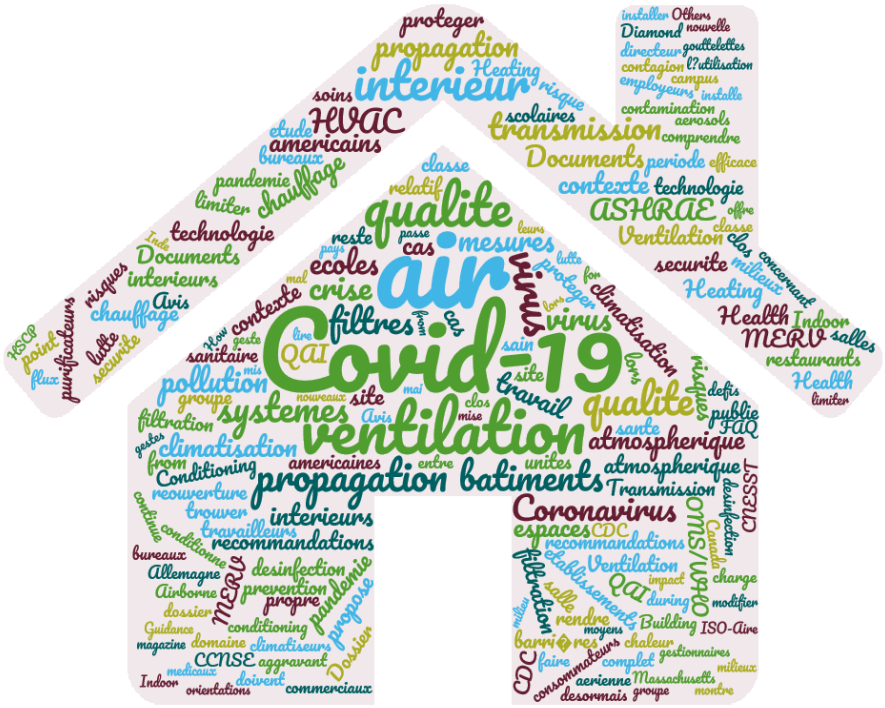

Bulletin de veille AéroCovid
N°120 – 03/09/2025

Objectif : *Air intérieur, ventilation, climatisation et propagation du Covid-19*

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS. Les éléments issus de cette veille sont founis sans garantie d'exhaustivité.

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Tobaldi, D. M., Cuscunà, M.

Advancing Air Sustainability: Light-induced Removal of Airborne Pollutants.

In: Contribution of Colloidal Materials to Air, Water and Soil Environmental Sustainability: From Basic Concepts to Advanced Applications. Royal Society of Chemistry; 2025.

In this chapter, we will firstly provide a description of physical removal methods for air pollutants. After that, we will focus our discussion on light-induced ...

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Macrae, A., Lopes, R. N., Allil, R. C. D. S. B., Werneck, M.

Aerobiology, post COVID-19, within the emerging Industrial Revolution 5.0 and Society 5.0.

Discover Environment, Vol. **3** n°(1), (2025)

In this perspective, aerobiology includes microbes, dust, insects, birds and airplanes and the importance of aerial ecosystems in modern society. In 2020, the SARS-CoV-2 virus opened the World's eyes to the global spread of a virus, the fast global spread caused by people travelling on planes. Billions of people were quarantined, studying moved online and most nonessential work was done at home via the internet. The "stay at home" policy, saved millions of lives, slowed transmission rates but also had a huge negative impact on industrial, economic, and social wellbeing. The pandemic arrived at a time when climate changes were being felt in different ways at different locations globally. A new global sustainable society (Society 5.0) was and is emerging that requires the new industrial revolution (Industry 5.0) to meet societal needs for a safer, healthier and sustainable existence. In 2022, as the pandemic receded, ChatGPT and AlphaFold became publicly available and again the World changed and with them Industry 5.0 arrived for the masses. In this perspective, all life in the air, its interactions, vectors, pathogens, and their impact on a global scale are presented confirming the importance of aerobiology in Society 5.0. Climate change, birds, insects, humans, microbiomes, viromes, airborne soil, dust and role of aviation are presented. Human impacts on aerobiology and vice versa are questioned and discussed. Technological advances to detect and control biological entities in the air are presented. Aerobiology is more than dust, microbes, filters, and detection technologies, it is all life in the air and its links to terrestrial and aquatic biology. This perspective provides a holistic understanding of the air ecosystem and its importance for Society 5.0.

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Zong, J., Chang, Y., Ai, Z., Hu, Y.

Aerosol dispersion dynamics and fallow time determination in a multi-chair dental office.

Journal of Building Engineering, Vol. **111**, (2025)

Multi-chair dental offices, with the simultaneous treatment of multiple patients, contribute to multiple aerosol emission sources, significantly increasing the risk of airborne cross-infection and exposure. This study intends to explore the appropriate fallow time (FT) for treatment compartments in a multi-chair dental office during multiple-patient treatments. The marginal benefit index is introduced to evaluate the FT required for balancing daily appointments with exposure risk reduction in a twelve-chair dental office (12-DO). This study first investigates the effect of office configuration, environmental conditions, and multiple-patient treatments on aerosol distribution, and then evaluates aerosol transport across compartments during multiple-patient treatments. The results show that, compared to the single-chair dental office, larger spaces

and more air supply in multi-chair dental offices result in fewer suspended particles in the treatment compartment but more outside the compartment during single-patient treatment. Compared to single-patient treatment in 12-DO, the particle count within a specific compartment increased by 4.5 %–6.4 % during multiple-patient treatments. However, the trend and the time to reach a steady state of particle count reduction are similar during both single-treatment and multiple-treatment scenarios. A 20-min FT is eventually recommended for compartments in 12-DO at 6 ACH when the marginal benefit of extending this period approaches nearly zero, ensuring particle counts in the doctor-patient interaction zone fall below 0.6 % of their original levels. This study is intended to deepen the understanding of aerosol distribution during dental treatments and provide evidence for revising FT guidelines, ultimately contributing to the reduction of airborne cross-infection risks in multi-chair dental offices.

