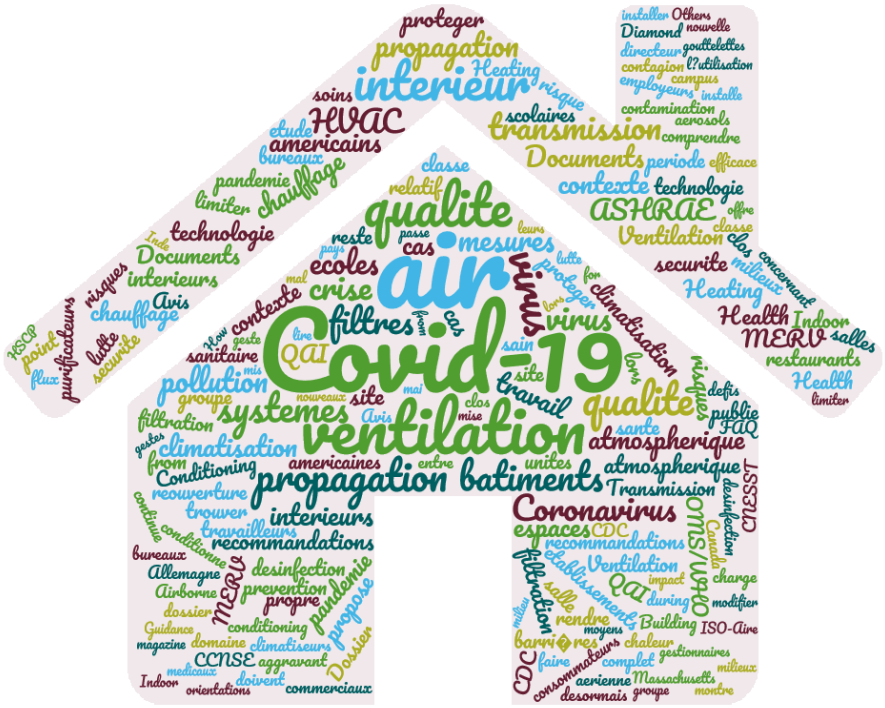

Bulletin de veille AéroCovid
N°121 – 17/09/2025

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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Google Scholar, Lens et WoS

Roussel, I.

After the Pandemic (2020–2022), the Regard About Disease and Health Has Changed in France: Has COVID-19 Sparked New Health Practices?

In: COVID-19: Impacts on Health and Health Systems. Springer Nature Switzerland; 2025. 255-270 p.

The World Health OrganizationWorld Health Organization (WHO) (WHO) raised the highest level of alert on the COVID-19 pandemicCOVID-19 pandemic in May 20231, which does not mean that COVID-19 has disappeared. It is time to draw conclusions. In the aftermath of the pandemic (2020–2022), the way we look at illness and health has changed in FranceFrance since this episode which caused the death of 116,000 people. On the one hand, it is a question of learning the lessons of this pandemic which has led people to say “that nothing will ever be the same again” and, on the other hand, the spread of this virus has left many after-effects which are necessary to deal with. The hospital crisis has not disappeared, the psychologicalPsychological effects consequences combined with solastalgia linked to climate changeClimate change are numerous, mistrust against vaccinesVaccines and against the scientific approach to medicine has increased while preventionPrevention in the framework of global healthGlobal health is increasingly necessary.

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Paliulis, D.

Analysis of Indoor Air Pollution by CO and VOC in a Smart Building.

Rocznik Ochrona Środowiska, Vol. **27**, (2025), 379-387 p.

The article analyses the changes over time of two parameters (CO and VOC) measured by a new indoor air pollution sensor. For this research, measurement data gathered from a selected indoor room over a four-week period were used. The measurements were divided into four different stages. Stage 1: The ventilation system in the investigated room was operational, while the complex air treatment device was not. Stage 2: Neither the ventilation system nor the complex air treatment device was functioning in the room. Stage 3: The complex air treatment device was operational, and the ventilation system was also working. Stage 4: Both the complex air treatment device and the ventilation system were operational in the room. Additionally, due to the quarantine announced in Lithuania during the COVID-19 pandemic, employees were not present in the workplace. The study determines the interdependence of the parameters recorded by the air pollution sensor and how they change over time.

