
# Rapport de veille n° 55

# Aéraulique et COVID-19

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# Google Scholar, Lens et WoS

Lahdentausta, L., Sanmark, E., Lauretsalo, S., Korkee, V., Nyman, S., Atanasova, N.*, et al.*
**Aerosol concentrations and size distributions during clinical dental procedures.**
Heliyon, Vol. **8** n°(10), (2022)

Background Suspected aerosol-generating dental instruments may cause risks for operators by transmitting pathogens, such as the SARS-CoV-2 virus. The aim of our study was to measure aerosol generation in various dental procedures in clinical settings. Methods The study population comprised of 84 patients who underwent 253 different dental procedures measured with Optical Particle Sizer in a dental office setting. Aerosol particles from 0.3 to 10 µm in diameter were measured. Dental procedures included oral examinations (N = 52), restorative procedures with air turbine handpiece (N = 8), high-speed (N = 6) and low-speed (N = 30) handpieces, ultrasonic scaling (N = 31), periodontal treatment using hand instruments (N = 60), endodontic treatment (N = 12), intraoral radiographs (N = 24), and dental local anesthesia (N = 31). Results Air turbine handpieces significantly elevated <1 µm particle median (p = 0.013) and maximum (p = 0.016) aerosol number concentrations as well as aerosol particle mass concentrations (p = 0.046 and p = 0.006) compared to the background aerosol levels preceding the operation. Low-speed dental handpieces elevated >5 µm median (p = 0.023), maximum (p = 0.013) particle number concentrations,> 5 µm particle mass concentrations (p = 0.021) and maximum total particle mass concentrations (p = 0.022). High-speed dental handpieces elevated aerosol concentration levels compared to the levels produced during oral examination. Conclusions Air turbine handpieces produced the highest levels of <1 µm aerosols and total particle number concentrations when compared to the other commonly used instruments. In addition, high- and low-speed dental handpieces and ultrasonic scalers elevated the aerosol concentration levels compared to the aerosol levels measured during oral examination. These aerosol-generating procedures, involving air turbine, high- and low-speed handpiece, and ultrasonic scaler, should be performed with caution. Clinical significance Aerosol generating dental instruments, especially air turbine, should be used with adequate precautions (rubber dam, high-volume evacuation, FFP-respirators), because aerosols can cause a potential risk for operators and substitution of air turbine for high-speed dental handpiece in poor epidemic situations should be considered to reduce the risk of aerosol transmission.

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Kim, Y. I., An, S., Huh, J., Kim, Y.-S., Heo, J., Song, I.-S.*, et al.*
**Aerosol suppression from a handpiece using viscoelastic solution in confined dental office.**
Physics of Fluids, Vol. **34** n°(10), (2022)

Aerosolized droplets are produced en masse in dental practices; these aerosols disperse in the surrounding space, posing a health threat if the patient is infected with a transmittable disease, particularly COVID-19. Here, a viscoelastic polyacrylic acid (PAA) solution was used to minimize liquid aerosolization and limit the travel distance of aerosols. The PAA concentration was varied to evaluate its effect on aerosolization and droplet size resulting from procedures using dental handpieces, which include tooth cutting, grinding, and polishing. In addition, a thermocouple was inserted at the center of the model tooth to measure its temperature during a handpiece operation. The temperature data suggest that the cooling performance of the PAA solution is comparable to that of pure water in operations in the occlusal and facial directions. The PAA solution droplets splattered on the patient's facial area during the handpiece operation are markedly larger than those of pure water, which is evidence of the settling of the PAA droplets, preventing further transmission. Accordingly, the travel distance of the aerosolized PAA droplets was limited by viscoelastic

resistance to droplet detachment. This comparison of the aerosol suppression capability between water and PAA solutions confirms the benefit of using viscoelastic solutions for various dental operations.

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Freedman, D. O.
**Air Travel and SARS-CoV-2: Many Remaining Knowledge Gaps.**
Journal of Travel Medicine, (2022)

COVID-19 is with us indefinitely and air travel is a necessity. Needed research has lagged due to pandemic disruption but must not stall due to COVID indifference. A US government report proposes that national aviation authorities, not health agencies, take the lead. Research priorities and study designs are proposed.

