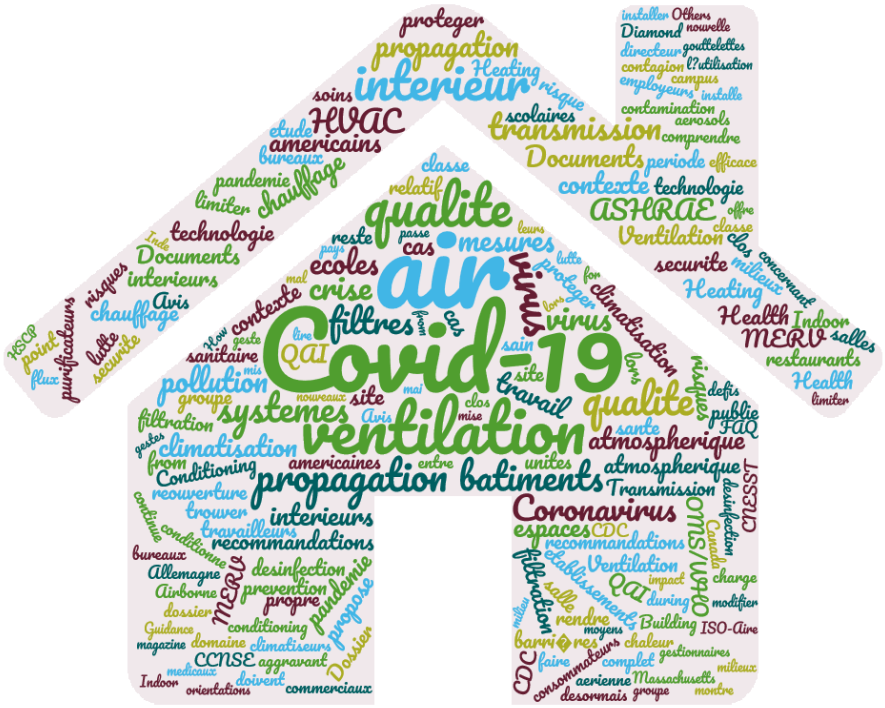

Bulletin de veille AéroCovid
N°111 - 12/03/2025

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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Çoşgun, A., Koyun, T.

Assessment of indoor air quality at a university hospital using CFD and GIS.

International Journal of Environmental Science and Technology, (2025)

Because the air conditioning systems in hospital operating rooms, which are among the most difficult work environments in the healthcare sector, require a certain level of quality in the settings, their installation, operation, maintenance, and design have become an important part of engineering applications. The main functions of these systems are air distribution (air velocity, air flow patterns, flow direction), humidification, and filtering (removal of dust particles, bacteria, viruses, and fungi), and these functions serve to preserve the surgical macro and micro settings and provide the ideal conditions to prevent contamination. The factors that affect the design of ventilation systems in operating rooms include surgical lights, medical equipment, and personnel. Among these factors, thermal loads and the presence of obstacles are particularly important. The design of the air flow patterns in operating rooms is crucial for ensuring air quality and providing patients and surgical team members with a healthy environment. Some situations that affect the performance of ventilation systems in hospitals, especially operating rooms, may be listed as the number of employees, door openings and the associated rate of increase in particle concentrations in the environment, corridors, the frequency at which doors are opened and closed, as well as the air flow rate changing depending on this frequency, and operating room contaminations. In this study, particulate matter (PM) measurements were made for PM0.3, PM0.5, PM1, and PM5 concentrations in Operating Room 19 at Akdeniz University Hospital, which is world-famous for face transplants, in Turkey, and these measurements were analyzed using the GIS (geographic information system) method and the ANSYS CFD (computational fluid dynamics) package program. The results were evaluated from an engineering perspective. Accordingly, it was determined that spatial maps of factors that affect indoor air quality, including temperature, humidity, PM, and VOC, could be produced using the GIS method, and the results could be evaluated better using a CFD package program. It is seen that PM distributions in an operating room could be evaluated from an engineering perspective using the GIS and CFD methods together. The unique aspect of the study is the fact that spatial distribution maps of PM reaching an operating table in an operating room were created, and different analysis techniques were used to investigate relevant parameters.

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Giraldo-Pérez, J. P., Bruse, J. L., Odriozola, J., Mejía-Gutiérrez, R.

Balancing indoor air quality and ventilation efforts via deep reinforcement learning: An agent-based approach applied to an office building.

