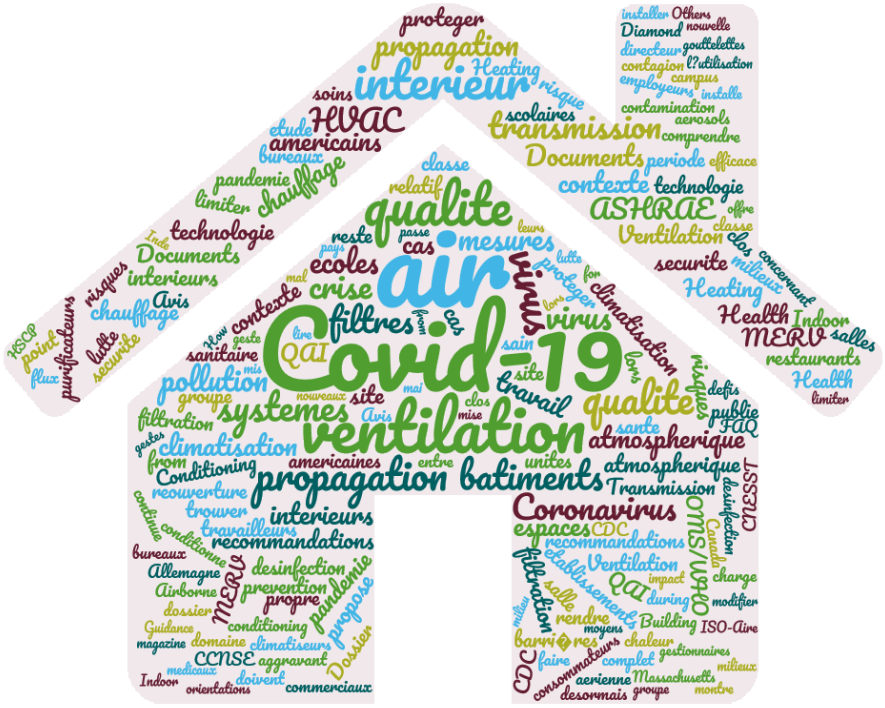

Bulletin de veille AéroCovid
N°114 – 23/04/2025

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.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

Les bulletins de veille sont disponibles sur le portail documentaire de l'INRS. L'abonnement permet de recevoir une alerte mail lors de la publication d'un nouveau bulletin (bouton « M'abonner » disponible après connection à son compte).

Google Scholar, Lens et WoS

Miller, J. D., Springston Jr, J. P. J., Marcham, C. L., Krause, J. D., Hung, L.-L., Baker, W. A.

Aerosolized Transmissible Diseases Guidance Document.

AIHA Journal, Vol. n°(1), (2025)

Prior to COVID-19, pandemic influenza viruses have emerged four times in the previous one hundred years. This includes “Spanish” influenza (H1N1) in 1918, “Asian” influenza (H2N2) in 1957, “Hong Kong” influenza (H3N2) in 1968, and H1N1 “swine” influenza in 2009 (Saunders-Hastings & Krewski, 2016; Taubenberger, 2005). In early May 2024, the first reported human case of avian flu (H5N1) that had also infected cows in the US appeared in the literature (Uyeki et al., 2024). In late August 2024, OSHA released a hazard alert providing information for dairy workers on avian influenza in dairy cattle, together with personal protective equipment (PPE) recommendations (OSHA, 2024). Genetic sequencing of some of the newer variants revealed a “rapid evolutionary progression” (Singh et al., 2024). As of December 2024, at least 46 human case patients with mild H5N1 infection and one case of critical illness have been reported (Ison & Marrazzo, 2024; Garg et al., 2024). This emphasizes that the lessons learned from previous epidemics and pandemics need to be incorporated into occupational health practice now and in the future. In response to the 2009 H1N1 pandemic, the AIHA (2009) adopted a position statement on that outbreak and worker health. This guidance document serves as an update to provide a more comprehensive analysis of lessons learned from the two most recent pandemics: H1N1 in 2009 and COVID-19 in 2019-2023.

