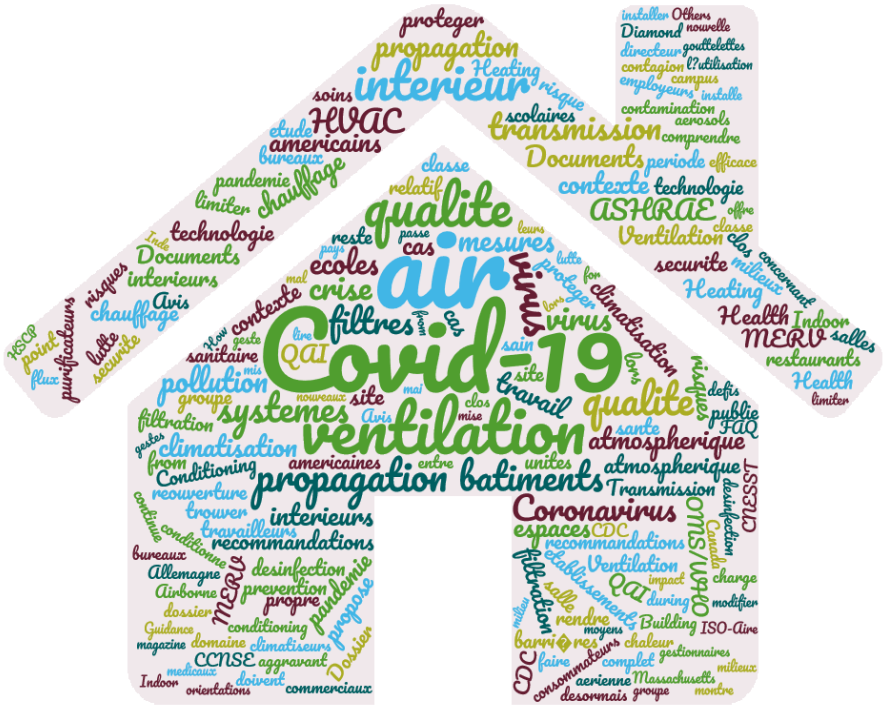

Bulletin de veille Aéraulique et COVID-19
N°105 – 04/12/2024

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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Iwamura, N., Tsutsumi, K., Hamashoji, T., Arita, Y., Deguchi, T.

Carbon Dioxide Levels as a Key Indicator for Managing SARS-CoV-2 Airborne Transmission Risks Across 10 Indoor Scenarios.

Cureus, Vol. **16** n°(11), (2024)

This study aimed to quantify the airborne transmission risk of SARS-CoV-2 in various indoor environments.

Methods

Using indoor carbon dioxide (CO2) levels, we estimated the probability of airborne transmission and the basic reproduction number (R0) across 10 hypothetical indoor scenarios, including a college classroom, restaurant, classical music concert, live event, city bus, crowded train, hospital room, home, shogi match, and business meeting, using an analysis based on the modified Wells-Riley model.

Results

The relationship between airborne transmission rates and indoor CO2 concentrations was visualized with and without the use of masks. Without masks, at an indoor CO2 concentration of 1,000 ppm, airborne transmission rates were high in a home (100%), business meeting (100%), and hospital room (95%); however, they were moderate in a restaurant (55%), at a shogi match (22%), and at a live concert (21%); and low in a college classroom (1.7%), on a city bus (1.3%), at a classical music concert (1.0%), and on a crowded train (0.25%). In contrast, R0 was high at a live event (42.3), in a restaurant (15.9), in a home (3.00), and in a hospital room (2.86), indicating a greater risk of cluster infections. An examination of reduced airborne infection risk through surgical mask use and improved ventilation across various scenarios revealed that mask-wearing was highly effective in hospital rooms, in restaurants, at shogi matches, and in live concerts. Ventilation was particularly useful in hospital rooms, in restaurants, and at shogi matches.

Discussion and conclusion

In all indoor scenarios, a positive linear relationship existed between airborne transmission risk and indoor CO2 levels. The risk varied markedly across scenarios and was influenced by factors such as mask use, ventilation quality, conversation, and exposure duration. This model indicates that the risk of SARS-CoV-2 airborne transmission can be easily predicted using a CO2 meter.