Energy and Buildings, Vol. **335**, (2025) The COVID-19 pandemic highlighted the critical role of Heating, ventilation, and air conditioning (HVAC) systems in mitigating airborne disease transmission within indoor environments. While increasing active building ventilation improves Indoor Air Quality (IAQ), it also leads to higher energy consumption. With buildings projected to account for over 30 % of global energy demand by 2050, balancing IAQ and energy efficiency has become a pressing challenge for building designers and operators. However, existing research has predominantly focused on optimizing heating and cooling aspects of HVAC systems for thermal comfort and cost reduction, often neglecting optimal ventilation control for IAQ and energy efficiency. This paper presents a novel approach that combines Deep Reinforcement Learning (DRL) with Agent-Based Modeling (ABM) to optimize an open-loop HVAC ventilation control in office buildings. Unlike standard driven methods that rely on static equations and do not adapt to realistic occupancy patterns, our DRL agent takes into account stochastic user behavior simulated within the ABM environment. Simulation results demonstrate that, at times, the applied ventilation standard exceeds common target carbon dioxide (CO2) levels and tends to over-ventilate on less or

sporadically used rooms, leaving potential for energy savings associated with ventilation efforts. A brute-force (BF) approach, optimizing ventilation rates iteratively using the ABM environment, avoided over-ventilation best while maintaining CO2 levels closest to the desired targets. However, the DRL agent achieved similar performance while requiring substantially less computational efforts than the BF method. This work contributes to the development of intelligent HVAC control systems that can balance IAQ and ventilation efforts better than static ventilation guidelines and thus promotes post-pandemic, sustainable building design and operation.

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Pelletier, K.-P.

Exposition professionnelle aux virus de la COVID-19 en milieu de soins par l'air et évaluation de l'efficacité de l'isolement par pression négative.

Université Laval. Thèse 2024

L'objectif de cette étude est d'identifier l'exposition des travailleurs au virus SARS-CoV-2 à l'intérieur et à l'extérieur de la chambre du patient. Le premier objectif de cette étude était de caractériser l'émission virale des patients positifs à la COVID-19. Des échantillons d'air ont été collectés sur une période de 24 heures à l'intérieur des chambres des patients positifs. Les données cliniques des patients échantillonnés ont été recueillies par le personnel de santé pour tenter de prédire les variations des taux d'émission des patients. Le deuxième objectif de l'étude était d'évaluer la contamination de l'air à l'extérieur des chambres des patients. Des surfaces ont été utilisées comme indicateur indirect de la contamination de l'air. Ces surfaces ont été échantillonnées avant et pendant 6 semaines consécutives après le nettoyage pour analyser l'évolution de la contamination virale dans le temps. L'ARN de SARS-CoV-2 était présent dans 63,7 % des échantillons d'air collectés, et le taux moyen d'émission était mesuré à 1,11E+06 génomes/personne/heure. Aucune donnée clinique collectée n'avait de relation significative avec le taux d'émission des patients. L'échantillonnage de surface montre une quantité détectable d'ARN viral sur 4 des 15 surfaces, et aucune contamination jusqu'à 6 semaines après le nettoyage. La détection de l'ARN viral dans l'air des chambres des patients, mais l'absence de facteurs expliquant les variations des taux d'émission observés, confirme la nécessité de comprendre l'émission du virus par les patients pour mieux protéger les travailleurs de la santé. L'échantillonnage de surface effectué à l'extérieur des chambres indique que l'isolement des patients positifs au virus de la COVID-19 dans des chambres à pression

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Gu, Y., Yang, W., Zhong, K., Yang, Z.

Factors shaping fungal contamination emissions from cooling coils: An experimental study across hot-humid and hot-dry climates in Shanghai.

Building and Environment, Vol. **275**, (2025)

Cooling coils in air-conditioning systems can compromise indoor air quality by fostering fungal growth and dispersing spores, posing health risks to occupants. However, the climate and operational factors shaping coil-induced airborne fungal contamination remain unclear, impeding the development of effective mitigation strategies. This study developed a lab-scale system with three coil rows to examine fungal contamination dynamics during the transition from the hot-humid plum rain season to the hot-dry heat wave period in Shanghai. A 55-day experiment was conducted following a standard office-hour schedule (9:00 to 17:00), with daily fungal sampling from air, coil surfaces, and condensate. Results showed that coil-induced fungal contamination depends on climate, system's operation duration, and coil row position, with condensate often heavily polluted. Humid climates amplified fungal emissions, particularly upon morning coil activation. Fungal level in downstream air increased by 24.5% on hot-humid mornings but decreased by 36.3% on hot-dry mornings. Hot-humid conditions also enriched allergenic species, such as Aspergillus and Malassezia, in downstream air. Additionally, continuous coil operation heightened fungal exposure risks, emitting respirable fungal particles into downstream air at nearly triple the upstream levels after three consecutive hot-humid mornings. Rear-row coils were the dominant emission sources, as evidenced by a

“J-shaped” fungal distribution on coil surfaces: front-row coils cleared fungal deposits via condensate drainage, while rear-row coils retained moisture, promoting fungal proliferation and spore dissemination. These findings underscore cooling coils as substantial indoor fungal sources in hot-humid climates upon activation, emphasizing the need for targeted rear-row coil maintenance to mitigate fungal emissions.