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Park, J., Park, S., Choi, H. S., Hwang, J.

Air purifier and ventilation fan effects on SARS-CoV-2 airborne transmission in vehicle: Infection risk analysis with zonal and CFD models.

Process Safety and Environmental Protection, Vol. **201**, (2025)

Predictive epidemiological models help design effective strategies against airborne disease transmission. To this end, this study compares zonal and computational fluid dynamics (CFD) models for simulating airflow, aerosol dispersion, and infection risk in a private vehicle. Three scenarios were assessed: no mitigation, ventilation fan only, and air purifier only, with airflow rates set to 8.33 × 10−3 m^3 /s (500 L/min or 5 ACH), consistent with EPA and CDC recommendations. Both models captured similar qualitative trends, but significant quantitative discrepancies arose. In the no-mitigation case, CFD predicted infection risks up to 100 × higher than the zonal model due to better resolution of stagnation and turbulent dispersion. With the ventilation fan active, the zonal model predicted higher risks for downstream passengers, while CFD revealed more realistic dilution via recirculation and directional flow. CFD results showed that ventilation reduced average infection risk by 81.99 %, and the purifier by 76.88 %, relative to no mitigation. For rear passengers, the purifier achieved a greater reduction (89.98 %) than ventilation (73.67 %), highlighting spatial trade-offs between flow-driven and localized interventions. Taken together, the zonal model offers computational efficiency and reliable trend prediction, particularly in purifier-dominated or well-mixed environments. CFD, with its ability to resolve flow direction and turbulence, excels in capturing spatial variability. Together, these models form a complementary toolkit for infection risk assessment, adaptable to both rapid evaluations and detailed flow-sensitive analyses.

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Saad, M. A., Hassan, A., Hanafy, A., Salem, M., William, M.

Assessing HVAC airflow modulation strategies to reduce short-term aerosol transmission in office environments.

Scientific Reports, Vol. **15** n°(1), (2025)

Airborne transmission of respiratory pathogens in indoor environments remains a significant global health challenge. While existing research broadly addresses ventilation effectiveness, there is a critical need to understand how specific diffuser placements influence early-phase aerosol dispersion immediately following a cough event. This study uses Computational Fluid Dynamics (CFD) with an Eulerian–Lagrangian approach and the Discrete Phase Model to analyze initial droplet transport, evaporation, and nuclei concentration under different air distribution configurations. The results demonstrate that conventional parallel exhaust configurations, though effective at reducing overall particle mass, can fail to control the lateral spread of infectious nuclei in the short term. In contrast, placing exhaust diffusers above the cough source reduces the lateral particle spread by approximately 40% compared to conventional layouts. Additionally, maintaining the WHO-recommended two-meter distance results in an 82–89% reduction in particle number concentration during the early dispersion phase. These findings underscore the importance of diffuser placement for controlling short-term particle dispersion immediately after a cough

event in mechanically ventilated office environments. The study's scope is limited to early-phase dispersion dynamics within a 10-second simulation period, and further research is needed to assess long-term aerosol suspension, removal mechanisms, and infection risk. Nonetheless, the results offer practical insights for HVAC design and support the integration of ventilation strategies with physical distancing measures to reduce near-field exposure risks.

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Suh, J. W., Kim, J. Y., Sohn, J. W., Lee, S. E., Kim, H. J., Chi, W. J.*, et al.*

Assessment of dry-fogged hydrogen peroxide as an "untact" room disinfection automation system for rapid terminal decontamination of a single isolation room in a healthcare institution.

Antimicrobial Resistance & Infection Control, Vol. **14** n°(1), (2025), 92 p.

This study evaluates the efficacy of dry-fogged hydrogen peroxide (dHP) as an "untact" room disinfection automation system (URDAS) for rapid terminal room decontamination.

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Wang, Y., Gong, G., He, X.

Assessment of the effect of indoor air stability and airflow field on the multi-person infection risk.

Journal of Hazardous Materials, Vol. **496**, (2025)

The transmission of pollutants and viral aerosols is an important way to cause indoor respiratory infections. Influence of ventilation modes and indoor air stability (IAS) on infection risk of the sitting breathing microenvironment of four people were simulated by CFD. Ventilation efficiency and infection risk were assessed using the contaminant dispersion index (CDI) and a Wells-Riley model based on SF6. The results show that unstable, upper supply and lower return contribute to the uniform indoor airflow and the average indoor wind speed is approximately twice that of other working conditions. Under the upper supply and lower return, the average SF6 concentration in the breathing microenvironment under unstable condition was 20.4 % lower than stable condition. Unstable can increase the intensity of turbulent fluctuations, enhance vertical diffusion, break the accumulation of pollutants, rapidly dilute and remove SF6 in the breathing microenvironment. Upper supply and lower return can reduce the average CDIb by 30–65 % within 15–30 min under unstable condition which has the strongest pollutant diffusion capacity. Under stable condition, the transient infection risk at the location next to the infected person is lower than that under unstable condition. Ventilation strategies and indoor air stability will have an impact on infection risk after 16 min. The combination of upper supply lower return and unstable condition can reduce the infection risk of three susceptible individuals by 51.3 %, 35.6 % and 11.4 % than that under stable condition, respectively.

