virus dynamics in addition to the HVAC system and control is needed. Additionally, Computational Fluid Dynamics (CFD) methods are able to accurately capture indoor airflow distribution for these scenarios, but are too slow to be used for applications such as long-term analyses or control evaluations requiring small time steps. This dissertation hypothesizes that there are HVAC operation and control strategies that can reduce virus transmission with minimal impacts on sustainability factors, and modeling advances can help support these evaluations and provide guidance to building operators. Based on this hypothesis and the described research gaps, five fundamental research challenges are identified to address the application needs for evaluating HVAC operation strategies to mitigate indoor virus transmission. These five challenges are addressed with corresponding research objectives and tasks in this dissertation.

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Li, P.
Applications of Ultraviolet-C Light in Improving Indoor Air Quality with Engineering and Photometric Approaches.
Iowa State University, Agricultural and Biosystems Engineering, Iowa, United States. Thèse 2023

Infectious diseases such as seasonal influenza and more recently COVID-19 can be transmitted via aerosols and spread from one person to another. Improving indoor air quality (IAQ) has become vital for the public to combat disease transmission in indoor air through mitigating inhalable aerosols. Air cleaning devices with filtration and targeted treatment capabilities can help improve IAQ. An air cleaning prototype was evaluated and upgraded by adding UV-C (germicidal) light and tested on its removal efficiency on viable airborne bacteria and particulate matter (PM). The combination of filtration and UV-C treatment provided 'double-barrier' assurance for air purification and lowered the risk of spreading infectious micro-organisms. [...]

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Cooper, B. S., Evans, S., Jafari, Y., Pham, T. M., Mo, Y., Lim, C.*, et al.*
The burden and dynamics of hospital-acquired SARS-CoV-2 in England.
Nature, (2023)

Hospital-based transmission had a dominant role in Middle East respiratory syndrome coronavirus (MERS-CoV) and severe acute respiratory syndrome coronavirus (SARS-CoV) epidemics1,2, but large-scale studies of its role in the SARS-CoV-2 pandemic are lacking. Such transmission risks spreading the virus to the most

vulnerable individuals and can have wider-scale impacts through hospital-community interactions. Using data from acute hospitals in England, we quantify within-hospital transmission, evaluate likely pathways of spread and factors associated with heightened transmission risk, and explore the wider dynamical consequences. We estimate that between June 2020 and March 2021 between 95,000 and 167,000 inpatients acquired SARS-CoV-2 in hospitals (1% to 2% of all hospital admissions in this period). Analysis of time series data provided evidence that patients who themselves acquired SARS-CoV-2 infection in hospital were the main sources of transmission to other patients. Increased transmission to inpatients was associated with hospitals having fewer single rooms and lower heated volume per bed. Moreover, we show that reducing hospital transmission could substantially enhance the efficiency of punctuated lockdown measures in suppressing community transmission. These findings reveal the previously unrecognized scale of hospital transmission, have direct implications for targeting of hospital control measures and highlight the need to design hospitals better equipped to limit the transmission of future high-consequence pathogens.

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Ji, J., Wang, H., Wang, L., Ramazi, P., Kong, J. D., Watmough, J.
Climate-dependent effectiveness of nonpharmaceutical interventions on COVID-19 mitigation.
Math Biosci, Vol. **366**, (2023)

Environmental factors have a significant impact on the transmission of infectious diseases. Existing results show that the novel coronavirus can persist outside the host. We propose a susceptible–exposed–presymptomatic–infectious–asymptomatic–recovered–susceptible (SEPIARS) model with a vaccination compartment and indirect incidence to explore the effect of environmental conditions, temperature and humidity, on the transmission of the SARS-CoV-2 virus. Using climate data and daily confirmed cases data in two Canadian cities with different atmospheric conditions, we evaluate the mortality rates of the SARS-CoV-2 virus and further estimate the transmission rates by the inverse method, respectively. The numerical results show that high temperature or humidity can be helpful in mitigating the spread of COVID-19 during the warm summer months. Our findings verify that nonpharmaceutical interventions are less effective if the virus can persist for a long time on surfaces. Based on climate data, we can forecast the transmission rate and the infection cases up to four weeks in the future by a generalized boosting machine learning model.