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Norvihoho, L. K., Liu, Y., Yin, J., Zhu, X.-G., Yu, H.-T., Wang, Q.-D.*, et al.*

Infectious cough droplet dynamics in a makeshift hospital isolation ward.

Physics of Fluids, Vol. **37** n°(2), (2025)

The COVID-19 pandemic highlighted the need for rapidly deployable healthcare facilities, leading to increased use of modular construction methods. Nonetheless, knowledge about airflow patterns and the spread of bioaerosols in these wards remains insufficient, potentially heightening the risk of cross-infection among healthcare workers and patients. This paper presents a ventilation design for a modular negative-pressure ward aimed at reducing the spread of infectious particles. We investigate the effects of various ventilation designs, patient postures (sitting and supine), and air changes per hour (ACH) on the spread of infectious cough droplets in an airborne infection isolation room using large eddy simulation and the Eulerian–Lagrangian model. Findings show that ceiling exhaust grilles (design 2) resulted in the lowest radial dispersion (3.64 m) at 12 ACH, while sidewall exhausts (baseline) performed best at higher ACH levels. Seated patients had quicker droplet evaporation compared to those in a supine position. The best setups for reducing droplet survival included exhaust grilles at the bed's bottom and ceiling, maintaining a minimum of 12 ACH. Cases 5 and 13, with grilles over the patient's head and at the bed's bottom, showed the lowest concentrations of DPM, under 0.008 km−3 near the source and less than 0.001 km−3 mid-room. Sitting posture consistently led to lower DPM concentrations. This research emphasizes the critical role of exhaust placement in reducing droplet re-circulation and transmission risks, ultimately contributing to improved ventilation strategies and infection control in AII rooms.

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Zhang, F., Shan, K., Wang, S.

Risk assessment-based particle sensor location optimization for non-unidirectional cleanrooms concerning air distribution uncertainties.

Building and Environment, (2025)

Air conditioning systems in cleanrooms require a huge amount of clean air to maintain the desired indoor air cleanliness, resulting in significant energy consumption. A major challenge in achieving energy-efficient control of such systems is obtaining accurate and reliable measurements of particle concentration which is essential for precisely controlling minimum but sufficient airflow rate. Therefore, this paper proposes a risk assessment-based method for optimizing particle sensor locations in non-unidirectional cleanrooms, addressing the limitations of conventional empirical methods for sensor placement. Two sensor performance indexes, "systematic measurement bias" and "spatial violation risk", are formulated to balance measurement accuracy and the risk of unsatisfactory air cleanliness at a sensor location. This optimization method is explored through experimentally validated computational fluid dynamics simulations based on a typical non-unidirectional cleanroom. The results show that the proposed method can be conveniently implemented to optimize the sensor location under various scenarios, and improve the particle monitoring performance by optimizing the number of sensors and the location of source. Compared to a commonly-used practical sensor placement method, the proposed method can reduce the spatial violation risk by 31%.

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Dhillon, R. S., Karan, A., Garry, R. F., Srikrishna, D.

Steps to prevent and respond to an H5N1 epidemic in the USA.

Nature Medicine, (2025)

Steps should be taken now to prevent an epidemic of H5N1 in humans and prepare for an outbreak should it occur.

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Zhang, J., Liu, S., Liu, J.

Study on the effect of targeted ventilation purification technology on pathogen aerosol removal in ward.

ASim2024, The 5th Asia Conference of the IBPSA. December 8th – 10th, 2024, Osaka, Japan

Negative pressure isolation wards (NPIWs) can provide treatment for COVID-19 patients during a pandemic. However, breathing releases aerosols containing pathogens, resulting in a potential infection risk for health care workers (HCWs). Robust ventilation in NPIWs can potentially reduce the infection risk, but can also increase energy consumption. Therefore, it is important to decrease energy consumption in NPIWs. This study proposes TARGETING, a new index for assessing the targeting of ventilation systems. The air curtain ventilation (ACV) achieved better comprehensive benefits, with an TARGETING of 1.3 and energy saving is about 35.9-58.0%.

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