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Shi, J., Lv, Y., Wu, W., Liu, D., Guo, D., Duan, X.*, et al.*

Characterization of particle emissions and microbial exposure risks in endoscopy room.

Building and Environment, Vol. **284**, (2025)

Healthcare workers in respiratory and gastrointestinal endoscopy rooms face an elevated risk of respiratory infections due to close patient contact and exposure to potentially infectious airborne particles. Although previous studies have quantified particle generation during endoscopic procedures, most have assumed pathogenicity without verification and have primarily focused on isolated procedural steps, lacking comprehensive analysis across the full procedural timeline. Moreover, limited research has addressed differences in airborne microbial exposure across distinct endoscopy room types. In this study, we conducted continuous particle monitoring and microbiological sampling during 186 endoscopic procedures across two types of endoscopy rooms. We quantitatively assessed the generation of potentially infectious particles and identified key high-emission events during endoscopic procedures, examined the clinical

factor influencing this event, and characterized differences in airborne microbial exposure. Our findings revealed a significant increase in airborne particles during procedures, with airway reflex responses being a major contributing factor. Procedure duration and anesthesia type were found to significantly affect the duration of these responses. Microbiome analysis showed distinct pathogenic profiles between room types: Pseudomonas aeruginosa, associated with respiratory infections, was prevalent in gastroscopy rooms, while bronchoscopy rooms exhibited a higher abundance of Mycobacterium tuberculosis, indicating a potential risk for tuberculosis transmission. These results suggest that healthcare workers may face procedure-specific occupational exposure risks.

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Chadha, N. K., Powell, J., Leitmeyer, K., Felton, M., Baldelli, A., Rooney, M.*, et al.*

Development and validation of the airway surgery enclosure for high-risk aerosol-generating airway procedures: a bench and clinical study.

Scientific Reports, Vol. **15** n°(1), (2025)

Procedures on the upper airway in patients with respiratory viruses are considered to carry the greatest risk of infection spread to operating room personnel through aerosolization. Appropriate personal protective equipment must be worn, but availability varies worldwide and resources may be limited. We describe the development, validation, and safe implementation of a reusable enclosure with an inexpensive, acrylic design, for use in high-risk airway procedures. Examples of common yet high-risk, aerosol-generating procedures performed with the Airway Surgery Enclosure (ASE) include laryngo-bronchoscopy, suspension laryngoscopy for removal of airway lesions, and rigid bronchoscopy including airway foreign body removal. The ASE demonstrated an 87–94% reduction in aerosolized particle concentration compared to ambient room levels. Bench testing validated the containment capability through laser-based particle imaging and air sampling, while clinical evaluations confirmed ergonomic feasibility and usability. While the ASE provides significant reductions in aerosol exposure, implementation challenges include integration with existing operating room workflows, material durability over repeated sterilization cycles, and cost considerations for widespread adoption. Further studies are needed to assess long-term clinical effectiveness and user adaptability.

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Scott, A., Zaman, Q.

Effects of the Global Pandemic on indoor air quality in dental surgeries: Evaluating practical alternatives to current guidelines and regulations in Scotland.

AHFE International 2025

The COVID-19 pandemic focused attention on the role of ventilation on improving indoor air quality to mitigate against the risk of spread of infection. The aim of this study was to evaluate the effectiveness of increased ventilation and explore an alternative solution for improving indoor air quality to mitigate the risk of airborne infection in dental surgeries. Dental surgeries present a specific risk of airborne infection due to the bio-aerosols generated by high-speed dental instruments such as drills and air-water syringes. Studies show that particulate matter, volatile organic compounds, and carbon dioxide levels often exceed recommended thresholds during dental procedures, contributing to poor indoor air quality and increased health risks. To mitigate these risks, regulatory bodies recommended increasing air changes per hour to 10-12 in dental surgeries. Implementing such systems poses significant physical, financial, and regulatory challenges, alongside ongoing high energy consumption costs. The study evaluated the rapid changes to the requirements and guidance to avoid the risk of airborne infections in dental surgeries during the COVID-19 pandemic. A prototype for an at-source aerosol extraction device was developed and tested in a live dental surgery using an air quality monitor to determine if it could effectively remove aerosols at-source. The prototype was an articulated hose with nozzle positioned close to the patient's mouth and connected to the existing surgery suction pump, which aspirates fluid during dental procedures. Air quality was monitored in the dental surgery during similar aerosol-generating procedures with 10 air changes an hour and then

using the aerosol extraction device. The test results indicated that this alternative strategy performed better than providing 10 air changes an hour with the average of particulate matter of 1µg, 2.5µg, 4µg and 10µg recording an average concentration of 0.19mg/m3 compared to 0.33mg/m3 when using 10 air changes per hour. These results demonstrate that an at-source extraction device could provide a viable alternative to high ventilation strategies. In conclusion, this study demonstrates that an at-source extraction device could mitigate against airborne infections in a cost-effective and energy efficient manner. Further testing, including larger sample size and computational fluid dynamics modelling, is needed to refine the design and assess its applicability across different dental settings. This research provides an opportunity for revising existing guidelines and explore alternative indoor air quality management solutions that ensure both practitioner and patient safety.