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Duill, F. F., Schulz, F., Jain, A., Van Wachem, B., Beyrau, F.
Comparison of Portable and Large Mobile Air Cleaners for Use in Classrooms and the Effect of Increasing Filter Loading on Particle Number Concentration Reduction Efficiency.
Atmosphere, Vol. **14** n°(9), (2023)

This study focuses on the effect of portable and large filter-based air cleaners (HEPA filters), which became popular indoors during the COVID-19 pandemic, and their suitability for classrooms (here 186 m3). The decay rates of the particle number concentration (PNC) were measured simultaneously at up to four positions in the room. It was found that the different air outlet configurations of the units have an effect on the actual PNC removal in the room when operated at the same volume flow rates. This effect of the airflow efficiency of the air cleaners (AP) in a classroom is quantified with an introduced Air Cleaning Efficiency Factor in this study to identify beneficial airflows. In this context, the effect of filter loading in long-term operation on the cleaning effect is also investigated. The emitted sound pressure levels of the APs are given special attention as this is a critical factor for use in schools, as well as power consumption. A total of six different devices were tested-two portable APs and four large APs. In order to achieve the necessary volume flow rates, three or four of the portable units were used simultaneously in one room, while only one of the large units was used per room. When used at the same air circulation rates in the room, the portable APs exhibit higher sound pressure levels compared to the large APs. At air circulation rates of 4-5 h-1, the portable APs exceeded a value of 45 dB(A). Two of the four large units reach sound pressure levels below 40 dB(A) at air circulation rates of 4-5 h-1,

whereby both large units, which are positioned on the rear wall, realize a homogeneous dilution of the room air. This is achieved by an air outlet directed horizontally at a height above 2 m or diagonally towards the ceiling, which points into the room and partly to the sides. On the other hand, an air outlet directed exclusively to the sides or horizontally into the room at floor level to all sides achieves lower particle decay rates. To investigate the influence of the filter loading, three large APs were operated in a school for a period of one year (190 days with 8 h each). For the three APs, long-term operation leads to different changes in PNC reduction efficiency, ranging from -3% to -34%. It is found that not only the size of the prefilter and main filter has a significant influence, but also whether there is a prefilter bypass that negatively affects the loading level of the main filter. At the same time, it was shown that one type of AP, measuring the pressure drop across the filters and readjusting the fan, kept the circulation rate almost constant (up to -3%) over a year.

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Yoo, S.-J., Yamauchi, S., Park, H., Ito, K.
Computational Fluid and Particle Dynamics Analyses for Prediction of Airborne Infection/Spread Risks in Highway Buses: A Parametric Study.
Fluids, Vol. **8** n°(9), (2023)

Highway buses are used in a wide range of commuting services and in the tourist industry. The demand for highway bus transportation has dramatically increased in the recent post-pandemic world, and airborne transmission risks may increase alongside the demand for highway buses, owing to a higher passenger density in bus cabins. We developed a numerical prediction method for the spatial distribution of airborne transmission risks inside bus cabins. For a computational fluid dynamics analyses, targeting two types of bus cabins, sophisticated geometries of bus cabins with realistic heating, ventilation, and air-conditioning were reproduced. The passengers in bus cabins were reproduced using computer-simulated persons. Airflow, heat, and moisture transfer analysis were conducted based on computational fluid dynamics, to predict the microclimate around passengers and the interaction between the cabin climate and passengers. Finally, droplet dispersion analysis using the Eulerian-Lagrangian method and an investigation of the spatial distribution of infection/spread risks, assuming SARS-CoV-2 infection, were performed. Through parametric analyses of passive and individual countermeasures to reduce airborne infection risks, the effectiveness of countermeasures for airborne infection was discussed. Partition installation as a passive countermeasure had an impact on the human microclimate, which decreased infection risks. The individual countermeasure, mask-wearing, almost completely prevented airborne infection.