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Zheng, J., Tao, Q., Chen, Y.
**Airborne infection risk of inter-unit dispersion through semi-shaded openings: A case study of a multi-storey building with external louvers.**
Building and Environment, Vol. **225**, (2022)

Building design for natural ventilation and indoor air quality have become increasingly important during the past decades. Investigating airflow routes of airborne transmission and evaluating the potential infection risk in the multi-storey building is helpful to the reduction of airborne transmission. Therefore, this study applies compu-tational fluid dynamics simulations to investigate the inter-unit dispersion pattern of gaseous pollutant between different units through semi-shaded openings. The airflow exchange and pollutant dispersion in a multi-storey building is driven by wind-induced natural ventilation. External shading louvers, which are widely used in building facades to reduce heat gain from solar radiation, are chosen to establish the semi-shaded environment. Experimental validation is performed to make sure the accuracy of numerical settings in airflow investigation of semi-shaded openings. The airflow characteristics around semi-shaded openings is analyzed in the numerical simulations. The re-entry ratio of tracer gas and the airborne infection risk of COVID-19 is investigated in the cases with different louvers' locations and source units. The results show that the airflow is commonly slower in the semi-shaded space between louvers and openings. But the ventilation rate is not always consistent with the airflow speed because of the diversion effect from louver slats. The inter-unit infectious risk in the worst unit rises from 7.82% to 26.17% for windward shading, while it rises from 7.89% to 22.52% for leeward shading. These results are helpful to the further understanding of inter-unit transmission of infectious respiratory aerosols through external openings with complex structures.

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Dancer, S. J.
**Airborne SARS-CoV-2.**
BMJ, Vol. **377**, (2022)

Time for an indoor air revolution. Debate over the exact mode of transmission of SARS-CoV-2 has been intense. This is entirely reasonable, given that the mechanism of spread determines preventive and potentially lifesaving policies. But the choice between respiratory aerosol or droplet settled on short range droplets, which neatly circumvented any risk outside the fabled 2m zone. This choice gave rise to social distancing, hand and surface hygiene, and masks, but not to improved indoor air quality.And so the debate smoulders on, as Duval and colleagues (doi:10.1136/bmj-2021-068743) report from their linked systematic review supporting the role of long distance airborne transmission of SARS-CoV-2. The review examined covid-19 transmission events in a variety of indoor community settings ranging from fitness facilities, offices, buses, and restaurants to choir venues and a church, but not hospitals, hospices, or care homes. The inclusion of care

home outbreaks might have strengthened overall findings, along with more recent studies detailing nosocomial clusters among vaccinated healthcare workers.

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Rodríguez, D., Urbieta, I. R., Velasco, Á., Campano-Laborda, M. Á., Jiménez, E.
**Assessment of indoor air quality and risk of COVID-19 infection in Spanish secondary school and university classrooms.**
Building and Environment, Vol. **226**, (2022)

Despite the risk of transmission of SARS-CoV-2, Spanish educational centers were reopened after six months of lockdown. Ventilation was mostly adopted as a preventive measure to reduce the transmission risk of the virus. However, it could also affect indoor air quality (IAQ). Therefore, here we evaluate the ventilation conditions, COVID-19 risk, and IAQ in secondary school and university classrooms in Toledo (central Spain) from November 2020 to June 2021. Ventilation was examined by monitoring outdoor and indoor CO2 levels. CO2, occupancy and hygrothermal parameters, allowed estimating the relative transmission risk of SARS-CoV-2 (Alpha and Omicron BA.1), Hr, under different scenarios, using the web app COVID Riskairborne. Additionally, the effect of ventilation on IAQ was evaluated by measuring indoor/outdoor (I/O) concentration ratios of O3, NO2, and suspended particulate matter (PM). University classrooms, particularly the mechanically ventilated one, presented better ventilation conditions than the secondary school classrooms, as well as better thermal comfort conditions. The estimated Hr for COVID-19 ranged from intermediate (with surgical masks) to high (no masks, teacher infected). IAQ was generally good in all classrooms, particularly at the university ones, with I/O below unity, implying an outdoor origin of gaseous pollutants, while the source of PM was heterogeneous. Consequently, controlled mechanical ventilation systems are essential in educational spaces, as well as wearing well-fitting FFP2–N95 masks indoors is also highly recommended to minimize the transmission risk of COVID-19 and other airborne infectious diseases.