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Johnson, L. R., Manoj, D., Varughese, B. T., James, R. I.

Evaluating the effectiveness of a novel cost-effective aerosol containment chamber for high-risk autopsies: a pilot study.

Scientific Reports, Vol. **15** n°(1), (2025)

Autopsy personnel face substantial occupational risks from exposure to infectious agents, particularly during aerosol-generating procedures like bone sawing. The COVID-19 pandemic highlighted these dangers, underscoring the need for innovative safety solutions in resource-limited settings without negative-pressure autopsy suites. To address this, we developed a Low-Cost Infection Containment Chamber (LCICC)—a full-length, transparent, and impermeable structure designed to contain aerosols during high-risk autopsy procedures. This study evaluated the efficacy of LCICC using goat skulls to simulate aerosol generation during sawing. Aerosol densities were measured under both open-air conditions and with LCICC use, employing fluorescein dye for visualization and particle counter for quantification. Statistical analysis confirmed the chamber's effectiveness in reducing occupational exposure. LCICC demonstrated a substantial reduction in aerosol levels, ranging from 85.96 to 88.38% across all particle sizes. Median aerosol densities were consistently recorded at 10.50 mg/m³ with LCICC use, compared to 74.80 to 90.40 mg/m³ in open-air conditions. LCICC's affordability, ease of assembly, and reliable performance position it as a groundbreaking tool for protecting healthcare workers, particularly in low-resource settings. This innovation addresses critical gaps in autopsy safety protocols, offering a practical solution to mitigate risks associated with infectious aerosols while advancing occupational health standards in forensic pathology.

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Guldana, A., Niyetbay, S., Zhanguzhinov, A., Kassabekova, G., Jartayeva, D., Alimova, K.*, et al.*

Impact of Airflow Disturbance from Human Motion on Contaminant Control in Cleanroom Environments: A CFD-Based Analysis.

Buildings, Vol. **15** n°(13), (2025)

The growing demands for sanitary regulations in medical facilities, particularly operating rooms, highlight the importance of ensuring high air quality and minimizing airborne hospital-acquired infections. Improperly designed ventilation systems may lead to contamination of up to 90–95% of patients, especially in light of evolving threats, such as COVID-19. This study focuses on enhancing the energy efficiency and performance of air conditioning and ventilation systems for cleanrooms, where air recirculation is not permissible. A novel energy-efficient direct-flow air treatment scheme is proposed, integrating a heat pump system with adjustable thermal output. A computational fluid dynamics CFD model of a clean operating room was developed to assess the impact of inlet air velocity on aerosol particle removal and airflow stabilization time. The model also considers the effect of personnel movement. The results supported optimized air distribution, reducing microbial contamination risks, with less than 10 CFU/m3, and improved thermal performance. The proposed system was evaluated for energy and cost efficiency compared to conventional setups. Findings can inform the design and operation of cleanroom ventilation in surgical

environments and other high-tech applications. This research contributes to improving indoor air quality and reducing infection risks while enhancing sustainability in healthcare infrastructure.

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Carter, T. J., Shaw, D. R., Eadie, E., Jimenez, J. L., Olsiewski, P. J., Peng, Z.*, et al.*

The Impact of UVC Light on Indoor Air Chemistry: A Modeling Study.

Environmental Science & Technology, Vol. **59** n°(31), (2025), 16543-16555 p.

Germicidal ultraviolet light (GUV) is gaining attention for air disinfection, particularly following the COVID-19 pandemic. GUV air cleaning devices use 222 or 254 nm light to remove airborne and surface pathogens from indoor environments, although their impact on indoor chemistry has received limited attention. This modeling study investigates the impact of GUV light on indoor air pollutant concentrations. In a simulated, occupied classroom using a 222 nm lamp with an average room irradiance of 1 μW cm–2, the predicted ozone production rate was 0.33 mg h–1 for an air change rate of 0.5 h–1, leading to surface interactions with occupants and inanimate surfaces that formed secondary products including nonanal, decanal, and 4-oxopentanal. By contrast, ozone concentration increased by 0.19 mg h–1 at 0.5 h–1 in the presence of a 254 nm lamp with an average room irradiance of 15 μW cm–2, primarily due to infiltration. The long-term health benefits of GUV light disinfection need to be quantitatively compared to the health harms due to GUV-induced pollution to allow a more complete assessment of the benefits of this technology.

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Zhu, Z., Gao, G., Hu, Y., Zhao, X.

Impact of ventilation and ambient temperature on COVID-19 transmission in clinic waiting rooms: A computational fluid dynamics approach.

PLoS One, Vol. **20** n°(8), (2025)

The ongoing COVID-19 pandemic underscores the necessity of understanding the transmission dynamics in enclosed, high-risk environments, such as clinic waiting rooms. This study used computational fluid dynamics (CFD) to investigate the behavior of virus-laden aerosols in clinic waiting rooms under six different scenarios with various temperatures and ventilation setups, offering insights into practical strategies for enhancing safety in healthcare environments. Key findings demonstrated that effective ventilation, through open windows and mechanical systems, can reduce virus-laden aerosol concentrations by up to 99.3% under optimal conditions (e.g., from 5.80 kg/m3 to 0.04 kg/m3By contrast, poorly ventilated scenarios exhibit significantly higher viral concentrations, which can rise as high as 5.80 kg/m3. A novel aspect of this research lies in the comprehensive modeling of human anatomy and aerosol interactions, which enhances the accuracy of viral-trajectory predictions. The practical implications include strategic recommendations for ventilation system design to mitigate transmission risks in clinical settings. These insights provide guidelines for healthcare facility design and emphasize the critical role of environmental control in reducing exposure to airborne pathogens.