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Orita, B. M., Azoia Lukiantchuki, M.

Analysis of the performance of different opening configurations in natural ventilation in collective wards: tests on the water table.

Encontro Nacional De Conforto No Ambiente Construído, Vol. **18** n°(1), (2025)

Natural ventilation is an important strategy for air renewal and thermal comfort of hospital users. This article aims to investigate the impact of different opening configurations on the performance of natural ventilation in hospital wards. The method was divided into 4 stages: definition of the generic model based on design parameters; construction of reduced physical models; water table tests to visualize the air flow and shape; and analysis of the results. Overall, the results indicate that cross ventilation allows for better distribution of

the air flow, reducing stagnation regions, while unilateral ventilation is less efficient. However, even with cross ventilation, the air flow does not reach the area of the patients' beds, highlighting the importance of the correct dimensioning and location of the openings. Therefore, solutions are suggested to optimize natural ventilation in the wards, such as the choice of typology and possible inclusion of extractor sheds.

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Tan, K. N. J.

Digital-twin-enabled resilience of building occupants against indoor disruptions.

Nanyang Technological University. Thèse 2025

Resilience, the ability of entities to bounce back to or beyond their pre-disrupted state, is widely regarded as essential. Digital twins, as virtual counterparts of physical entities that can monitor and provide feedback in real time, are well positioned to enhance the resilience of twinned entities during disruptions. However, their use has largely focused on control rather than resilience objectives. Given the global prevalence of urban living, this thesis explores how digital twins can be designed to enhance the resilience of building occupants to indoor disruptions by reducing bodily harm and fatalities.

Addressing the challenges of the COVID-19 pandemic and concerns over airborne disease transmission in enclosed spaces, the first research question investigated in this thesis asks, “During an airborne disease pandemic, how can digital twin technology be applied to mechanical ventilation systems to enhance the resilience of indoor space users to disease transmission?” The general concept of digital-twin-enabled resilience and its quantification metrics were first established, then defined specifically for building occupants and disease transmission in terms of infection risk. A digital twin prototype was developed to adapt a conventional mixing ventilation system in real time based on the resilience metrics. Simulations of infectious aerosol dispersion in a dining hall, with and without the prototype, showed that community-level resilience improved by up to 74%, though individual-level outcomes varied.

To investigate the observation that a disruption response can benefit a community while harming certain individuals, and how digital twins can consider this, the second research question asks, “During a building fire, how can digital twin technology enhance the fire resilience of occupants through personalized dynamic evacuation guidance while considering the trade-off in the resilience on the individual and community levels?” Individual and community fire resilience were defined in terms of asphyxiant and heat doses, and total evacuation time, respectively. A digital twin framework for an evacuation guidance system and a novel route-finding algorithm were developed to manage this trade-off. Simulations of fire evacuation involving 500 occupants in an underground shopping mall, with and without a digital twin prototype incorporating the framework and algorithm, showed that the prototype improved individual and community fire resilience by 6%–64% and 14%, respectively.

The trustworthiness of digital twins can be challenged by the uncertainties in their underlying models and devices, hindering practical adoption. To improve the reliability of digital twins with resilience objectives, the third research question asks, “How can digital twins quantify and account for uncertainties in the tenability limits and damage of their twinned entities?” A probabilistic approach involving kernel density estimation was developed to quantify the uncertainty in tenability limits arising from variability in pre-disruption states of the entities while a conservative approach was proposed to account for loss uncertainty through assimilation of real-time data. The approaches were demonstrated in the context of fire evacuation, using the digital twin prototype and simulations from the previous chapter.

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Sya’adah, N. L., Dwiyanti, R. D., Nurlailah, N.

Effectiveness of HEPA Filters in Reducing Airborne Bacteria in Public Health Laboratory Rooms in Bontang City, Indonesia.

Tropical Health and Medical Research, Vol. **7** n°(2), (2025), 77-86 p.