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Dai, H., Zhao, B.
**Association between the infection probability of COVID-19 and ventilation rates: An update for SARS-CoV-2 variants.**
Building Simulation, (2022)

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of the current coronavirus disease 2019 (COVID-19) pandemic, is evolving. Thus, the risk of airborne transmission in confined spaces may be higher, and corresponding precautions should be re-appraised. Here, we obtained the quantum generation rate (q) value of three SARS-CoV-2 variants (Alpha, Delta, and Omicron) for the Wells-Riley equation with a reproductive number-based fitted approach and estimated the association between the infection probability and ventilation rates. The q value was 89–165 h−1 for Alpha variant, 312–935 h−1 for Delta variant, and 725–2,345 h−1 for Omicron variant. The ventilation rates increased to ensure an infection probability of less than 1%, and were 8,000–14,000 m3 h−1, 26,000–80,000 m3 h−1, and 64,000–250,000 m3 h−1 per infector for the Alpha, Delta, and Omicron variants, respectively. If the infector and susceptible person wore N95 masks, the required ventilation rates decreased to about 1/100 of the values required without masks, which can be achieved in most typical scenarios. An air purifier was ineffective for reducing transmission when used in scenarios without masks. Preventing prolonged exposure time in confined spaces remains critical in reducing the risk of airborne transmission for highly contagious SARS-CoV-2 variants.

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Kawasaki, T., Kikuta, K., Hayashi, M., Bando, M., Hasegawa, K., Sawachi, T.
**A comprehensive survey analysis focusing on the effect of living literacy on residential environment and health recognition under COVID-19 in Japan.**

Indoor Air, Vol. **32** n°(10), (2022)

Appropriate knowledge and actions of residents in housing are expected to reduce health effects, defined as "living literacy." With the spread of COVID-19 and the diversification of lifestyles, a quantitative evaluation of a comprehensive model that includes living literacy in the housing environment is required. In this study, the author conducted two web-based surveys of approximately 2000 different households in Japan during the summer of 2020 and winter of 2021, and a statistical analysis based on the survey results. As a result, ventilation by opening windows was observed as a new resident behavior trend under COVID-19. In addition, structural equation modeling using the survey samples confirmed the certain relationship between living literacy and subjective evaluation of the indoor environment and health effects in both periods.

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Franceschini, P. B., Liguori, I. N., Neves, L. D. O.
**Condições de conforto térmico e QAI em salas de aula naturalmente ventiladas durante a pandemia de Covid-19.**
Ambiente Construído, Vol. **22** n°(4), (2022), pp. 217-231

In order to achieve good thermal comfort and indoor air quality (IAQ) conditions in naturally ventilated classrooms, adequate air change rates must be ensured. In 2020, this issue became especially relevant due to the Covid-19 pandemic, since it may contribute to minimize the transmission potential of respiratory diseases. This study aims to evaluate the thermal comfort and IAQ conditions of a naturally ventilated classroom, in order to identify scenarios that contribute, simultaneously, to the reduction of the risk of dissemination of the SARS-CoV-2 virus and to the maintenance of thermal comfort for users. Environmental variables were monitored in a classroom before and during the Covid-19 pandemic and a simulation model was calibrated. Scenarios varying the number of occupants and the air change rate were simulated in order to assess the impact of these variables on the CO 2 concentration, on the infection probability and on the indoor operative temperature. The best scenario showed a reduction of 42% in the concentration of CO 2 and 33% in the infection probability and an increase of 60% in comfort hours, compared to the worst scenario. However, the strategies adopted must be analysed for each situation, as well as the risks and benefits for classroom occupants.

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Costanzo, S., Flores, A.
**COVID-19 Contagion Risk Estimation Model for Indoor Environments.**
Sensors, Vol. **22** n°(19), (2022)

COVID-19 is an infectious disease mainly transmitted through aerosol particles. Physical distancing can significantly reduce airborne transmission at a short range, but it is not a sufficient measure to avoid contagion. In recent months, health authorities have identified indoor spaces as possible sources of infection, mainly due to poor ventilation, making it necessary to take measures to improve indoor air quality. In this work, an accurate model for COVID-19 contagion risk estimation based on the Wells-Riley probabilistic approach for indoor environments is proposed and implemented as an Android mobile App. The implemented algorithm takes into account all relevant parameters, such as environmental conditions, age, kind of activities, and ventilation conditions, influencing the risk of contagion to provide the real-time probability of contagion with respect to the permanence time, the maximum allowed number of people for the specified area, the expected number of COVID-19 cases, and the required number of Air Changes per Hour. Alerts are provided to the user in the case of a high probability of contagion and CO2 concentration. Additionally, the app exploits a Bluetooth signal to estimate the distance to other devices, allowing the regulation of social distance between people. The results from the application of the model are provided and discussed for different scenarios, such

as offices, restaurants, classrooms, and libraries, thus proving the effectiveness of the proposed tool, helping to reduce the spread of the virus still affecting the world population.