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Schmohl, A., Nagele-Renzl, A., Buschhaus, M.

Inactivation of Continuously Released Airborne Virus by Upper-Room UVC LED Irradiation Under Realistic Testing Conditions.

Environments, Vol. **12** n°(7), (2025)

Ultraviolet (UV) radiation can be used to inactivate microorganisms, with upper-room UV germicidal irradiation (UR-UVGI) representing a promising approach. This study investigated the inactivation of the airborne surrogate virus Phi6 by a UR-UVGI system based on light-emitting diodes (LEDs) in a realistic test setup. Two test scenarios were used, one with continuous Phi6 release, simulating a source located in the room and leading to a dynamic equilibrium, and the second simulating a situation in which the source has

left the room and an exponential decay is evaluated. The “Incremental Evaluation Model” was adapted and used to evaluate the dynamic equilibrium measurement. At a position in the breathing direction 5 m away from the Phi6 source, the loss coefficient (air exchange rate) was 25 h−1 in the first scenario and 30 h−1 in the second. These results show that UR-UVGI systems can effectively inactivate microorganisms. However, at 1 m distance from the Phi6 source perpendicular to the breathing direction, only minimal inactivation was observed due to short-circuit airflow. At this position, the loss coefficient was <2 h−1 in the first scenario and 17 h−1 in the second scenario, indicating that short-circuit airflows can only be detected by dynamic equilibrium measurements.

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Feng, Y., Li, D., Marchisio, D., Vanni, M., Buffo, A.

Indoor Transmission of Respiratory Droplets Under Different Ventilation Systems Using the Eulerian Approach for the Dispersed Phase.

Fluids, Vol. **10** n°(7), (2025)

Infectious diseases can spread through virus-laden respiratory droplets exhaled into the air. Ventilation systems are crucial in indoor settings as they can dilute or eliminate these droplets, underscoring the importance of understanding their efficacy in the management of indoor infections. Within the field of fluid dynamics methods, the dispersed droplets may be approached through either a Lagrangian framework or an Eulerian framework. In this study, various Eulerian methodologies are systematically compared against the Eulerian–Lagrangian (E-L) approach across three different scenarios: the pseudo-single-phase model (PSPM) for assessing the transport of gaseous pollutants in an office with displacement ventilation (DV), stratum ventilation (SV), and mixing ventilation (MV); the two-fluid model (TFM) for evaluating the transport of non-evaporating particles within an office with DV and MV; and the two-fluid model-population balance equation (TFM-PBE) approach for analyzing the transport of evaporating droplets in a ward with MV. The Eulerian and Lagrangian approaches present similar agreement with the experimental data, indicating that the two approaches are comparable in accuracy. The computational cost of the E-L approach is closely related to the number of tracked droplets; therefore, the Eulerian approach is recommended when the number of droplets required by the simulation is large. Finally, the performances of DV, SV, and MV are presented and discussed. DV creates a stratified environment due to buoyant flows, which transport respiratory droplets upward. MV provides a well-mixed environment, resulting in a uniform dispersion of droplets. SV supplies fresh air directly to the breathing zone, thereby effectively reducing infection risk. Consequently, DV and SV are preferred to reduce indoor infection.

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Kanaan, M., Gazo-Hanna, E., Amine, S.

Mathematical Modelling of Upper Room UVGI in UFAD Systems for Enhanced Energy Efficiency and Airborne Disease Control: Applications for COVID-19 and Tuberculosis.

Mathematical and Computational Applications, Vol **30** n°(4), (2025).

This study is the first to investigate the performance of ultraviolet germicidal irradiation (UVGI) in underfloor air distribution (UFAD) systems. A simplified mathematical model is developed to predict airborne pathogen transport and inactivation by upper room UVGI in UFAD spaces. The proposed model is substantiated for the SARS-CoV-2 virus as a simulated pathogen through a comprehensive computational fluid dynamics methodology validated against published experimental data of upper room UVGI and UFAD flows. Simulations show an 11% decrease in viral concentration within the upper irradiated zone when a 15 W louvered germicidal lamp is utilized. Finally, a case study on Mycobacterium tuberculosis (M. tuberculosis) bacteria is carried out using the validated simplified model to optimize the use of return air and UVGI implementation, ensuring acceptable indoor air quality and enhanced energy efficiency. Results reveal that the UFAD-UVGI system may consume up to 13.6% less energy while keeping the occupants at acceptable levels of M. tuberculosis concentration and UV irradiance when operated with 26% return air and a UVGI output of 72 W.

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Obitková, D., Čereiová, C., Mráz, M., Pavlík, E.

Microbial contamination of air filters of air conditioning system of urban buses.

Epidemiol Mikrobiol Imunol, Vol. **74** n°(2), (2025), 107-112 p.