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Aganovic, A., Buonanno, G., Cao, G., Delmaar, C., Kurnitski, J., Mikszewski, A.*, et al.*

Comparative assessment of airborne infection risk tools in enclosed spaces: Implications for disease control.

Infectious Disease Modelling, Vol. **10** n°(1), (2025), 338-352 p.

The COVID-19 pandemic, caused by SARS-CoV-2, highlighted the importance of understanding transmission modes and implementing effective mitigation strategies. Recognizing airborne transmission as a primary route has reshaped public health measures, emphasizing the need to optimize indoor environments to reduce risks. Numerous tools have emerged to assess airborne infection risks in enclosed spaces, providing valuable resources for public health authorities, researchers, and the general public. However, comparing the outputs of these tools is challenging because of variations in assumptions, mathematical models, and data sources. We conducted a comprehensive review, comparing digital

airborne infection risk calculators using standardized building-specific input parameters. These tools generally produce similar and consistent outputs with identical inputs. Variations mainly stem from model selection and the handling of unsteady viral load conditions. Differences in source term calculations, including particle emission concentrations and respiratory activity, also contribute to disparities. These differences are minor compared to the inherent uncertainties in risk assessment. Consistency in results increases with higher ventilation rates, showing a robust trend across models. However, inconsistencies arose in the inclusion of face masks, often due to the lack of detailed efficiency values. Despite some differences, the overall consistency underscores the value of these tools in public health strategy and infectious disease control. We also compared some of the model's efforts to conduct retrospective assessments against reported transmission events by assuming input parameters to the models so that the calculated risk would closely fit the original outbreak infection rate. Thus, validating these models against past outbreaks remains challenging because of the lack of essential input information from observed events. This comparative analysis demonstrates the importance of transparent data sources and justifiable model assumptions to enhance the reliability and precision of risk assessments.

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Xie, H., Jia, H., Ji, J., Qian, Y., Meng, H., Li, J.*, et al.*

Development and experimental validation of a thermal inactivation model for airborne bacteria and its application in Trombe wall systems.

Building and Environment, Vol. **268**, (2025)

Thermal inactivation technology is an effective and safe method to control indoor bioaerosols. A predictive mathematical model describing the effect of residence time and exposure temperature on the thermal inactivation process of Klebsiella pneumoniae (K. pneumoniae), Escherichia coli (E. coli) and Staphylococcus aureus (S. aureus) in aerosol was developed. A continuous flow experimental system was set up to determine the survival ratio of bioaerosols under the wall temperature of 45–120 °C and residence time of 1.5–12 s. The experimental results showed that the thermal stability in the order from high to low was S. aureus > K. pneumoniae > E. coli. The inactivation model was developed based on the first-order kinetic model and Arrhenius equation and the model parameters were identified through particle swarm optimization (PSO) algorithm with the input of time-dependent exposure temperature calculated by computational fluid dynamics (CFD). The survival ratio calculated by the present model corresponded well with that observed in the experiment, with root mean square error (RMSE) being 0.0445, 0.0433 and 0.0376 for K. pneumoniae, E. coli and S. aureus, respectively. Based on the heat and mass transfer model for Trombe wall, it was found that solar-driven thermal inactivation could reduce the indoor bacterial concentration by up to 57 % for E. coli with thermal efficiency being 0.424 under solar irradiance of 496 W/m2 and ambient temperature of 12.8 °C. In this way, solar driven thermal inactivation is a promising and sustainable method to deal with indoor bioaerosols.

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Rong, P., Zhou, W., Wang, J., Zhang, H.

Evaluating thermal comfort and air quality in buses with different ventilation strategies in Hong Kong.