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Okokon, E., Chibuzor, M., Ezema, C., Bernard, M., Barde, V., Oyo-Ita, A.*, et al.*

The effectiveness of air-cleaning technologies against COVID-19 transmission in healthcare settings.

Frontiers in Environmental Health, Vol. **Volume 4 - 2025**, (2025)

Background: The healthcare setting is a high-transmission-risk environment for COVID-19. Attending clinicians and patients are at risk of infection if measures are not established to secure the microbial safety of the health facility. Air cleaning technologies may deliver a safer clinical environment by depleting airborne viral concentrations.

Aim: This systematic review aims to assess the effectiveness of air-cleaning methods in preventing COVID-19 transmission in health facilities and the effectiveness of air cleaning rated by microbial depletion.

Method: This study is a rapid systematic review.

Results: No study assessed COVID-19 transmission relative to the air cleaning methods. HEPA filtration produced a more rapid and thorough removal of aerosols from health facilities. HEPA filtration showed mixed performance in removing COVID-19 viral RNA from a routine care ward and an intensive care unit (ICU). Meta-analyses could not be conducted due to dissimilarities in included studies.

Conclusion: The reviewed papers demonstrate that HEPA filtration hastens the depletion of aerosols from the indoor space in the health facility. Further translation of this finding to prevent COVID-19 transmission should assume the relevance of room occupancy density, virus-free outdoor air supply, recirculated filtered

air, virus source strength, number of sources, and the use of facemasks by health workers and visitors to the health facility.

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Yao, G., Xu, H., Liu, H., Liu, Z., Jiang, C., Zhuang, W.*, et al.*

Effectiveness of different ventilation strategies for mitigating airborne pathogen transmission in a multi-compartment dental clinic.

Journal of Building Engineering, Vol. **106**, (2025)

The potential risk of airborne cross-infection in multi-compartment dental clinics (MCDCs) requires significant attention. Ventilation systems are crucial for preventing airborne pathogens, but the data available for MCDCs are still inadequate. Therefore, this study evaluated the ventilation performance under different ventilation strategies in an MCDC, including different ventilation modes, the relative positions of ventilation openings and the patient treatment zone, and air changes per hour (ACH). Four aspects of airflow distribution, bioaerosol diffusion (deposition/escape rate and removal index (CRE)), relative exposure index (EP), and fallow time were focused. Ultrasonic scaling experimental data validated the accuracy of the numerical model. The results showed that the DSUR (Down-Supply Up-Return) mode exhibited the best ventilation performance, while the USDR (Up-Supply Down-Return) mode performed poorly due to airflow short-circuiting. In the USUR (Up-Supply Up-Return) mode, the relative positioning of ventilation openings and the patient treatment zone should ensure airflow aligns more consistently with the bioaerosol release direction, promoting quick bioaerosol transport to the outlet as the ACH increases. This boosted the CRE from 0.85 to 1.43 and reduced surface deposition. While the EP decreased significantly within 30 min post-treatment, an 18-min fallow time remained necessary in the DSUR mode. Bioaerosol control in the DSUR mode at 6 ACH matched or exceeded that of other modes at 12 ACH, demonstrating that optimizing the ventilation mode was more effective for creating a safe environment than simply increasing the ventilation rate. These findings can provide a reference for the ventilation design of MCDCs, promoting a healthier dental care environment.

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Franklin, E. B., Wheeler, A., Ward, J., Mynard, C., Lynton, D., Humphries, R.*, et al.*

Effects of Germicidal UV Air Disinfection Devices on Indoor Air Quality in an Unoccupied Aged Care Facility.

