

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

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

1

Google Scholar, Lens et WoS

Sun, Y., Haghnazari, D., Huang, C.-Y., Baig, A., Kim, M., Cunningham, A., *et al.*

[Air Purifier Intervention for Respiratory Viral Exposure in Elementary Schools: A Secondary Analysis of a Randomized Clinical Trial.](#)

JAMA Network Open, Vol. 8 n°(10), (2025)

The magnitude of school respiratory virus exposure and the effectiveness of environmental mitigation measures remain unclear. To evaluate whether portable high-efficiency particulate air (HEPA) purifiers are associated with reduced respiratory virus exposure in elementary school classrooms, this ad hoc secondary analysis was performed between July 2023 and September 2024 and used data from a cluster-randomized, placebo-controlled trial (School Inner-City Asthma Intervention Study) of HEPA purifiers conducted from September 2015 to June 2020. A total of 200 classrooms from 39 public schools in Northeastern US were enrolled and randomized. Classrooms were randomized 1:1 to receive either active HEPA purifiers or visually identical sham HEPA units (4 per classroom). School staff and investigators were blinded to intervention assignments. The primary outcome was high viral exposure, identified by K-means clustering of individual viral concentrations. Secondary outcomes included viral diversity (defined as number of detected virus types) and individual viral concentrations. Week-long bioaerosol samples were collected 3 times during 1 school year, and concentrations of 19 respiratory viruses were quantified by digital droplet polymerase chain reaction. Of the 200 enrolled classrooms (91 in the sham purifier group and 109 in the HEPA purifier group) analyzed, the median (IQR) class size was 19 (18-20) and the median (IQR) grade was 3 (2-5). A total of 532 bioaerosol samples were collected; viruses were detected in 524 samples (98.5%), with a median (IQR) of 3 (2-5) viruses per classroom. Rhinovirus was most prevalent (476 [89.5%]), while respiratory syncytial virus A and B (66 [12.4%] and 127 [23.9%]) as well as influenza A and B (94 [17.7%] and 76 [14.3%]) were also detected. High viral exposure was present in 118 samples (22.2%). The HEPA purifier intervention was not associated with lower odds of high viral exposure (odds ratio [OR], 0.50; 95% CI, 0.08-3.25; $P = .46$) but did correspond to a modest reduction in viral diversity ($\beta = -1.02$; 95% CI, -1.68 to -0.35 ; $P = .003$). Elastic net regression identified relative humidity, grade, winter season, and coarse particulate matter as the environmental risk factors for viral exposure. In this secondary analysis, HEPA purifiers were not associated with a reduction in high viral exposure but were associated with a modest decrease in viral diversity. Multicomponent interventions may be needed to mitigate respiratory viral exposures in schools.

Roberts, B. M., Adzic, F., Hamilton-Smith, A., Iddon, C., Wild, O., Cook, M., *et al.*

[Air quality at mass gatherings: assessing ventilation and occupancy in marquees to evaluate airborne infection risk during the COVID-19 pandemic.](#)

Building and Environment, (2025)

The COVID-19 pandemic led to the cancellation of mass gathering events to slow the transmission of the SARS-CoV-2 virus, partially due to evidence that the virus can spread via airborne routes, especially in densely occupied, poorly ventilated spaces. Structures such as marquees (large tents), are commonly used at mass gathering events and were a frequently designated "outdoor safe space" during the COVID-19 pandemic. There is, however, scant evidence as to whether semi-outdoor buildings are sufficiently ventilated relative to the occupancy levels to reduce airborne transmission. As part of the largest study of mass gathering events to date, we measured ventilation and occupancy at 80 real events. We compared seven semi-outdoor spaces and one indoor space. Our results showed that most semi-outdoor buildings

were sufficiently ventilated relative to the occupancy (mean CO₂ <800 ppm). Short peaks in CO₂ concentration of up to 1,200 ppm indicated intermittent, but brief, periods of insufficient ventilation relative to the occupancy in some spaces. High occupant density, heterogeneous occupant distribution (crowding), and poor ventilation management strategies negatively influenced the indoor air quality. Event management strategies, such as intervals between events, improved air quality. We conclude that semi-outdoor buildings are not inherently low-risk with respect to long-range airborne pathogen transmission and so require careful consideration for the ventilation provision relative to the occupancy. The evidence presented, using the largest field study of its kind worldwide, provides key evidence to inform revisions to building regulations and pandemic preparedness plans concerning the use of semi-outdoor buildings.