Results in Engineering, Vol. **24**, (2024)

This study employed computational fluid dynamics (CFD) simulations to investigate the influence of air-conditioning exhaust position, supply velocity and direction on air quality and thermal comfort in a fully occupied bus. Air quality was evaluated employing CO2 concentration as an indicator, while thermal comfort was assessed via the Predicted Mean Vote (PMV) index. The findings reveal that air supply velocity and direction have significant impacts on passengers' thermal comfort. In winter, a closed air supply can maintain thermal neutrality in the cabin (|PMV|<0.5). Increasing the supply velocity from 0.5 m/s to 3 m/s shifts head-level sensation from slightly cool (PMV<-0.5) to cold (PMV<-1.5). Adjusting the air supply direction to the left or right can effectively eliminate cool areas (PMV<-1) at the head level otherwise

caused by the 1.5m/s downward airflow. Additionally, both the supply velocity and the exhaust position predominantly affect the air quality in the cabin. At a low velocity of 0.5 m/s, the average CO2 concentration at the breathing level reaches 6670.79 PPM, far exceeding the health threshold of 3500 PPM set by the Hong Kong bus air quality standard. An increase in velocity to 1.5 m/s alleviates the average CO2 levels to 2863.85 PPM within the healthy range. Furthermore, relocating the exhaust forward can further improve air quality by 4.10 %, reducing CO2 concentration to 2746.50 PPM. Optimal conditions for air quality and thermal comfort are achieved with an air supply velocity of 1.5 m/s, a leftward direction, and the exhaust located at the middle of the ceiling.

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Zhang, Y., Hui, F. K. P., Duffield, C., Gao, C. X.

Exploring the Decision-making of IAQ Interventions in post-covid Australia.

Transdisciplinary Workplace Research. 4th-7th September 2024. Edinburgh Napier University

The COVID-19 pandemic posed a significant challenge for facilities managers to manage the workplace with Facilities Management Interventions (FMI) for infection control. This paper explores the decision-making of FMI implemented for infection control in post-COVID Australia. Through 41 semi-structured interviews with facilities managers, health and safety managers, and infection control experts, we examined the decision-making process and factors related to indoor air quality (IAQ) interventions. Thematic analysis identified six main factors determining FMI decision-making: compliance, occupant impact, organisational characteristics, financial characteristics, building characteristics, and environmental impacts. This research reveals the challenges for FMs in adapting existing workplaces to meet occupant health and energy efficiency goals. It contributes to workplace research and benefits scholars and practitioners who design and manage workplaces in the post-pandemic era.

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Vernon, J. J., Vinall-Collier, K., Csikar, J., Emms, G., Lancaster, P. E., Nattress, B. R., *et al.*

Future-Proofing Dentistry: A Qualitative Exploration of COVID-19 Responses in UK Dental Schools.

Eur J Dent Educ, (2024)

ABSTRACT Introduction The COVID-19 pandemic had extensive influence on dental education. UK dental schools were compelled to respond with substantial adaptations to clinical training approaches and environments to mitigate educational impact. Materials and Methods The Surveying Pandemic Education Response in Higher Education Dental Schools (SPEARHEAD) study aimed to retrospectively evaluate the diverse responses of UK dental schools to the COVID-19 pandemic. All UK dental schools were invited to participate in semi-structured interviews to ascertain institutional responses, with transcripts subjected to thematic framework analysis. Results and Discussion Ten UK dental schools contributed to the study and three main themes were identified: student education, environment, and procedures and equipment. The most common approach to student education was the reduction of student numbers in clinical areas; however, this increased supervisory demands. While there was widespread acknowledgement of the need for enhanced ventilation, implementing the necessary modifications was frequently constrained by building configurations and financial implications. Numerous procedural adjustments were implemented, accompanied by widespread adoption of enhanced personal protective equipment. Fallow periods were common, although differing durations underscored the need for data-driven guidance. Many schools transitioned towards electric speed-controlled handpieces, but the need to reflect real-world scenarios often led to a reversion to air turbines. Conclusion UK dental schools showed initiative, resilience, and ingenuity in safeguarding students from enduring irretrievable educational setbacks amidst the challenges posed by the COVID-19 pandemic. Validating a data-driven strategy for addressing future threats would facilitate a unified response, minimising the educational repercussions and bolstering the resilience of dental training.