The use of HVAC in urban buses in developed countries increases the comfort and indoor air quality in the means of ground transportation. The microbial contamination was studied on outlet and inlet surfaces of 5 air filters removed from the urban buses HVAC during regular maintenance. To acquire samples from both the outlet and the inlet sides of the filters, dry swabbing technique was used. Cultivation was performed on different selective or selective-diagnostic agars, to cultivate viable bacteria. To identify the bacterial species, Gram stain and immerse microscopy was used. Selected colonies underwent the proteomic study (MALDI-TOF) as well. After identification, bacteria were quantified. The bacteria of the genus Bacillus - Bacillus cereus, Bacillus subtilis, Bacillus licheniformis, Bacillus pumilus, Bacillus flexus prevailed on both inlet and outlet surfaces of the filters. The members of genera Staphylococcus, Brevibacillus, Peribacillus or Paenibacillus were also identified. The quantification of colony forming units showed low contamination of the outlet surfaces of filters 1 and 2. The contamination of inlet and outlet sides of filters 3, 4, and 5 was comparable, revealed nearly the same contamination of inlet and outlet surfaces. In the case of filters 3, 4 and 5 we recommend more frequent filter changing or more efficient filter choice.

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Adjei, F. A., Afriyie, A.

Mitigating the spread of emerging and resurgent airborne infectious diseases: Strategies, challenges and future directions.

International Journal of Science and Research Archive, Vol. **16** n°(01), (2025), 1443-1451 p.

The resurgence of airborne infectious diseases, including measles, COVID-19, and tuberculosis, has raised significant public health concerns globally. These diseases, transmitted through respiratory droplets or aerosols, present unique challenges, particularly in indoor spaces where vulnerable populations are at greater risk. This article provides a comprehensive review of current strategies to mitigate airborne infectious diseases, examining both emerging and resurgent threats. It categorizes and evaluates interventions such as source control (masking and physical distancing), ventilation improvements, and air filtration, assessing their real-world effectiveness in reducing infection rates and enhancing indoor air quality. The article also explores the synergistic effects of combining multiple strategies and addresses implementation challenges related to cost, compliance, and infrastructure. It highlights gaps in current knowledge, particularly regarding the integration of advanced technologies and the long-term impact of combined interventions. The review concludes by proposing future research directions aimed at refining mitigation strategies, optimizing ventilation and air purification systems, and integrating artificial intelligence to enhance public health responses. Ultimately, it advocates for a holistic, evidence-based approach to improve public health preparedness against airborne infectious diseases.

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Varun, S. E.

Modeling human movement and infection risk: A CFD-Based study of indoor transmission.

Oslo Metropolitan University. Thèse 2025

This thesis investigates the risk of airborne infection transmission in indoor environments using high-resolution computational fluid dynamics simulations integrated with quanta-based modeling. A simplified office scenario is studied, consisting of one infected and one susceptible individual under different ventilation and movement conditions. The objective is to quantify infection probability over time, using a spatially resolved simulation approach.

A user-defined function was developed and implemented in CONVERGE CFD to track the dispersion of virus-laden droplets, accumulate quanta concentration in each computational cell, and calculate the time-dependent infection probability. The modeling framework builds upon the modified Wells-Riley model as formulated by a recent study of the literature, and includes adaptive mesh refinement and mesh sensitivity analysis to ensure numerical accuracy.

Three case studies were conducted: (1) a moving, speaking infected individual with 1.6 ACH ventilation, (2) a stationary infected individual under the same ventilation rate, and (3) a moving, speaking infected individual with increased ventilation at 3.2 ACH. Results show that occupant movement causes wake turbulence that disperses droplets across the room, and that increasing the ventilation rate reduces overall infection risk by improving aerosol dilution. The impact of combined respiratory activity and movement was observed to increase quanta dispersion compared to stationary conditions.

This study highlights the importance of modeling localized airflow patterns when assessing airborne infection risk and demonstrates the value of CFD-based methods in improving ventilation design and mitigation strategies for confined indoor spaces.

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R. Naren Aadhithya, K. Balamurugan, N. Gobinath,V. Adithya, S. Vignesh, R. Radha

Numerical investigation on the virus transmission during sneeze, cough, and speech scenarios from an infected individual in an isolation room.

Journal of Hazardous Materials Advances, Vol. **19**, (2025)

Numerical simulation plays a crucial role in understanding and mitigating the airborne transmission of infectious aerosols in enclosed environments. Reducing airborne virus transmission in air-conditioned environments has become vital in ensuring occupant safety. This study uses computational fluid dynamics (CFD) to simulate virus dispersion in an indoor setup and assesses a negative pressure isolation room design. The system comprises a quarantine room and a common room, with a suction vent and pressure outlet installed in the quarantine area. A pressure differential prevents cross-room transmission while the suction vent captures airborne particles. The study evaluates virus emissions during sneezing, coughing, and speaking. Without intervention, particles linger for 20 s, 10.4 s, and 6.5 s respectively. With the proposed model, particles are cleared 11.25 s, 6.4 s, and 1.4 s sooner. Additionally, a 3 K temperature reduction within 5 s was observed, enhancing airflow effectiveness. The findings demonstrate that negative pressure environments can significantly reduce particle persistence and exposure risk. The present work could support the development of safer indoor spaces. Further studies could focus on scale the system to multi-room configurations and optimize energy consumption in long-term operations.

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Choi, N., Bivolarova, M. P., Wargocki, P.

Performance of a prototype of the push-pull type personalized air curtain (PPAC) aimed to reduce respiratory infection risks.