Air is a basic human need whose quality needs to be maintained, especially in closed environments such as laboratories. Several factors, such as temperature, humidity, lighting, occupancy density, and ventilation systems, affect the presence of microorganisms in the room. Laboratory users can control microorganisms that cause air contamination by using High Efficiency Particulate Air (HEPA) filters. This study aims to determine the effect of HEPA filter use on the number of airborne germs in laboratory rooms. This type of research is an analytical observational study with a cross-sectional design, with nine rooms as research objects. Air samples were taken six times in each room, namely twice before the use of the HEPA filter (0 hour), twice after the use of the HEPA filter for 3 hours without activity, and twice after the use of the HEPA filter for 3 hours with laboratory service activities. Statistical tests used one-way ANOVA to analyze the data. The results showed that the average number of airborne germs before the use of the HEPA filter was 357,667 CFU/m³. After 3 hours of use of the HEPA filter without activity, the number decreased to 177,444 CFU/m³. After 3 hours of active HEPA filter use, the number of airborne bacteria decreased to 124 CFU/m³. The statistical test results showed a significance value of 0.000 (p < 0.05), which means there was a significant difference between groups. The conclusion is that the use of HEPA filters has a substantial effect on reducing the number of airborne bacteria in the Bontang City Health Laboratory room. Future researchers are advised to increase the duration of HEPA filter use and identify the types of bacteria in the laboratory room.

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Baduashvili, A., Radonovich, L., Leslie, L., Pease, S., Brickson, C., Chockalingam, L.*, et al.*

Engineering Infection Controls to Reduce Indoor Transmission of Respiratory Infections.

Annals of Internal Medicine, Vol. **178** n°(9), (2025), 1314-1325 p.

Background: Engineering infection controls include a wide range of interventions used indoors to reduce occupants? exposure to respiratory pathogens. Purpose: To identify and describe primary studies evaluating the effects of engineering infection control interventions designed to reduce the spread of respiratory infections transmitted through indoor air. Data Sources: MEDLINE, Embase, Global Health, Cochrane Central Register of Controlled Trials, CINAHL, Scopus, and Environmental Science Collection from database inception to 12 December 2023. Study Selection: English-language primary research articles evaluating engineering infection control interventions. Data Extraction: Publication information, population characteristics, intervention details, and all relevant outcomes were abstracted by a reviewer and verified by a second, senior reviewer. Data Synthesis: A total of 672 studies published between 1929 and 2024 were identified. Most (n = 606) evaluated environmental samples only, 57 included human participants, and 9 included sentinel animal subjects. About half of the studies included at least 1 intervention classified as pathogen inactivation (n = 405), with fewer involving pathogen removal (n = 200) or air exchange or dilution (n = 143). Across all studies, about half (n = 332) measured the quantity of viable nonpathogenic organisms from air samples, followed by the quantity of nonbiological particulates (n = 197) or viable pathogenic organisms (n = 149). Harms, such as toxic byproducts, were rarely measured. Limitation: Exclusion of non?English-language publications and gray literature. Conclusion: There is substantial heterogeneity in the available evidence. Gaps in evidence include studies measuring efficacy outcomes that are highly relevant for human infection transmission or harms. Refinements in classification of interventions and outcomes could strengthen reporting of these evaluations. Primary Funding Source: National Institute for Occupational Safety and Health at the Centers for Disease Control and Prevention. (Registered on Open Science Framework

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Onkangi, R., Kuga, K., Ito, K.

Is exhaled carbon dioxide an appropriate tracer for assessing airborne transmission risk?

Building and Environment, Vol. **285**, (2025)

Understanding the inhalation exposure to exhaled carbon dioxide (CO2) and respiratory droplets in close-contact interactions is critical for assessing airborne infection risks in indoor environments. This study

presents a numerical analysis comparing the spatiotemporal transport and inhalation of exhaled CO2 (modeled as a passive scalar) and virus-laden droplets (modeled using a Lagrangian discrete phase model) under various interpersonal distances, body postures, and respiratory activities (namely speaking and coughing). The results showed that although fine droplets (<5 μm) exhibit similar dispersion patterns to CO2 owing to their aerodynamic behavior, larger droplets deviate significantly because of gravitational and inertial forces. The arrival time and inhalation amount of CO2 were often earlier and higher, respectively, than those of the droplets, particularly in speaking scenarios. However, in coughing cases, the rapid dilution of the exhaled CO2 jet led to an underestimation of droplet exposure. Furthermore, exhaled CO2 did not account for dermal and nasal deposition, particularly for larger droplets. These findings highlight that CO2 can serve as a useful tracer for visualizing airflow and aerosol-like behavior but not as a reliable proxy for droplet transmission risk. Collectively, accurate risk assessment requires the integration of particle-specific dynamics, evaporation, and realistic emission profiles.