ACS ES&T Air, (2025)

The COVID-19 pandemic has precipitated renewed interest in germicidal ultraviolet (GUV) for indoor air disinfection. However, UV-C radiation from these devices can produce indoor air pollutants including ozone, oxygenated volatile organic compounds (OVOCs), and ultrafine particles. A month-long study of indoor air quality effects of GUV was undertaken in an unoccupied aged care facility in Melbourne, Australia under both mechanical ventilation (~3 air changes h–1) and natural ventilation (~1 h–1) conditions. Upper room GUV-254 and whole room GUV-222 devices were tested. GUV-222 produced ~670 μg/h of ozone resulting in <1 ppb enhancements in indoor ozone. GUV-222 also produced small increases in OVOCs, particularly acetic acid and methanol, that were <1 ppb with mechanical ventilation, and <2 ppb with natural ventilation. Small acetaldehyde enhancements (~0.1 ppb) were associated with GUV-254. GUV was not associated with changes in indoor particles. GUV-222 and -254 initiated OVOC enhancements were insensitive to indoor ozone but exhibited strong temperature and humidity sensitivities, suggesting UV-initiated surface chemistry rather than gas phase chemistry as the key driver of GUV OVOC enhancements. Overall, ventilation and changes in outdoor pollutants had substantial effects, while GUV produced small but measurable effects on indoor air quality in a real-world urban setting.

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Arumuru, V., Yadav, H.

Indoor Transmission of Respiratory Diseases and Influencing Factors—A Critical Review.

Transactions of the Indian National Academy of Engineering, (2025)

The outbreak of COVID-19 has disrupted the world's economy and impacted people's lives significantly. Humanity struggled to combat this pandemic, simultaneously resuming normalcy in techno-economical activities. From a sustainability and energy conservation perspective, curbing the transmission of these respiratory diseases in indoor environments is challenging. To reduce the transmission of these respiratory diseases, the factors affecting the transmission of droplets in indoor spaces, along with proper mathematical modelling and their physics, need serious consideration. Hence, this review discusses the factors influencing indoor transmission, the factors responsible for the virus transmission, and probabilistic research methods. The paper also discusses some deterministic approaches, like CFD models with Eulerian and Lagrangian methods, taken by the researchers to understand the transmission of the particles observing the trajectories of the evaporating droplets. The present finding suggests that Eulerian and Lagrangian provide the spatial distribution of the particle concentration in the air. However, the Lagrangian is preferred over the Eulerian approach as it can track the evaporating droplets and give their trajectories in the air. The focus is on engineering recommendations to mitigate the transmission of SARS-COV-2 in indoor spaces. Appropriate engineering controls like sufficient ventilation, filtration of pathogen aerosols, use of purifiers in synchronisation with ventilation systems, and personal protective equipment are effective ways to reduce the risk of transmission in indoor environments. The major challenge is optimising energy consumption in indoor environments with existing infrastructure. This review will be helpful to both the public and agencies in combating respiratory disease transmission in indoor environments.

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Peng, Z., Ma, B., Henze, D., Miller, S., De Gouw, J., Jimenez, J.

Is there an optimal wavelength for germicidal ultraviolet air disinfection?

ChemRxiv, (2025)

Germicidal UV (GUV) disinfection is effective against airborne pathogens, but it has been recently reported to increase indoor air pollution. Conventional GUV at 254 nm is applied in the upper room only due to skin/eye safety limits, while "Far UVC" (e.g. at 222 nm) is applied across the whole room due to less restrictive safety limits, enabling simpler installation and disinfection. We investigate GUV between 185 and 310 nm by modeling, in search of an optimal wavelength with both high disinfection and safety. For a specific fluence rate, GUV-induced air pollution health risks are at least ~20 times larger below 245 nm than above it. This is mainly due to O3 production through O2 photolysis below 245 nm, with a contribution from particulate matter formation from enhanced volatile organic compound oxidation. When normalized to a constant CDC-recommended disinfection rate of 5 equivalent air changes per hour (eACH), pollution risk below 245 nm is also at least ~20 times that above 245 nm. At very high disinfection rates such as 20 eACH, the difference between the ratios below and above 245 nm is smaller, but still a factor of ~20. Our results show a clear advantage of upper-room GUV vs. Far UVC for indoor air quality. These results appear robust despite substantial uncertainties in absolute disinfection efficiencies, which are a critical limitation for widespread GUV application. Thus, there is no optimal GUV wavelength across all important criteria (exposure limits, disinfection efficiency, indoor air quality, and logistic requirements), and these tradeoffs should be considered in different situations to maximize the overall benefit. Use of Far UVC may require simultaneous deployment of air cleaning for pollution. As new practical UV light sources at wavelengths other than 222 and 254 nm keep being developed, this study provides guidance for evaluating and selecting wavelength(s) for GUV air disinfection.