Building and Environment, Vol. **282**, (2025)

We present a prototype of the desktop-mounted push-pull personalized air curtain (PPAC) system. The system comprises a supplying unit and a capturing unit, which together create a lateral air barrier between an infector and an infectee. This air barrier is designed to block, entrain, and capture infectious aerosols generated during respiratory activities in close proximity. The performance of the PPAC was examined in the office mock-up with a breathing thermal manikin and a heated cylinder, simulating two individuals sitting face-to-face at an 80 cm distance. The room was ventilated using either mixing or displacement ventilation, each supplying 20 L/s of clean outdoor air. A tracer gas was dosed into the exhaled air of the manikin to emulate infectious aerosol, and its concentration was measured at multiple locations to estimate the system's performance. The PPAC was tested at varying distances from the breathing manikin and with different airflow rates, while the manikin exhaled at different flow rates to simulate various aerosol releases.

When the PPAC was used, tracer gas concentration reduced considerably. The estimated capture efficiency reached nearly 60 %, comparable to the performance of some personal protective equipment. Capture efficiency improved with higher PPAC airflow rate and when the system was placed closer to the infector. Further developments of the PPAC are necessary to understand its performance using actual aerosols. Still, our results show the considerable potential of using this type of solution for reducing infection risks in buildings with mostly sedentary occupants, such as schools and open-plan offices.

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Kumar, A., Verma, P., Kaushik, R.

Photocatalytic inactivation and disinfection of bioaerosols: a review.

Environmental Chemistry Letters, (2025)

Bioaerosols represent a major health issue because they contain viruses, bacteria, biological fragments or residues and fungal spores. Humans are exposed to nearly 104 viable bacteria and 104 viable fungi per cubic metre of indoor air. Here, we review bioaerosols with emphasis on their sources, behaviour, detection methods, mitigation, transmission, and photocatalytic disinfection. Disinfection methods include fibrous photocatalytic membranes with interception efficiency comparable to commercial masks and high bactericidal efficiency, Z-scheme and S-scheme heterojunctions-based materials, biofilms loaded with composite catalysts, and photocatalytic filters coupled with air ionizers. Bioaerosols inactivation reaches 99.99% in 4 h under ultraviolet light, and 99.3% in 14.1 s under visible light using advanced heterojunction photocatalysts.

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Kinahan, S. M., Huston, D., Silcott, D. B., Arestad, R., Silcott, B. E., Silcott, R. M.*, et al.*

Quantifying infectious disease mitigation and HVAC system performance using tracer particles on USNS Mercy class hospital ships.

Aerosol Science and Technology, (2025), 1-15 p.

To reduce airborne infectious disease risks, older clinical spaces need to reevaluate their HVAC design and infection mitigation strategies, considering modern recommendations. Infectious aerosols can spread from patient to patient, staff to patient, and vice versa, with nosocomial infections jeopardizing patient recovery. This study compared aerosol removal rates across care wards on a Navy hospital ship, the USNS Mercy, which went into service in 1986. Experimentally, baseline HVAC performance was characterized in three open care wards at five patient beds. The baseline conditions contrasted with those resulting from multiple portable air purifier (HEPA filter unit) arrangements. Real-time data was provided by fluorescent aerosol spectrometers placed to detect contaminant spread of fluorescent microspheres. Modeling aerosol concentration decay enabled calculation of an effective air-change-rate, or aerosol clearance rate, while integrating particle counts over a test allowed calculations of exposure risk relative to a simulated patient. Generally, additional portable HEPA units demonstrated improved aerosol clearance, allowing the older design to reach modern 6 air change per hour standards. Locating patients closer to the HVAC exhaust, and further from recirculation vents reduced spread of contamination to nearby spaces, but retained elevated concentrations within the ward. Conversely, patients closer to recirculation returns reduced exposure within the ward but increased spread to nearby wards. Similarly, a tradeoff exists with placement of HEPA units closer to recirculation returns more protective of nearby spaces, and less protective within the ward. Many of the datapoints here can be extended to open-ward style facilities with patients with communicable airborne diseases.

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Jones, B., Iddon, C., Zaatari, M., Wargocki, P., Bruns, R.

Risk modeling for ASHRAE Standard 241-2023 — Control of infectious aerosols.

Building and Environment, Vol. **283**, (2025)

This paper describes the risk assessment modeling used to establish airflow requirements in ASHRAE Standard 241 (2023) – Control of Infectious Aerosols. The standard sets minimum equivalent clean airflow rates per person (ECAi) to reduce long-range airborne disease transmission indoors during high infection risk periods. These requirements cover buildings and occupancy categories such as correctional facilities, schools, healthcare facilities, commercial spaces, and residences. The modeling employs the Wells–Riley infection risk model to estimate infection probability from inhaling aerosols over one hour. A probabilistic approach accounts for uncertainties, especially in key parameters like viral load, which can vary widely. Input parameters are based on SARS-CoV-2 data, as it was the primary motivation for the standard and provides higher-quality data. ECAi values are set to achieve a 0.1% hourly infection probability 96% of the time across different occupancy categories, resulting in ECAi values between 10-45Ls−1perperson. The standard focuses on long-range transmission and serves as one protective layer, complementing vaccines and personal protective equipment. Uncertainties are significant so the ECAi values represent informed estimates rather than precise values. This risk-based method provides a rational approach for setting minimum airflow requirements to mitigate airborne infection risks during outbreaks.