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Cheng, Y., Wen, R., Wang, Y., Sun, X., Jiang, S., Chen, Z., *et al.*

The hidden factor in COVID-19 rehabilitation: how does the microenvironment in mobile cabin hospitals impact patient recovery? An observational study.

Therapeutic Advances in Infectious Disease, Vol. **11**, (2024)

Backgrounds:

Existing studies on the treatment of emergency infectious diseases have primarily focused on the pathogen and the human immune system. However, human health is intricately connected to environmental factors, and this interaction becomes particularly during large-scale public health emergencies. Few studies have examined the impact of spatial differences in the microenvironment on the rehabilitation rate of patients with the Omicron variant infection.

Objective:

This study employs causal inference statistical methods and spatial analysis to investigate how the hospital microenvironment affects the rehabilitation of COVID-19 patients in a mobile cabin hospital, so as to provide a scientific basis for the spatial arrangement of patients in mobile cabin hospitals.

Design:

Observational study.

Methods:

This study used the clinical information of 6291 patients admitted in a mobile cabin hospital in Shanghai, from April 9 to May 9, 2022, during the pandemic. Exploratory spatial data analysis and fixed-effects regression analysis were conducted to understand whether the microenvironment around the patients' beds in the cabin impacted their rehabilitation.

Results:

The results indicate that the rehabilitation condition of patients is affected by spatial differences of microenvironment. Both the mean and minimum CT values of the surrounding patients show a significant positive correlation with the rehabilitation of patients. The further the distance from the vent is, the more the rehabilitation speed of the patients is affected by the CT values of the surrounding patients.

Conclusion:

These findings offer valuable insights for bed allocation, patients' stratification and management, and ventilation management in the mobile cabin hospitals during public health emergencies.

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Sankurantripati, S., Duchaine, F.

Indoor Air Quality Control for Airborne Diseases: A Review on Portable UV Air Purifiers.

Fluids, Vol. **9** n°(12), (2024)

The spread of airborne diseases such as COVID-19 underscores the need for effective indoor air quality control. This review focuses on ventilation strategies and portable air purifiers as key mitigation solutions. Ventilation systems, including natural and mechanical approaches, can reduce pathogen concentrations by improving airflow. However, combining ventilation with portable air purifiers, particularly those using HEPA filters, ESP filters, and UV-C radiation, can enhance Indoor air quality. While HEPA and ESP filters focus on trapping airborne particles, UV-C radiation can inactivate pathogens by disrupting their RNA. A review of UV air purifiers reveals a lack of studies on their efficacy and effectiveness in real-world settings. A thorough investigation into the performance of this mitigation solution is necessary, focusing on varying key factors, such as purifier placement, airflow dynamics, and UV dosage, to ensure optimal effectiveness.

High-fidelity computational methods are essential in accurately assessing these factors, as informed by the physics of airborne transmission. Such advanced computations are necessary to determine the viability of portable UV air purifiers in mitigating airborne transmission in enclosed environments such as hospitals and public spaces. Integrating advanced air purification technologies with proper ventilation can improve safety in indoor environments and prevent future disease-related outbreaks.

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Installation Guidance IAQ. LoRaWAN Wireless Indoor Air Quality Sensor

Sontay 2024

Measuring CO2 levels can serve as a good indicator of the indoor air quality. CO2 concentrations within a building often are used to indicate whether adequate fresh air is being supplied to the space. Indoor CO2 concentration is directly proportional to the number of people in a building and the ability of the ventilation system to dilute the CO2 generated by occupants.

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Jia, Q., Yang, H., Wang, J.

Numerical analysis and control of contaminant leakage during personnel movement across differential pressure zones.