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Mathur, G.

Modeling Virus Infection Risks in Automobile Cabin.

WCX 2025 - April 8 -10 - Detroit, Michigan

In the post Covid era, risk of infection in conditioned space is getting attention and has generated a lot of interest for the design of the new systems and strategies for the management and operations of the

existing HVAC systems. Risk management plays a key role where the amounts of outside air and recirculated airs can be used to mitigate the propagation of the virus within the conditioned space. In other words, ventilation plays a huge role within the conditioned space along with strategies based on UV irradiation, ionization and use of highly efficient filters. Different air purification systems have been created by the researchers based on the titanium oxide-based UV photocatalysis system, filters with MERV ratings higher than 11 (ASHRAE Standard 52.2) and HEPA filters. Recent ASHRAE standard 241 (2023) on infectious diseases recommends using high ventilation rates within the conditioned space to reduce virus concentration, and hence, to reduce the risk of infection. Determining risk of infection is difficult as we cannot conduct tests by exposing the passengers to different viruses in vehicle. Instead, empirical models have been developed to predict probability of risk of infection based on a number of variables. This risk of infection is then multiplied by the total population to determine the people infected within the cabin. In this investigation the author has determined the risk of infection by using Wells-Riley and Gammaitoni-Nucci correlations to determine risk of infection for occupants when an infector is present in the vehicle cabin.

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Huang, J., Khan, R., Zhai, C., Ding, X., Zhang, L.-S., Wu, J.-M.*, et al.*

Nanostructure-controlled Cu-doped MnO2 for ozone synergistic catalytic disinfection.

Results in Chemistry, Vol. **15**, (2025)

The development of efficient disinfection techniques that can persistently eradicate viruses or disrupt their transmission is of paramount significance for curbing the spread of pandemics. Existing disinfection techniques commonly suffer from secondary pollution and difficulty in achieving continuous disinfection while ensuring safety and effectiveness, particularly in crowded environments. In this study, we adopted ozone synergistic catalytic oxidation (OSCO) technology for the highly efficient disinfection of bacteria and viruses. The OSCO route is based on the catalytic decomposition of ozone into active radicals in the presence of an optimized rod-like Cu/MnO2 catalyst. The high catalytic activity of the Cu-doped MnO2 catalyst can be attributed to the presence of numerous oxygen vacancies, which facilitate the catalytic decomposition of ozone into active radicals. This method serves multiple purposes, including the eradication of bacteria and viruses as well as the prompt decomposition of ozone to prevent any potential leakage. A disinfection rate of 99.9 % for both Staphylococcus albicans and H1N1 viruses was achieved within 20 min. The catalyst also demonstrated exceptional efficiency in degrading residual ozone, achieving a high removal rate of 99.99 % within 25 min, thus assuring safe disinfection. Density functional theory (DFT) calculations further supported that Cu doping induced lattice defects in MnO2, promoting the formation of interfacial oxygen vacancies and in turn favoring the catalytic oxidation process. The current OSCO technology offers a highly efficient and secure disinfection method with a wide range of potential applications in various fields.

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Xu, J., Zhai, H., So, L. K., Wang, C., Guo, H.

Performance evaluation of a recirculated personalized air curtain combined with displacement ventilation in mitigating indoor airborne transmission.