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Rogak, S. N., Rysanek, A., Lee, J. M., Dhulipala, S. V., Zimmerman, N., Wright, M.*, et al.*
**The effect of air purifiers and curtains on aerosol dispersion and removal in multi-patient hospital rooms.**
Indoor Air, Vol. **32** n°(10), (2022)

Airborne transmission of disease is of concern in many indoor spaces. Here, aerosol dispersion and removal in an unoccupied 4-bed hospital room were characterized using a transient aerosol tracer experiment for 38 experiments covering 4 configurations of air purifiers and 3 configurations of curtains. NaCl particle (mass mean aerodynamic diameter similar to 3 mu m) concentrations were measured around the room following an aerosol release. Particle transport across the room was 1.5-4 min which overlaps with the characteristic times for significant viral deactivation and gravitational settling of larger particles. Concentrations were close to spatially uniform except very near the source. Curtains resulted in a modest increase in delay and decay times, less so when combined with purifiers. The aerosol decay rate was in most cases higher than expected from the clean air delivery rate, but the reduction in steady-state concentrations resulting from air purifiers was less than suggested by the decay rates. Apparently, a substantial (and configuration-dependent) fraction of the aerosol is removed immediately, and this effect is not captured by the decay rate. Overall, the combination of curtains and purifiers is likely to reduce disease transmission in multipatient hospital rooms.

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Shinohara, N., Ogata, M., Kim, H., Kagi, N., Tatsu, K., Inui, F.*, et al.*
**Evaluation of shields and ventilation as a countermeasure to protect bus drivers from infection.**
Environmental research, (2022)

We evaluated the deposition of droplets and droplet nuclei-generated by simulated coughing and talking from three points in a bus-on the driver's face and on surfaces around the driver (e.g., the steering wheel), based on whether countermeasures were taken, and assuming that an infected passenger was talking to the driver. When a shield, such as acrylic boards or polyvinyl chloride (PVC) sheets, was used as the countermeasure, the deposition of artificial droplets (>4 mum), emitted from beside or behind the driver, on his eyes, mouth, and cheeks reduced by two to three orders of magnitude or more. Deposition on the surfaces around the driver was also reduced following the use of shields. For artificial droplet nuclei (1.3 mum of polystyrene latex (PSL)) emitted from atomizers beside the driver, the operation of the ventilation fan (VF) and air conditioner (AC), and defroster (DEF) greatly reduced the driver's exposure, while the use of the shield did not. The infection risk of the driver was estimated through exposure to the virus via transfer to the mucosa via hands or surface-to-finger, direct adhesion on the mucosa, and direct inhalation of droplets and droplet nuclei. This is under the assumption that the droplets and droplet nuclei measured in this study are 40% the diameter of those after immediately leaving the mouth of the infected person and are constant regardless of particle size. When using the shield, total infection risk via droplet, airborne, and contact transmission was decreased by 75.0-99.8%. When the shield was not installed, the infection risk decreased by 9.74-48.7% with the operation of the VF, AC, and/or DEF.

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Das, D., Babik, K. R., Moynihan, E., Ramachandran, G.
**Experimental studies of particle removal and probability of COVID-19 infection in passenger railcars.**
Journal of Occupational and Environmental Hygiene, (2022), pp. 1-22

ABSTRACTA series of experiments in stationary and moving passenger railcars was conducted to measure the removal rates of particles in the size ranges of SARS-CoV-2 viral aerosols, and the air changes per hour

provided by the existing and modified air handling systems. The effect of ventilation and air filtration systems on removal rates and their effects on estimated probability (i.e., risk) of infection was evaluated in a range of representative conditions: (1) for two different ratios of recirculated air (RA) to outdoor air (OA) (90:10 RA:OA and 67:33 RA:OA); (2) using minimum efficiency reporting value (MERV) filters with standard (MERV-8) and increased (MERV-13) filtration ratings; and (3) in the presence and absence of a portable high-efficiency particulate-air (HEPA) room air purifier system operated at clean air delivery rate (CADR) of 150 and 550 cfm. The higher efficiency MERV-13 filters significantly increased particle removal rates on average by 3.8 to 8.4 hr-1 across particle sizes ranging from 0.3 to 10 µm ($p<0.01$) compared to MERV-8 filters. The different RA:OA ratios and use of a portable HEPA air purifier system had little effect on particle removal rates. MERV-13 filters reduced the estimated probability of infection by 42% compared to MERV-8 filters. Use of a HEPA-air purifier with a MERV-13 filter causes a 50% reduction in estimated probability of infection. Upgrading the efficiency of HVAC filters from MERV-8 to MERV-13 in public transit vehicles is the most effective exposure control method resulting in a clear reduction in the removal rates of aerosol particles and the estimated probability of infection.