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Shukla, S., Singh, D., Maurya, A., Manocha, C., Sharma, S., Kumar, V.*, et al.*

Machine learning-driven strategies for optimal design of heating, ventilation, and air-conditioning (HVAC) filter media.

Sep Purif Technol, (2025)

The COVID-19 pandemic has highlighted the critical need to improve indoor air quality (IAQ) through efficient air filtration, especially in heating, ventilation, and air-conditioning (HVAC) systems. While dedicated high-performance filters are effective, their high-pressure drops result in significant energy consumption when used in HVAC systems. Herein, we report the application of machine learning (ML) models to predict filtration efficiency and pressure drop, enabling the design and optimisation of filter media in HVAC. Specifically, three ML models, Gaussian process regression (GPR), artificial neural network (ANN), and decision tree (DT), have been trained on a dataset obtained from the literature. The dataset comprised key structural parameters of a wide range of filter media. The GPR model emerged as the most reliable predictor, exhibiting the highest coefficient of determination (R2) and lowest root mean squared error (RMSE) in predicting filtration efficiency and pressure drop, rendering it the most reliable predictor for small and uncertain datasets. The robustness of the GPR model is further confirmed via validation with commercially available filter media. In addition, the ML models accurately capture the established relationship between filtration efficiency and its characteristic drop at the most penetrating particle size (MPPS).

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Fong, M.-L. A., Chan, W.-K.

Natural Ventilation Technique of uNVeF in Urban Residential Unit Through a Case Study.

Urban Science, Vol. **9** n°(8), (2025)

The present study was motivated by the need to enhance indoor air quality and reduce airborne disease transmission in dense urban environments where high-rise residential buildings face challenges in achieving effective natural ventilation. The problem lies in the lack of scalable and convenient tools to optimize natural ventilation rate, particularly in urban settings with varying building heights. To address this, the scientific technique developed with an innovative metric, the urbanized natural ventilation effectiveness factor (uNVeF), integrates regression analysis of wind direction, velocity, air change rate per hour (ACH), window configurations, and building height to quantify ventilation efficiency. By employing a field measurement methodology, the measurements were conducted across 25 window-opening scenarios in a 13.9 m2 residential unit on the 35/F of a Hong Kong public housing building, supplemented by the Hellman Exponential Law with a site-specific friction coefficient (0.2907, R2 = 0.9232) to estimate the lower floor natural ventilation rate. The results confirm compliance with Hong Kong's statutory 1.5 ACH requirement (Practice Note for Authorized Persons, Registered Structural Engineers, and Registered Geotechnical Engineers) and achieving a peak ACH at a uNVeF of 0.953 with 75% window opening. The results also

revealed that lower floors can maintain 1.5 ACH with adjusted window configurations. Using the Wells–Riley model, the estimation results indicated significant airborne disease infection risk reductions of 96.1% at 35/F and 93.4% at 1/F compared to the 1.5 ACH baseline which demonstrates a strong correlation between ACH, uNVeF and infection risks. The uNVeF framework offers a practical approach to optimize natural ventilation and provides actionable guidelines, together with future research on the scope of validity to refine this technique for residents and developers. The implications in the building industry include setting up sustainable design standards, enhancing public health resilience, supporting policy frameworks for energy-efficient urban planning, and potentially driving innovation in high-rise residential construction and retrofitting globally.

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Zabihi, M., Li, R., Brinkerhoff, J.

A Novel Aerosol Induction-Removal System for Mitigating Airborne Disease Transmission in Shared Indoor Environments.