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Mohammadian-Hafshejani, A.
COVID-19: Current Status and Necessary Measures for Prevention of Future Outbreaks.
Epidemiol Health System J, Vol. **10** n°(3), (2023), 146-147 p.

This manuscript aims to provide an update on the current status of COVID-19 worldwide and the necessary measures to be taken to prevent an increase in the number of cases in the future.

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Genz, S., Bellmann, L., Matthes, B.
Do German Works Councils Counter or Foster the Implementation of Digital Technologies? First Evidence from the IAB-Establishment Panel.
Jahrbucher Fur Nationalokonomie Und Statistik, Vol. **239** n°(3), (2019), 523-564 p.

As works councils' information, consultation and co-determination rights affect the decision process of the management, works councils play a key role in the implementation of digital technologies in establishments. However, previous research focuses on the potential of digital technologies to substitute for labor and its

impact on labor market outcomes of workers. This paper adds the role of industrial relations to the existing literature by analyzing the impact of works councils on the implementation of digital technologies. Theoretically, the role of works councils in the digital transformation is ambiguous. Using establishment data from the IAB Establishment Survey of 2016 combined with individual employee data from the Federal Employment Agency and occupational level data about the physical job exposure, empirical evidence indicates an ambivalent position of works councils towards digital technologies. The sole existence of works councils is associated with statistically significant lower equipment levels with digital technologies. However, works councils seem to foster the equipment with digital technologies in those establishments, which employ a high share of workers who are conducting physical demanding job activities. Thus, this study highlights the importance of establishment-level workforce representation for the digital adoption process within Germany.

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Choudhary, K., Krishnaprasad, K. A., Zgheib, N., Ha, M. Y., Balachandar, S.
Effect of room size, shape, AC placement, and air leakage on indoor airborne viral transmission.
Building and Environment, Vol. **244**, (2023)

We conducted Euler-Lagrange Reynolds-Averaged Navier-Stokes simulations with statistical overloading to investigate the effect of room shape, air-condition (AC) location, and the presence of an open window on indoor airborne viral transmission, particularly as it relates to the spatio-temporal distribution of viral-laden droplet nuclei. Two room geometries were considered with two different AC types positioned at different locations within each room. We considered the case of perfect filtration where pathogens can exit the room through ventilation, air leakage through an open window, turbulent wall deposition, and by gravitational settling onto the bottom floor. We observe the room-averaged concentration to decay at the rate estimated from the well-mixed model and therefore to be independent of room size and shape or AC type and placement. It is also independent of whether or not there is an open window. However, we find that the departure from well-mixedness, which has been quantified using a time-and source-to-sink separation-dependent correction function gamma, is affected by room shape and AC placement. More specifically, indoor spaces where the AC is installed on one end of the room allow droplet nuclei ejected on one end of the room to travel longer distances before being removed from the room as opposed to indoor spaces in which the AC is installed at the center of the room. The present results allow generalization of a simple model for the accurate prediction of viral quanta inhaled by an individual in any indoor environment.

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Donskey, C. J.
High technology and low technology measures to reduce risk of SARS-CoV-2 transmission.
American Journal of Infection Control, Vol. **51** n°(11, Supplement), (2023), A126-A133 p.

During the coronavirus disease 2019 (COVID-19) pandemic, a variety of low technology and high technology measures have been proposed to reduce the risk for transmission. Identifying those measures likely to be useful in reducing viral transmission without undue expense or potential for adverse effects has been a challenge for infection control programs. The challenge has been compounded by the lack of tools that can be used to assess the risk for viral transmission in different settings. This review discusses practical tools that can be used to assess ventilation and airflow and evaluates some of the low technology and high technology measures that have been proposed as control measures for COVID-19. Some typical questions posed to infection control programs during the pandemic are presented to illustrate real-world application of the concepts being discussed.

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Barber, V. P., Goss, M. B., Franco Deloya, L. J., Lemar, L. N., Li, Y., Helstrom, E.*, et al.*
Indoor Air Quality Implications of Germicidal 222 nm Light.

Environmental science & technology, Vol. **57** n°(42), (2023), 15990-15998 p.