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Rahvard, A. J., Karami, S., Lakzian, E.

**Finding the Proper Position of Supply and Return Registers of Air Condition System in a Conference hall in Term of COVID-19 Virus Spread.**

International Journal of Refrigeration, (2022)

The outbreak of the COVID-19 has affected all aspects of people's lives around the world. As air transmits the viruses, air-conditioning systems in buildings, surrounded environments, and public transport have a significant role in restricting the transmission of airborne pathogens. In this paper, a computational fluid dynamic (CFD) model is deployed to simulate the dispersion of the COVID-19 virus due to the coughing of a patient in a conference hall, and the effect of displacement of supply and return registers of the air conditioning system is investigated. A validated Eulerian-Lagrangian CFD model is used to simulate the airflow in the conference hall. The particles created by coughing are droplets of the patient's saliva that contain the virus. Three cases with different positions of supply and return registers have been compared. The simulation results show that case1 has the best performance; since after 80 s in case 1 that the inlet registers are in the longitudinal wall, the whole particles are removed from space. However, in other cases, some particles are still in space.

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Hishamuddin, M. I., Mansor, H., Zahaba, M., Yusoff, N. M., Gunawan, T. S.

**Fuzzy Logic Controller of Indoor Air Quality Monitoring and Control System for Risk Reduction of COVID-19 Transmission.**

IEEE 8th International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA). 26-29-8 septembre 2022, Melaka, Malaysia

The risk of Coronavirus disease (COVID-19) was reported to be higher in the indoor environment due to poor ventilation systems. A good and efficient ventilation system in enclosed spaces can help reduce the risk of infection. Thus, it is important to monitor the efficiency of the ventilation system. Therefore, this research aims to develop an indoor air quality (IAQ) monitoring and control system using the fuzzy logic controller (FLC). Three IAQ parameters were selected in this study (temperature, relative humidity (RH), and carbon dioxide ($CO_2$) concentration). In addition, benchmark testing was done to test the efficiency of the IAQ monitoring and control system. The system's engine is a microcontroller, which collects data on IAQ parameters, and is equipped with an exhaust fan as the ventilation strategy. The device aids in monitoring IAQ parameters and is equipped with an exhaust fan as the ventilation strategy. The device, which aids in monitoring IAQ, was created using a machine learning technique, fuzzy logic controller. The performance of

the proposed air quality monitoring and control system was also investigated and validated through several experiments. The system was tested by modifying each parameter individually while keeping the controlled parameters safe. In addition, the tests were changed to include the existence of a controller in the system to see how ventilation affects the measured metrics. The test revealed that without the controller, the parameters take a long time to return to their initial values, however with the controller, the readings return to their original values faster than normal. The system also demonstrated that by following the fuzzy rules set, it is capable of handling two parameters at the same time.

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Borodinecs, A., Palcikovskis, A., Jacnevs, V.
**Indoor Air CO2 Sensors and Possible Uncertainties of Measurements: A Review and an Example of Practical Measurements.**
Energies, Vol. **15** n°(19), (2022)

Since the COVID-19 outbreak, special attention has been paid to proper ventilation and building management systems. The indoor air CO2 concentration level is still used as an effective indicator to evaluate indoor air quality. Many different sensors have appeared on the market in the last two years. However, calibration procedures and guidance on proper installation have not been well described by manufacturers. The research method is based on a review of technical parameters. The practical measurements of CO2 concentration were taken using different sensors. For these purposes three different premises were selected. It was found that CO2 measurement failure happened in residential buildings without mechanical ventilation. Meanwhile, in well ventilated buildings all sensors have shown similar results and the difference between sensors located in different zones was minimal.