Building and Environment, (2025)

Ensuring high indoor air quality is crucial for mitigating airborne disease transmission, particularly in shared environments. This study introduces a novel aerosol removal device based on an induction-removal (jet-sink) airflow concept, designed to actively direct exhaled pathogens into a localized purification system while maintaining occupant comfort. Unlike conventional personalized ventilation (PV) systems, which rely on high-velocity air jets that may cause discomfort, the proposed device manipulates the airflow near the individual to efficiently capture and remove contaminated aerosols. Fully transient computational fluid dynamics (CFD) simulations based on an Eulerian-Lagrangian approach were conducted over a 30-minute real-time period in a consultation setting, incorporating human effects such as thermal plumes, breathing, and aerosol dispersion. The performance of the novel aerosol removal device was compared against a conventional PV system, a PV-PE, and a baseline HVAC scenario. The novel device removed up to 94% of exhaled aerosols, reducing the probability of infection to 9.5%, compared to 47.6% with PV, 38% with PV-PE, and over 91% in the baseline case. Additionally, the induction-removal system maintained its effectiveness even with slight occupant misalignment, whereas PV system exhibited a dramatic increase in infection risk when occupants shifted positions. By creating a controlled airflow pattern, this novel approach enhances aerosol capture and purification, offering a more reliable, adaptive, and comfortable solution for reducing airborne infection risks in enclosed spaces over extended exposure durations. This study highlights the potential of airflow engineering in improving indoor air quality and protecting occupant health.

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Hou, Y., You, R.

A practical concurrent gasper-operation strategy for controlling airborne disease transmission in an economy-class aircraft cabin with personalized displacement ventilation.

Building and Environment, Vol. **285**, (2025)

Airborne disease transmission in aircraft cabins is closely influenced by airflow patterns. Gaspers, commonly used by passengers, play a critical role in shaping the local airflow. Our previous study investigated the working mechanism of an individual gasper and found that adjusting a receptor’s gasper appropriately could effectively protect the receptor. However, in practice, multiple gaspers are operated simultaneously by passengers, and their interaction with the main airflow significantly complicates the contaminant transport in the cabin. Therefore, this study aims to identify an executable gasper operation strategy for passengers to control the transmission of airborne diseases. We first proposed a seat-type-dependent gasper operation strategy based on the working mechanism of a single gasper from our previous study. Random gasper operation under realistic conditions was innovatively used as the benchmark. The two operation strategies were then applied in a seven-row section of a single-aisle, fully occupied, economy-class aircraft cabin with a personalized displacement ventilation system for numerical simulations. The results showed that when the source passenger was in the window seat or middle seat,

the proposed operation strategy with full utilization reduced the mean exposure index by at least 25.4 % for most passengers, except those seated directly in front of the source passenger. When the source passenger was in the aisle seat, there was no significant difference between the proposed strategy and random operation in controlling the transmission. These findings provide practical guidance for gasper operation in aircraft cabins to mitigate airborne transmission risks.

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Destrieux, A., Jangra, R., Hensel, K., Machala, Z.

Review on scientific studies and commercial indoor air purification devices: Focus on plasma-catalytic technology.

Journal of Electrostatics, Vol. **137**, (2025)

According to World Health Organization, urban populations spend 90 % of their time in indoor environments. Accentuated by the recent COVID-19 pandemic, this raises important concerns about the quality of the indoor air, which often contains various types of contaminants within three main categories: biological, volatile organic compounds, and particulate matter. Several technologies already exist for removing contaminants from indoor air, such as electrostatic based methods or filtration. Although these technologies are well established, they often target only one or two groups of contaminants. This review focuses on a promising technology: nonthermal plasma combined with catalysts. After an overview of indoor air contaminants, their sources, and the typical methods used for their removal, a highlight is put on the available commercial indoor air purification devices. The latter are rarely described in literature, and the comparison with lab-scale experiments are difficult due to the lack of information and available data from the manufacturers. The limitations of those systems are also discussed. As most of these commercial devices use combinations of various conventional technologies, the last part focuses on the ongoing research on plasma-catalytic systems. The main mechanisms are presented along with recent literature. Finally, some perspectives for its future development are proposed.

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