Achar, J., Venter, R., Van Schalkwyk, J., Booie, Z., Mahlobo, Z., Palmer, Z., *et al.*

[Detection of aerosolized Mycobacterium tuberculosis DNA from adults being investigated for pulmonary tuberculosis using an electrostatic sampler in a South African primary care setting.](#)

Open Forum Infectious Diseases, (2025)

Non-sputum-based diagnosis of tuberculosis is a public health priority. Little is known about the feasibility of detecting Mycobacterium tuberculosis complex (Mtb) DNA in respiratory aerosols in primary care, its diagnostic value, and clinical and microbiological characteristics associated with detection. We recruited symptomatic adults self-presenting to South African primary care clinics with a sputum Xpert MTB/RIF Ultra (Ultra) result. Cough aerosols were collected on-site using TB Hotspot detectOR (THOR), a novel electrostatic aerosol sampler, and tested by Ultra. Environmental and laboratory controls were collected. Predictors of aerosol Mtb DNA (AMD) detection were assessed. Amongst 137 participants, 71 (52%) had medium or high and 34 (25%), had negative sputum Ultra semi-quantitative results. Compared to sputum Ultra detection, AMD detection sensitivity and specificity was 46.6% (95%CI: 42.5, 50.7) and 76.5% (95%CI: 70.4, 82.5) respectively. Sensitivity was higher in people with a sputum-Ultra semi-quantitation category of high (56.9%; 95%CI: 51.1, 62.7). Factors associated with AMD detection were male sex with sputum Ultra semi-quantitative result medium or greater (aRR 3.26; 95%CI: 1.11, 9.55; p=0.024) and reported fever (aRR 0.58; 95%CI: 0.29, 1.07; p=0.099). Sputum-to-aerosol ratios were ≥ 0.75 in three participants, suggesting a high capacity to expel Mtb DNA. Despite rigorous decontamination, AMD was detected from 30% of environmental samples highlighting THOR's potent sampling capability and potential nosocomial transmission risks. Electrostatic aerosol sampling is feasible in primary care to detect people with infectious tuberculosis. Deployment of this and other practical aerosol sampling tools might help to characterize predictors of tuberculosis transmission.

Sedighi, A. A., Nasiri, F., Haghighat, F.

[A framework for realistic estimation of indoor environments airborne infection risk: evaluating ASHRAE standard 241.](#)

Building and Environment, Vol. **287**, (2026)

This study critically evaluates common modeling assumptions in estimating respiratory infection transmission risk within indoor environments, using Computational Fluid Dynamics (CFD) simulations. It highlights the limitations of assuming a fixed number and predefined locations of infectious individuals. To address these limitations, the study introduces a computational method that integrates probability distributions with numerical simulation data, providing a more realistic assessment of infection risk. Using the proposed approach, this study introduces a novel method for estimating infection risk that accounts for dynamic variations driven by real-world epidemic conditions. By integrating epidemiological data, the approach quantifies how infection transmission risk changes significantly with societal infection prevalence, occupancy, and ventilation rate. Comparisons of the proposed model with ASHRAE Standard 241—based on a modified Wells-Riley model—highlight that the latter tends to overestimate infection risk, potentially leading to unnecessary increases in ventilation and energy consumption. The analysis further shows that

while both approaches converge under specific conditions (when the product of infection rate and population size is a whole number), only the proposed model reproduces the stepwise changes in risk that reflect realistic, discrete variations in the number of infectious individuals. Ultimately, this study underscores the importance of accurate assumptions and probabilistic modeling in CFD-based assessments of indoor infection transmission. The proposed framework provides a more robust and realistic basis for ventilation system design, balancing infection control effectiveness with energy efficiency.

Patel, J., Nunayon, S. S., Zhong, L.