Journal of Building Engineering, Vol. **98**, (2024)

Artificial pressure differential environments play a vital role in various fields, including healthcare, industrial applications, and laboratory safety. Despite numerous studies conducted in this area, contaminant leakage due to personnel movement across pressure zones remains a significant challenge, increasing the risk of infection or contamination. This study aims to systematically analyze and control contaminant particle leakage during such movements, using numerical simulations and field experiments that incorporate the moving mesh method. This study investigates the effects of pressure gradients, door types, and temperature differences on particle migration. The results indicate that maintaining a pressure gradient can reduce particle leakage by up to 35.33 %. Sliding doors proved more effective than hinged doors, reducing leakage by up to 74.36 %. Introducing a temperature difference between areas also decreased leakage by up to 64.9 %. These findings provide practical recommendations for optimizing the design of negative-pressure isolation wards and can be extended to other environments that maintain differential pressure. This study offers valuable insights into the control of contaminant leakage, contributing to improved indoor air quality and infection control.

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Song, C., Kong, B., Cheng, M., Li, Y., Shi, H.

Optimizing Ventilation Systems for Dual Objectives: Enhancing Thermal Comfort and Controlling Droplet Dispersion.

Aerosol Science and Engineering, (2024)

Optimizing the form and parameters of ventilation systems is crucial for enhancing the microenvironment around individuals, with a primary focus on human comfort in ventilation design. Additionally, controlling exposure concentrations of respiratory droplets is an essential strategy for dealing with respiratory infections. Therefore, a thorough examination of the relationship between the form and parameters of ventilation systems, human comfort, and the dispersion of droplets becomes particularly significant. This study utilizes computational fluid dynamics (CFD) to optimize ventilation systems, focusing on enhancing individual comfort and reducing droplet dispersion in indoor environments, particularly in cruise cabins where the microenvironment significantly impacts passenger well-being. It evaluates three ventilation systems: orifice plate ventilation system (OPVS), ceiling mixed ventilation system (CMVS), and sidewall mixed ventilation system (SMVS). Employing the Entropy-weighted TOPSIS method, it optimizes ventilation temperature and relative humidity across 20 combinations to achieve optimal thermal comfort and airflow

uniformity. The findings indicate that OPVS offers the best thermal comfort and uniform airflow, with an ideal configuration at 21 °C and 60% relative humidity. It also investigates the placement of air purifiers under the optimal ventilation configuration (OPVS), revealing that positioning them near the breathing zone reduces droplet concentrations by 42.6%, while central placement achieves a reduction of 40.1%. This suggests central air purifier placement for practical applications, balancing droplet concentration reduction with minimal occupant disturbance. This work contributes to understanding ventilation strategies for managing respiratory diseases and ensuring indoor comfort.

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Li, L., Du, H., Meng, C., Fan, L., Liu, H., Han, X.*, et al.*

The relationship between indoor airborne culturable bacteria with passenger flow in 132 traffic stations during 2019–2020, China.

Journal of Environmental Management, Vol. **373**, (2025)

This study aims to provide technical support for the development of a rational administration strategy for indoor environment and passenger flow of stations. The analysis was conducted monitor data of long distance bus stations and train/high speed railway stations from the National project. The monitor and surveyed data included indoor airborne culturable bacteria (IAB), passenger flow, area and height of stations. Data analysis involved the use of paired non-parametric tests, correlation analysis, and mixed linear regression methods. A total of 132 pairs of stations were examined in this study. Additionally, significant variations were observed in the monitoring results for the IAB and passenger flow between 2019 and 2020 ($p < 0.05$). Specifically, the median values of these two factors in 2020 decreased by 50.52% and 48.33%, respectively, compared to 2019. ($p < 0.05$). A positive relationship between the daily average passenger flow and the IAB in long distance bus stations and train stations, particularly pronounced with medium sized waiting rooms, which located in subtropical cities with a general level of economic development. The mixed effect regression analysis revealed a significant association between passenger flow (OR = 1.564, 1.288–1.898), per capita volume (OR = 0.856, 0.733–0.998), and per capita area (OR = 0.806, 0.678–0.956) with the IAB ($p < 0.05$) just in long distance bus stations. It is crucial to regulate passenger flow and per capita area in the waiting room of long distance bus stations to mitigate the spread of airborne culturable bacteria during infectious disease epidemics.

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Nateghi, S., Marashian, S., Kaczmarczyk, J., Sadrizadeh, S.