One strategy for mitigating the indoor transmission of airborne pathogens, including the SARS-CoV-2 virus, is irradiation by germicidal UV light (GUV). A particularly promising approach is 222 nm light from KrCl excimer lamps (GUV222); this inactivates airborne pathogens and is thought to be relatively safe for human skin and eye exposure. However, the impact of GUV222 on the composition of indoor air has received little experimental study. Here, we conduct laboratory experiments in a 150 L Teflon chamber to examine the formation of secondary species by GUV222. We show that GUV222 generates ozone (O3) and hydroxyl radicals (OH), both of which can react with volatile organic compounds to form oxidized volatile organic compounds and secondary organic aerosol particles. Results are consistent with a box model based on the known photochemistry. We use this model to simulate GUV222 irradiation under more realistic indoor air scenarios and demonstrate that under some conditions, GUV222 irradiation can lead to levels of O3, OH, and secondary organic products that are substantially elevated relative to normal indoor conditions. The results suggest that GUV222 should be used at low intensities and in concert with ventilation, decreasing levels of airborne pathogens while mitigating the formation of air pollutants.

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Davey, A.
Metal-Organic Framework-Based Colorimetric Gas Sensors Toward an Improved Indoor Air Quality Monitoring.
University of California, Berkeley, Chemical Engineering, California, United States. Thèse 2023

As respiratory illness infections and related environmental antagonisms continue to beleaguer our contemporary moment, the construction of low-cost, scalable, highly sensitive, remarkably selective, ultralow power, and user-friendly technologies for detecting hazardous chemical species indoors remains imperative. Namely, the accumulation of carbon dioxide (CO 2) and select volatile organic compounds (VOCs) in indoor settings is associated with deleterious human health conditions, such as fatigue, headaches, and irritation of the throat. While commercialized indoor gas detectors exhibit desirable analyte sensitivity and long-term sensing endurance, these devices characteristically suffer from cost, bulk, and power requirements. Toward addressing these limitations, this work introduces amine-functionalized, dye-loaded metal-organic framework (MOF)-based chemical sensors whose color change upon exposure to indoor analytes produces a more passive, smaller, cheaper, and simpler alternative to existing technologies. In this dissertation, the iterative synthesis and spectroscopic characterization of color-based, MOF-based indoor analyte sensors are accomplished toward the realization of an ideal sensor for an improved indoor air quality monitoring.

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Adjei, F. A.
Modeling COVID-19 Risk in UW Classrooms.
University of Wyoming, Kinesiology & Health, Wyoming, United States. Thèse 2023

As respiratory illness infections and related environmental antagonisms continue to beleaguer our contemporary moment, the construction of low-cost, scalable, highly sensitive, remarkably selective, ultralow power, and user-friendly technologies for detecting hazardous chemical species indoors remains imperative. Namely, the accumulation of carbon dioxide (CO 2) and select volatile organic compounds (VOCs) in indoor settings is associated with deleterious human health conditions, such as fatigue, headaches, and irritation of the throat. While commercialized indoor gas detectors exhibit desirable analyte sensitivity and long-term sensing endurance, these devices characteristically suffer from cost, bulk, and power requirements. Toward addressing these limitations, this work introduces amine-functionalized, dye-loaded metal-organic framework (MOF)-based chemical sensors whose color change upon exposure to indoor analytes produces a more passive, smaller, cheaper, and simpler alternative to existing technologies. In this dissertation, the iterative

synthesis and spectroscopic characterization of color-based, MOF-based indoor analyte sensors are accomplished toward the realization of an ideal sensor for an improved indoor air quality monitoring

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Asai, T., Kurosaki, E., Kimachi, K., Nakayama, M., Koido, M., Hong, S.
Peak risk of SARS-CoV-2 infection within 5 s of face-to-face encounters: an observational/retrospective study.
Scientific Reports, Vol. **13** n°(1), (2023)