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Shang, W., Liu, J., Meng, H., Jia, L., Dai, X.

A RL-based human behavior oriented optimal ventilation strategy for better energy efficiency and indoor air quality.

Energy and Buildings, Vol. **345**, (2025)

In biological cleanrooms for pharmaceutical and biosafety laboratories, escalating cleanliness standards have made the high energy consumption associated with increased air change rates in ventilation systems untenable. Moreover, stringent pressure differential requirements are crucial in biological cleanrooms to ensure the physical isolation of pathogenic microorganisms. This study developed a multi-zone ventilation system model for a biopharmaceutical cleanroom using the Modelica language. A deep reinforcement learning (DRL) model was implemented in Python based on the actor–critic and proximal policy optimization (PPO) algorithms, utilising the Modelica model as the training environment. To maintain particulate matter (PM) concentrations and conserve energy, the DRL control model was trained to adjust air damper positions by identifying patterns in occupancy changes and pollutant concentration dynamics across various times and workspaces within the cleanroom. Results indicated that, relative to the conventional baseline control strategy, the developed reinforcement learning control approach achieved a 14.7 % reduction in energy consumption while maintaining pollutant concentrations within regulatory limits for cleanrooms, culminating in annual energy savings of 11,212.8 kWh. Additionally, pressure fluctuation ranges in the three controlled work zones of the cleanroom were diminished by 59.16 %, 9.58 %, and 29.32 %, respectively. SHapley Additive explanation (SHAP) analysis was employed to elucidate the contributing factors influencing the outputs of the developed DRL control model. Furthermore, the generalisation of the DRL control model was discussed by altering the control period and inner source of the PM.

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El Jaddaoui, I., Hamdi, S., Al Idrissi, N., Bakkali, F., Nejjari, C., Amzazi, S.*, et al.*

SARS-CoV-2 transmission pathways within the indoor environment.

Discover Public Health, Vol. **22** n°(1), (2025)

The rapid global spread of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has highlighted the value of comprehending the link between the indoor environment and infectious disease transmission. SARS-CoV-2 transmission pathways are still not fully understood. It can be promptly transported from person to person, but to a lesser extent, the virus can also be deposited on surfaces or aerosolized in the air. Indoor environments offer many possibilities for people to come into contact with viruses through the circulation of air and surfaces and through the way buildings enable people to interact with each other. This fact highlights the importance of architectural design, especially with modern buildings

designed to promote social mixing. The primary objective of this literature review is to report current knowledge on the viability and transmission of the SARS-CoV-2 virus within different types of indoor built environments, whether residential or institutional and to highlight the potential contribution of architectural design to virus transmission and containment. Understanding the spread of SARS-CoV-2 through indoor built environment-mediated pathways will aid in the development of effective social distancing measures and in making good decisions about how to avoid the transmission of the virus in built ecosystems.

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Joanie, L., Florent, R., Asmaâ, K., Marc, V., Valérie, L., Nathalie, T.*, et al.*

Supplemental information for "Fan Exhaust Air Sampling of Livestock Operations as a Proxy for Indoor Bioaerosol Monitoring".

Natural Sciences and Engineering Research Council of Canada (NSERC) 2025

Sampling bioaerosols at the sidewall fan exhaust of barns provides a representative picture of the indoor bioaerosols both for bacterial diversity and barn-specific indicators when the fans are in use. Air sampling was conducted using a high volume filter type air sampler placed both indoor of the barn and outdoor, two to three meters away from the sidewall extraction fans. This method appears promising for characterizing indoor air quality based on emissions and could be highly valuable in cases where biosecurity measures or outbreaks restrict access to barns.

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Angel, D. M., Luhung, I., De Sá, K. S. G., Peccia, J.

The Susceptibility of Airborne SARS-CoV-2 to Far-UVC Irradiation.

bioRxiv, (2025)

Far-UVC irradiation has emerged as a breakthrough disinfection technology for the treatment of indoor air. Far-UVC wavelengths (222 nm) from filtered krypton-chloride excimer lamps are effective at inactivating airborne viruses and safe for human exposure, thus enabling the continuous treatment of bulk air in occupied settings. This study quantifies the susceptibility of airborne SARS-CoV-2, aerosolized in human saliva, to far-UVC radiation. We measured fluence rate-based Z value susceptibility constants of 4.4 and 6.8 cm2 mJ-1 for airborne SARS- CoV-2 under 40% and 65% RH levels, respectively. At modeled far-UVC irradiation levels corresponding to 25% of the maximum safe human exposure limit, the resulting far-UVC equivalent air changes per hour (eACH) exceeded 62 hr^{-1} at 65% RH and were significantly greater than the corresponding airborne SARS-CoV-2 natural decay rate ((std. err.) of 5.4 ± 1.1 hr^{-1}, measured in the absence of far-UVC. These results define first-order loss rates for airborne SARS-CoV-2 under far-UVC exposure and support quantitative risk assessments and rational disinfection system implementation.Competing Interest StatementThe authors have declared no competing interest.

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Loureiro, A., Ferreira, A., Barros, N.

Systematic review of the literature on indoor air quality in healthcare units and its effects on health.

BMC Public Health, Vol. **25** n°(1), (2025)

Indoor air quality in healthcare facilities such as hospitals and health centres is increasingly considered an important factor for the health and well-being of their occupants, namely workers and patients/users.

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