Resource-efficient design of integrated personal exhaust ventilation and physical barriers for airborne transmission mitigation: A numerical and experimental evaluation.

Building and Environment, Vol. **268**, (2025)

This study investigates the performance of integrated personal exhaust ventilation and physical barriers in mitigating airborne transmission, addressing the critical need for effective infection control in indoor environments. Using computational fluid dynamics, we modeled aerosol dispersion in a test room and validated these results with experimental data. Experimental validation strengthened the computational findings by providing empirical evidence for system efficacy under varying airflow conditions. We examined various prevention levels, including no prevention measures, only physical barriers, and physical barriers integrated with personal exhaust ventilation. The designed system with a barrier height of 65 cm and a personal exhaust flow rate of 9 L/s per person demonstrated strong efficacy in mitigating airborne transmission. Further numerical analysis was conducted to evaluate the impact of critical parameters, including barrier height and exhaust flow rate, on the aerosol removal efficiency of the integrated system. Results indicate that reducing the barrier height to 45 cm and the exhaust flow rate to 6 L/s per person retains 95% of aerosol removal efficiency, offering the most cost-effective and sustainable design without compromising system's performance in limiting airborne transmission. These findings suggest that moderate adjustments can enhance system sustainability by enabling significant material and energy savings.

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Santos, R. A., Hasslocher-Moreno, A. M.

Study of the Microbiological Efficiency of a Hospital Ventilation System With Hepa Filtration in the Prevention of Airborne Pathogens.

Revista de Gestão Social e Ambiental, Vol. **18** n°(11), (2024

Objective: To evaluate the microbiological efficiency in air conditioning systems with HEPA filtration in an infectious disease hospital.

Theoretical Framework: Air conditioning in intensive care units and wards must consider the spread of microorganisms through respiratory pathways, as both patients and healthcare professionals are exposed to infectious agents transmitted by bioaerosols. Due to the possibility of environmental infection, there is a growing recognition that poorly designed air conditioning systems enhance the transmission of pathogens in areas with constant flow of individuals, particularly immunocompromised patients, who are more susceptible to infections. Air conditioning with HEPA filtration is a hospital engineering technique that shows great potential for filtering airborne contaminants, thereby reducing their dispersion in the environment.

Method: Air samples were collected using the active impaction method over a 32-week period in the intensive care unit and wards of a reference hospital for infectious diseases.

Results and Discussion: In the hospital environment, 67% of fungi and 33% of bacteria were identified, along with their respective subcategories. The colony-forming unit count exceeded the standards established by current regulations. The study highlights that hospital air is a pathway for the transmission and persistence of pathogenic microorganisms.

Research Implications: The importance of ensuring a safe and healthy hospital environment is emphasized.

Originality/Value: There are few studies addressing pathogens transmitted by bioaerosols. This study contributes to expanding knowledge on this topic and suggests the need for a review of current regulatory standards.

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Hayashi, M., Murata, S., Kikuta, K.

Ventilation characteristics in a hospital where a COVID-19 outbreak occurred in the winter of 2020.

Indoor Environments, Vol. **2** n°(1), (2025)

To clear the influences of ventilation performance on COVID-19 outbreaks in hospitals, the ventilation characteristics were investigated in a ward of an over-30-year-old hospital where a large outbreak occurred in the winter of 2020. At the early stage of the outbreak, nasal high-flow (NHF) was used in a treatment room for a week, and many patients stayed in multi-bed rooms during the outbreak. The viruses could expand not only with the infected staff or patients but also with the virus-contained air. To make an emergent ventilation measure plan, which the hospital requested, the actual performance of the air-conditioning and ventilation system and the ventilation characteristics were investigated using airflow volume meters, smoke testers, and a tracer gas CO2. The results of the measurements and the analysis showed the following. The ventilation rates had decreased to 30 % of the design value in the ward. The ventilation rate was decreased to 10 % in the treatment room where NHF was used, and the ventilation rates were decreased to 4–31 % in the rooms with six beds. The room doors were usually opened, and the opening had the effect of increasing the ventilation rate of the room. However, the virus-contained air could expand to the corridor and the other spaces. The air supply is stopped to keep room temperature at night, and the ventilation is thought to be very poor, especially if the doors are closed. Inadequate ventilation in the old buildings may have affected the hospital outbreak cases. It is essential to check the ventilation

characteristics regularly, especially in old buildings. The result contributed to the administrative notice “The Emergent Ventilation Measures to Control COVID-19 in Hospitals” in April 2021 in Japan.