The link between aerosol dynamics and viral exposure risk is not fully understood, particularly during movement and face-to-face interactions. To investigate this, we employed Particle Trace Velocimetry with a laser sheet and a high-speed camera to measure microparticles from a human mannequin's mouth. The average peak time in the non-ventilated condition (expiratory volume, 30 L; passing speed, 5 km/h) was 1.33 s (standard deviation = 0.32 s), while that in the ventilated condition was 1.38 s (standard deviation = 0.35 s). Our results showed that the peak of viral exposure risk was within 5 s during face-to-face encounters under both ventilated and non-ventilated conditions. Moreover, the risk of viral exposure greatly decreased in ventilated conditions compared to non-ventilated conditions. Based on these findings, considering a risk mitigation strategy for the duration of 5 s during face-to-face encounters is expected to significantly reduce the risk of virus exposure in airborne transmission.

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Montazeri, M. M., Raeiszadeh, M., Taghipour, F.
Radiation modeling of microplasma UV lamps for design analysis and optimization.
Journal of Environmental Chemical Engineering, Vol. **11** n°(3), (2023)

Microplasma UV lamps have recently emerged as viable excimer-based sources of UV radiation, garnering significant attention during the recent COVID-19 pandemic for their use in disinfection applications because of their ability to emit human-safe far-UVC (200-240 nm) spectrums. An accurate model to simulate the radiation profile of microplasma UV lamps is of paramount importance to develop efficient microplasma lamp-implemented systems. We developed a 3D numerical model of microplasma UV lamps using the ray optics method. The simulation results for lamp irradiance and fluence rate were experimentally validated with standard optical radiometry and actinometry measurements, respectively. To improve the optical efficiency of microplasma lamps, an in-depth analysis of radiation behavior inside the standard commercially available lamp was performed using the geometrical optics method, and several potential scenarios were explored. A 2D modeling of an individual microcavity indicated that the current common lamp design can be significantly improved by preventing radiation loss, and small modifications in optical design can greatly increase the energy performance of the system. Based on the findings of this study, several virtual design concepts were proposed, and their performances were numerically compared with that of the original design of commercial microplasma lamps. The developed model can potentially be integrated with hydrodynamic and kinetic models for the virtual prototyping of complex photoreactors operating with UV microplasma lamps.

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Paniagua, I. Y. H., Munoz, O. A., Perez, I. R., Garcia, O. A., Buendia, R. I. G., Ayala, G. L. A.*, et al.*
Reduced commuter exposure to PM2.5 and PAHs in response to improved emission standards in bus rapid transit systems in Mexico.
Environ Pollut, Vol. **335**, (2023)

We evaluated impacts of progressive technological updates to bus rapid transit (BRT) systems on in-cabin concentrations of particulate matter with an aerodynamic diameter ≤2.5 μm (PM2.5), and the various polyaromatic hydrocarbons (PAHs) to which commuters were exposed. PM2.5 samples were collected and

real-time concentrations measured from October 2017 to March 2020 inside cabins of BRT buses equipped with Euro IV, V and VI diesel emission standards in the Mexico City Metropolitan Area (MCMA). For effective comparison, similar samplings and measurements were carried out on trains in the MCMA underground (MCU) system. Peak in-cabin PM2.5 concentrations decreased significantly ($p < 0.05$) by 35% from Euro IV to Euro V buses, and by 80% from Euro IV to Euro VI buses. PM2.5 concentrations inside Euro VI buses were significantly lower ($p < 0.05$) than in Euro IV and Euro V buses and in underground trains. The in-cabin excess (ICE) of PM2.5 relative to ambient concentrations was significantly ($p < 0.05$) higher for Euro IV than for Euro V buses during morning the traffic peak, and consistently higher than for Euro VI buses. Indeed, ICEs calculated for Euro VI buses were always lower than those for electricity-powered underground trains. The frequency of hotspots decreased from Euro IV to Euro VI buses due to the combined effect of low emissions and closed, air-conditioned cabins. Concentrations of total PAHs including carcinogenic species also decreased from Euro IV to Euro V buses and were below limits of detection aboard Euro VI buses. This work shows that in real-life conditions, advanced diesel technologies and cabin design significantly reduce commuters' exposure to PM2.5 and to toxic PAH compounds.