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González-Sancha, R., Marín-García, D., Pinheiro, M. D., Oliveira, M.
**Legal regulation of ventilation rates in homes in Europe 2010–2022: Evolution and comparison study regarding Covid-19 recommendations.**
Building and Environment, (2022)

The airborne transmission of SARS-CoV-2, the virus that causes Covid-19 disease, has been recognized as an essential route of contagion, so adequate ventilation is vital indoors. For this reason, the research goal focuses on carrying out the study and evolutionary and comparison analysis of the regulation of ventilation rates in dwellings in Europe (2010–2022) and on determining whether modifications are necessary for the said regulation based on the recommendations of competent international organizations. To do this, the methodology followed initially starts from the study carried out in 2010 by Christine Dimitroulopoulou, in which the existing regulation in various European countries regarding ventilation in dwellings was studied. Once this study has been analysed, it continues to update and compare the regulation of the different European countries cited in the said work, detecting during the process if a modification is necessary based on the recommendations indicated by international organizations such as the WHO or ECDC. The results and conclusions indicate that few countries have significantly changed their ventilation rates. Although the existing ones may be admissible, requiring controlled ventilation in the different regulations would be convenient.

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Mcleod, R. S., Hopfe, C. J., Bodenschatz, E., Moriske, H. J., Pöschl, U., Salthammer, T.*, et al.*
**A multi-layered strategy for COVID-19 infection prophylaxis in schools: A review of the evidence for masks, distancing, and ventilation.**
Indoor air, Vol. **32** n°(10), (2022)

Implications for the academic and interpersonal development of children and adolescents underpin a global political consensus to maintain in-classroom teaching during the ongoing COVID-19 pandemic. In support of this aim, the WHO and UNICEF have called for schools around the globe to be made safer from the risk of COVID-19 transmission. Detailed guidance is needed on how this goal can be successfully implemented in a wide variety of educational settings in order to effectively mitigate impacts on the health of students, staff, their families, and society. This review provides a comprehensive synthesis of current scientific evidence and emerging standards in relation to the use of layered prevention strategies (involving masks, distancing, and ventilation), setting out the basis for their implementation in the school environment. In the presence of increasingly infectious SARS-Cov-2 variants, in-classroom teaching can only be safely maintained through a layered strategy combining multiple protective measures. The precise measures that are needed at any point in time depend upon a number of dynamic factors, including the specific threat-level posed by the circulating variant, the level of community infection, and the political acceptability of the resultant risk. By consistently implementing appropriate prophylaxis measures, evidence shows that the risk of infection from in-classroom teaching can be dramatically reduced. Current studies indicate that wearing high-quality masks and regular testing are amongst the most important measures in preventing infection transmission; whilst effective natural and mechanical ventilation systems have been shown to reduce infection risks in classrooms by over 80%.

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Park, S.-H., Yook, S.-J., Koo, H. B.

**Natural Ventilation and Air Purification for Effective Removal of Airborne Virus in Classrooms with Heater Operation.**

Toxics, Vol. **10** n°(10), (2022)

Mass COVID-19 infection cases in indoor spaces have been continuously reported since its global outbreak, generating increasing public interest in reducing the spread of the virus. This study considered a situation in which an infected individual continuously releases the virus into the air in a classroom, simulated by continuous injection of NaCl particles ≤ 5 mum, with heater operation during winter. The effects of applying natural ventilation and operating one or two air purifiers on the removal of virus-containing aerosols were experimentally compared and analyzed based on the spatiotemporal changes in NaCl concentration within the classroom. When a heater was operated with all windows shut, operating one and two air purifiers reduced the amount of the aerosol in indoor air by approximately 50 and 60%, respectively, compared to the case with no air purifier. Additionally, when the heater was operated with one or two air purifiers under natural ventilation, the amount of virus-containing aerosol in the air was reduced by 86-88% compared to the case with neither natural ventilation nor air purifier. Because natural ventilation significantly varies with weather conditions and particulate matter concentrations, combining natural ventilation with air purifiers in classrooms during winter needs to be adjusted appropriately.

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Sheraz, M., Mir, K. A., Anus, A., Kim, S., Lee, W. R.