Journal of Hazardous Materials, Vol. **494**, (2025)

To mitigate the risk of airborne transmission, we explored the integration of a recirculated personalized air curtain (rPAC) with displacement ventilation (DV) using computational fluid dynamics (CFD) simulations. The rPAC can utilize indoor air directly, drawing clean air from the lower room space supplied by the DV system. Our study assessed the effectiveness of the rPAC in reducing the intake fraction of expiratory droplets from transient coughing and steady speaking indoors. We categorized droplets into small (initial diameter ≤20 μm), medium (50 μm), and large (100 μm) sizes. Large droplets from both activities generally had negligible intake fractions. The rPAC effectively reduced the intake fraction from coughing and speaking, although its performance varied with respiratory activities and exhalation directions. At 0° and 30°, the rPAC reduced the intake fraction of small coughing droplets by over 90 % and medium droplets by

74 %-98 %, with significant reductions also observed for speaking. However, at 60°, the rPAC increased the intake fraction of medium coughing droplets and small droplets from speaking due to complex airflow-droplet interaction dynamics. This study highlights the potential of rPAC as an effective control measure to improve indoor air quality and mitigate respiratory disease transmission, though its effectiveness is influenced by exhalation direction and droplet size.

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Zhang, G., Xie, H., Li, N., Yu, B.

Solar ventilation wall for alleviating thermal and health risks of formaldehyde and virus infection.

Indoor and Built Environment, (2025)

The solar ventilation wall is a well-established passive solar system that can mitigate indoor formaldehyde pollution and virus infections, which could significantly impact health. This study introduced and evaluated a thermal purification composite ventilation wall system that utilizes solar energy to regulate indoor thermal conditions and air quality. Steady-state experiments with simulated light sources assessed its thermal efficiency and formaldehyde degradation. After 2?h of ultraviolet (UV) exposure at 300, 500 and 800?W/m², indoor temperatures rose by 2.5°C, 1.6°C and 1.0°C, with thermal efficiencies of 32.14%, 29.65% and 26.49%. Thermal catalytic oxidation reduced formaldehyde from 600?ppb to 207.1, 166.0 and 140.9?ppb, achieving degradation rates of 50.7%, 60.1% and 66.4%. Model validation showed that the root mean square deviation for temperature, formaldehyde concentration and the clean air delivery rate was below 5%, confirming reliability. Regional analysis identified solar radiation as the primary efficiency factor. From December to April, heating capacity and clean air volume across cities varied minimally, while UV disinfection of SARS-CoV-2 achieved a 96.22%?97.09% inactivation rate, demonstrating the system's potential.

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González-Gómez, M., Benito-Altamirano, I., Prades, J. D., Casals, O., Fabrega, C.

Ultra Low-Cost and Selective Water-Based Colorimetric Ink for Indoor CO2 Monitoring.

IEEE Sens J, (2025)

This work introduces a novel water-based colorimetric ink for CO2 monitoring, offering a significant advancement in indoor air quality assessment. The ink uses a highly specific and reversible reaction between CO2 and an amine, enabling precise detection within a broad operational range of 150-1500 ppm, encompassing typical indoor CO2 concentrations. Optimized rheological properties allow for seamless application on paper substrates, facilitating scalable production and widespread adoption. The resulting colorimetric labels exhibit exceptional resistance to common interfering gases, ensuring accurate and reliable CO2 readings even in challenging indoor environments with fluctuating humidity and temperature and potential cross-contamination. Rigorous characterization of the sensor showcases outstanding performance in terms of specificity, repeatability, and reproducibility, validating its robustness and suitability for real-world applications. To further enhance accuracy, a calibration methodology incorporating a signal compensation algorithm is proposed, effectively mitigating humidity-induced effects. The sensor response can be effortlessly captured using readily available and cost-effective electronic components, paving the way for an accessible and versatile solution for real-time CO2 monitoring in both residential and commercial settings. Moreover, the inherent versatility of this technology allows for integration with other colorimetric inks, opening doors to a multi-parametric sensing platform capable of monitoring a wider array of indoor air quality pollutants.

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