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Xiang, L., Lee, C. W., Zikanov, O., Abuhegazy, M., Poroseva, S. V.
Reduced-order modeling of transport of infectious aerosols in ventilated rooms.
Physics of Fluids, Vol. **35** n°(7), (2023)

A new approach to numerical modeling of airborne transmission of respiratory infections, such as COVID-19, influenza, or those caused by common rhinoviruses, is presented. The focus is on the long-range transport of infectious aerosol particles by air flows in indoor environments. The approach is based on the Eulerian description of the aerosol field and the reduced-order modeling (ROM) applied to reduce the computational cost of analysis. The ROM is based on the projection of a computational fluid dynamics (CFD) solution onto a Krylov subspace by an Arnoldi-type algorithm. The algorithm does not require access to the original discretization matrix and, therefore, can be applied to solutions of Eulerian transport problems by general-purpose CFD software, in which such a matrix is often unavailable. The model is validated for a realistic setting via direct comparison of its predictions with the results of the full-order CFD solution based on the Eulerian model and the data of Lagrangian tracking of aerosol particles. Applicability of the ROM to simulation of long-term evolution of the aerosol field and to assessment of infection hazard is demonstrated. Computational tests show that use of ROM reduces the computational cost of analysis by a factor of about 10(3) without a significant loss in the accuracy of the results.

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Farahi, F.
Soft Ionization: Improving Indoor Air Quality.
Ieee Transactions on Industry Applications, Vol. **59** n°(5), (2023), 5580-5586 p.

In this article we report two applications of a sub-category of air cleaning devices based on soft ionization that do not cause molecular fragmentation. A system that includes two unipolar ionizingmodules has been used to simultaneously produce positive and negative ions in the air. In one set of experiments a large chamber (28 m(3)) was used to study the effect of ions on reducing PM1.0 particles produced by a research grade calibrated cigarette. The data presented in this article were obtained using a carbon-brush-based bipolar ionizer and a MERV 10 filter with electret media in a recirculating HVAC system. Significant improvement in removal rate of fine and ultrafine particleswas achieved when using the bipolar ionizer in conjunction with the MERV 10 filter. The second set of experiments were conducted using a 36 m(3) chamber, following BSL-3 standards, to study the effect of ions on aerosolized SARS-CoV-2. Results of these investigations reveal the inactivation rate of SARS-CoV-2 are enhanced when ions are introduced in the air; inactivation rates were increased by more than 60% and 90% for ion densities of 10,000/cc and 18,000/cc.

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Canpolat, M., Sakalar, Ç., Bozkurt, S., Çoban, A. Y., Karaçayli, D., Toker, E.

Thermal Inactivation of Airborne SARS-CoV-2 by an Electric Fan Heater in Winter and Defining Conditions to Ensure That All the Air Passes through the Fan.

Journal of Thermal Science and Engineering Applications, (2023), 1-22 p.

The way the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is spread, especially in closed environments, is airborne transmission. The study aims to assess the thermal inactivation of airborne SARS-CoV-2 in a 30 m3 test room as a function of outlet temperature, airflow rate, and operating time of an electric heater, then define a condition to ensure that all air in the room passes through the electric heater. Aerosolized SARS-CoV-2 was delivered to the test room at an ambient temperature of 20 C and 40% humidity. Two electric heaters with different power and airflow rates were operated respectively in the test room to compare their efficiencies in the inactivation of airborne SARS-CoV-2. The first and second electric heaters had power, airflow rates, and outlet temperatures of 1.5 kW, 44 m3/h, 220 °C, and 3 kW, 324 m3/h, and 150 °C, respectively. A fan drew the outside air into the heater. In the first experiment, a 1.5 kW electric heater was operated in the test room for 80 minutes. In the second experiment, a 3 kW electric heater was used in the test room for 75 minutes. Airborne SARS-CoV-2 in the test room was inactivated by 99.00% and 99.96% in the first and second experiments, respectively. A condition is defined to ensure that all the air in the room passes at least once through the electric heater fan.

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