**SARS-CoV-2 airborne transmission: a review of risk factors and possible preventative measures using air purifiers.**

Environmental Science: Processes & Impacts, (2022)

The rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting worldwide death toll have prompted worries regarding its transmission mechanisms. Direct, indirect, and droplet modes are the basic mechanisms of transmission. SARS-CoV-2 spreads by respiratory droplets (size range >10 µm size ranges), aerosols (5 µm), airborne, and particulate matter. The rapid transmission of SARS-CoV-2 is due to the involvement of tiny indoor air particulate matter (PM2.5), which functions as a vector. SARS-CoV-2 is more contagious in the indoor environment where particulate matter floats for a longer period

and greater distances. Extended residence time in the environment raises the risk of SARS-CoV-2 entering the lower respiratory tract, which may cause serious infection and possibly death. To decrease viral transmission in the indoor environment, it is essential to catch and kill the SARS-CoV-2 virus and maintain virus-free air, which will significantly reduce viral exposure concerns. Therefore, effective air filters with anti-viral, anti-bacterial, and anti-air-pollutant characteristics are gaining popularity recently. It is essential to develop cost-effective materials based on nanoparticles and metal–organic frameworks in order to lower the risk of airborne transmission in developing countries. A diverse range of materials play an important role in the manufacturing of effective air filters. We have summarized in this review article the basic concepts of the transmission routes of SARS-CoV-2 virus and precautionary measures using air purifiers with efficient materials-based air filters for the indoor environment. The performance of air-filter materials, challenges and alternative approaches, and future perspectives are also presented. We believe that air purifiers fabricated with highly efficient materials can control various air pollutants and prevent upcoming pandemics.

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Oksanen, L.-M. a. H., Virtanen, J., Sanmark, E., Rantanen, N., Venkat, V., Sofieva, S.*, et al.*
**SARS-CoV-2 indoor environment contamination with epidemiological and experimental investigations.**
Indoor Air, Vol. **32** n°(10), (2022)

Abstract SARS-CoV-2 has been detected both in air and on surfaces, but questions remain about the patient-specific and environmental factors affecting virus transmission. Additionally, more detailed information on viral sampling of the air is needed. This prospective cohort study (N = 56) presents results from 258 air and 252 surface samples from the surroundings of 23 hospitalized and eight home-treated COVID-19 index patients between July 2020 and March 2021 and compares the results between the measured environments and patient factors. Additionally, epidemiological and experimental investigations were performed. The proportions of qRT-PCR-positive air (10.7% hospital/17.6% homes) and surface samples (8.8%/12.9%) showed statistical similarity in hospital and homes. Significant SARS-CoV-2 air contamination was observed in a large (655.25 m3) mechanically ventilated (1.67 air changes per hour, 32.4–421 L/s/patient) patient hall even with only two patients present. All positive air samples were obtained in the absence of aerosol-generating procedures. In four cases, positive environmental samples were detected after the patients had developed a neutralizing IgG response. SARS-CoV-2 RNA was detected in the following particle sizes: 0.65–4.7 µm, 7.0–12.0 µm, >10 µm, and <100 µm. Appropriate infection control against airborne and surface transmission routes is needed in both environments, even after antibody production has begun.

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Mariita, R., Davis, J. H., Lottridge, M. M., Randive, R. V., Witting, H., Yu, J.
**Towards a Healthy Car: UVC LEDs Inside Automobile HVAC Chamber Offers Effective Complementary Disinfection to Ensure Clean Cabin Air.**
Preprints, (2022)

Vehicle HVAC systems can accumulate and recirculate highly infectious respiratory diseases via aerosols. Integrating UVC to complement automobile HVAC systems can protect occupants from developing allergies, experiencing inflammatory problems, or acquiring respiratory infectious diseases by inactivating pathogenic organisms. UVC can add little to no static pressure with minimal space, unlike mercury lamps which are larger and heavier. Additionally, UVC LEDs are effective at low voltage and have no mercury or glass. While previous experiments have shown UVC LED technology can reduce bacteriophage Phi6 concentrations by 1 log in 5 minutes (selected as the average time to clean the cabin air), those studies had not positioned LED within the HVAC itself or studied the susceptibility of the surrogate at the specific wavelength. This study aimed to assess the disinfection performance of UVC LEDs in automotive HVAC systems and determine the dose-response curve for bacteriophage Phi6, a SARS-CoV-2 surrogate. To achieve this, UVC LEDs were installed in a car HVAC system. To determine inactivation efficacy, a model chamber of 3.5 m3, replicating the typical volume of a car,

containing the modified automobile HVAC system was filled with bacteriophage Phi6, and the HVAC was turned on with and without the UVC LEDs being turned on. The results revealed that HVAC complemented with UVC reduced bacteriophage Phi6 levels significantly more than the HVAC alone and reduced the viral concentration in the cabin by more than 1 LRV (90% viral reduction) in less than 5 minutes. The performance after 5 minutes is expected to be significantly better against SARS-CoV-2 because of its higher sensitivity to UVC, especially at lower wavelengths (below 270 nm). HVAC alone could not achieve a 90% viral reduction of bacteriophage Phi6 in 15 minutes. Applying UVC LEDs inside an HVAC system is an effective means of quickly reducing the number of aerosolized viral particles in the chamber, by inactivating microorganisms leading to improved cabin air quality.