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Hung, T.-Y., Yu, S.-H., Chen, Y.-C., Su, Y.-C., Chen, H.-L., Wu, B.-H.*, et al.*

Ventilation or Aerosol Extraction: Comparing the Efficacy of Directional Air Purifiers, HEPA Evacuators, and Negative Pressure Environments.

Journal of Hospital Infection, (2024)

This study evaluates aerosol exposure during various respiratory activities (breathing, tachypnea, coughing, and oxygen therapy) in environments with directional air purifiers (DAP), HEPA evacuators, and standard negative pressure (SNP) rooms to explore potential alternatives for addressing isolation room shortages.

Methods

Aerosol exposure was measured during various breathing conditions (normal, tachypnea, coughing, and recovery) with non-rebreather masks (NRM) and nasal cannulas (NC). The study analyzed aerosol velocity and concentrations at the head, trunk, and feet of a mannequin across settings including DAP, HEPA evacuator, SNP room, their combinations, and a reference group without intervention.

Results

The DAP, HEPA evacuator, and SNP environment all reduced aerosol build-up compared to the control group. The DAP and HEPA evacuator were consistently more effective than the SNP environment, especially during activities that increase expiratory flow. The HEPA evacuator showed higher aerosol concentrations at the head compared to the DAP when used with NRM or NC. Both the DAP and HEPA demonstrated better aerosol clearance than the SNP environment when minute ventilation exceeded 10 L/MIN.

Conclusion

DAP and HEPA evacuators provide effective aerosol reduction, suggesting their utility as alternatives to SNP isolation rooms during pandemics. While SNP environments continuously ventilate the space, DAP and HEPA evacuators are more efficient in early aerosol removal, preventing accumulation. However, aerosols dispersing in multiple directions during oxygen therapy can challenge the HEPA evacuator's single-point suction, unlike the broader coverage offered by the DAP.

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Lu, Y. H., Shi, X. R., Li, W. S., Lai, A. C. K.

Wavelength-specific inactivation mechanisms and efficacies of germicidal UVC for airborne human coronavirus.

Journal of Hazardous Materials, Vol. **484**, (2025)

Ultraviolet germicidal irradiation (UVGI) technology can inhibit the environmental transmission of airborne pathogens, but the dose-response behavior of airborne human coronavirus and wavelength-specific inactivation mechanisms are not well understood. This study investigated three competitive UVC sources for their inactivation efficacy and mechanisms against human coronavirus OC43 (HCoV-OC43). Results showed the following order of inactivation efficacy: 222-nm KrCl excimer lamp > 263-nm UV-LEDs > 254-nm low-pressure mercury lamp. The 222-nm KrCl excimer lamp achieved a 5-log inactivation of aerosolized HCoV-OC43 with a dose of less than 1 mJ/cm², while the 263-nm UV-LEDs had the highest genome damage rate constant at 7.08 ± 0.85 mJ/cm². Although 222-nm Far-UVC caused less genome damage, it affected viral proteins more significantly, specifically the nucleocapsid (N) and spike (S) proteins, which lead to compromising capsid integrity and binding ability to host cells. Capsid integrity RT-qPCR and

binding assay RT-qPCR used in this study could better monitor infectivity of airborne coronavirus than standard RT-qPCR. Additionally, significant lipid oxidation of HCoV-OC43 was observed under 222-nm irradiation, potentially impacting overall inactivation efficacy. This study provides detailed evidence on the effects of different UVC wavelengths on airborne HCoV-OC43, contributing to the optimization of UVC irradiation for indoor bioaerosol disinfection.

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