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Kumar, A., Moreno-Rangel, A., Khan, M. a. I., Piasecki, M.
**Ventilation and Indoor Air Quality.**
Atmosphere, Vol. **13** n°(10), (2022)

This Special Issue contains three papers related to indoor quality technologies and applicable techniques. The paper by Alexei et al. [17] tested the effectiveness of a novel window windcatcher device (WWC) for improving natural ventilation in buildings. The proposed window windcatcher has been shown to improve both thermal comfort and indoor air quality. Another interesting paper by Siebler et al. [18] evaluated indoor airborne virus transmissions using two methods (a generalized experimental set up and a trace gas method) for several ventilation measures. Readers will enjoy a review of indoor air quality cleansing technologies by Mata et al. [19]. The paper discusses physicochemical as well as biological technologies. Meta et al. [19] concludes that the optimum solution may involve the use of a combination of technologies to solve IAQ problems.
Overall, this Special Issue provides new information to the readers and introduce new research areas for solving IAQ problems. It is hoped that readers of this Special Issue will be inspired and their minds stimulated to conduct further research on IAQ issues.

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Chung, J. H., Kim, S., Sohn, D. K., Ko, H. S.
**Ventilation Efficiency According to Tilt Angle to Reduce the Transmission of Infectious Disease in Classroom.**
Indoor and Built Environment, (2022),

Understanding of the droplet transmission of respiratory diseases is necessary to control the outbreak of COVID-19. HVAC systems considering droplet transmission are commonly used to prevent numerous respiratory diseases by reducing indoor virus concentrations. The transmission of the virus was directly related to indoor flow patterns generated by HVAC systems. Thus, a study on operating conditions such as direction or the tilt angle was required. In this study, the effective ventilation rate and probability of droplet transmission according to the tilt angle of supply air and the number of people were studied. A CO2 tracer gas method was used to validate the results of simulations. The breathing plane and personal respiratory zone were introduced for the probability of droplet transmission. The result showed that ventilation performance showed 17% of the maximum difference among tilt angles. Various turbulent kinetic energies were obtained according to the seated positions, resulting in non-uniform CO2 concentration. Numerous conditions were examined with locational analysis of individuals. As a result, the flow rates for ventilation were recommended to be higher than 250 m3/h and 350 m3/h with a tilt angle of 60° for an occupancy of 8 and 16 people, respectively.

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Kitamura, H., Ishigaki, Y., Ohashi, H., Yokogawa, S.
**Ventilation improvement and evaluation of its effectiveness in a Japanese manufacturing factory.**

Scientific Reports, Vol. **12** n°(1), (2022)

A coronavirus disease 2019 (COVID-19) cluster emerged in a manufacturing factory in early August 2021. In November 2021, we conducted a ventilation survey using the tracer gas method. Firstly, we reproduce the situation at the time of cluster emergence and examined whether the ventilation in the office was in a condition that increased the risk of aerosol transmission. Secondly, we verified the effectiveness of the factory's own countermeasure implemented immediately after the August cluster outbreak. Furthermore, we verified the effectiveness of several additional improvement measures on the factory's own countermeasures already installed in August. Under the conditions of the cluster emergence, the air changes per hour (ACH) value was 0.73 ACH on average. The ACH value was less than 2 ACH recommended by the Ministry of Health, Labour, and Welfare, suggesting an increased risk of aerosol transmission. The factory's own countermeasures taken immediately in August were found to be effective, as the ACH value increased to 3.41 ACH on average. Moreover, it was confirmed that additional improvement measures on the factory's own countermeasures increased the ACH value to 8.33 ACH on average. In order to prevent the re-emergence of COVID-19 clusters due to aerosol infection in the office, it was found that while continuing the factory's own countermeasure, additional improvement measures should also be added depending on the number of workers in the room. In a company, it is important that workers themselves continue to take infection control measures autonomously, and confirming the effectiveness of the measures will help maintain workers' motivation. We believe it is helpful that external researchers in multiple fields and internal personnel in charge of the health and safety department and occupational health work together to confirm the effectiveness of conducted measures, such as in this case.

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