[Improved method for UV lamps irradiance characterization and life-cycle assessment for in-duct microbial inactivation.](#)

Journal of Building Engineering, Vol. **114**, (2025)

Accurate characterization of ultraviolet (UV) irradiance is essential for the effective design and evaluation of in-duct air disinfection systems. This study aims to develop a novel angular correction factor to address sensor detection-angle limitations. Experimental irradiance measurements were conducted for 222 nm excimer lamp, 254 nm mercury lamp, 265 nm UVC LED and 365 nm UVA LEDs, and their environmental sensitivity was assessed under varying air temperature, velocity, and relative humidity. The comparative life-cycle assessment evaluated energy, costs, and environmental impacts for achieving a 3-log microbial reduction. Findings show that the correction factor reduced overestimation by up to 30 % near lamp surfaces, with a maximum error (18 %) observed farther from the 254 nm lamp. Model-based scalability from single LED modules to full arrays yielded an average relative error of ± 13 %, supporting flexible LED arrangements. The 254 nm lamp output increased by 18 % as air temperature rose (25–35 °C) and decreased nearly to 80 % as velocity increased (0.5–2 m/s). In contrast, the 222 nm lamp and both LED systems showed minimal sensitivity, indicating greater operational stability under dynamic conditions. While LEDs and 222 nm offer their own advantages, they require higher energy and cost to achieve equivalent disinfection. Therefore, under continuous in-duct application, the 254 nm lamp is the most sustainable and cost-effective option among those tested. This study provides a validated, building-scale framework that improves measurement accuracy and supports energy-aware implementation, offering actionable guidance for optimized, sustainable deployment of UVGI in building ventilation systems.

Farhan, S., Das, P., Shabab, S.

[IoT-Based Health Monitoring System for Real-Time Vital Signs and Hospital Room Conditions Tracking.](#)

2025 International Conference on Quantum Photonics, Artificial Intelligence, and Networking (QPAIN). 31 July-2 Aug. 2025. Rangpur, Bangladesh

This paper introduces the design and implementation of a scalable, cost-effective IoT system for the simultaneous monitoring of patient health and room environment, uniquely integrating dual monitoring in a single platform. At the system's core is an ESP32 microcontroller, which continuously tracks key biomedical parameters, including heart rate, oxygen saturation, body temperature, and ECG signals, alongside environmental conditions such as room temperature, humidity, carbon monoxide concentration, air quality, and potential fire hazards. A local web server, hosted on the ESP32, provides real-time, browser-accessible dashboards with automated data refreshes every six seconds, eliminating reliance on external cloud services. Intelligent control logic activates a fan for poor air quality and a humidifier for low humidity. A manual emergency alert button triggers a buzzer for urgent notifications. Data is logged to MS Excel, and ECG signals are analyzed in MATLAB. This system enhances continuous care and reduces the burden on healthcare personnel by unifying health and environmental monitoring with responsive automation and local hosting.

Vera, J., Schillaci, E., Amani, A., Morozova, N., Rigola, J.

Numerical Simulation of Contaminant Transport and Infection Probability in Public Transport Vehicles.

Indoor Air, Vol. **2025** n°(1), (2025)

In this work, a numerical set-up is built to perform transient numerical simulations of airflow quality, contaminant transport, and risk of infection within enclosed spaces. In particular, the case of an urban bus is proposed by studying the probability of infection from SARS CoV-2 during typical urban travel. Different air supply units are analyzed: an air-conditioning device with partial outside air recirculation and an air purification system with continuous indoor air purification and different air diffuser configurations. The infection probability is evaluated using an original methodology based on the Wells-Riley model. The generation and transport of airborne infections are considered by solving a quanta transport equation that uses empirical values for quanta exhalation and inhalation rates. The flow field is solved once using URANS models. Next, different target positions for infectious and target susceptible people are simulated to build a general infection probability matrix, allowing the quantification of the risk of contagion by running a set of affordable transient simulations. Air age and PM2.5 concentration are also employed to evaluate general air quality. The numerical model, experimentally validated in past works, is verified here using a mesh convergence analysis. Hence, the different air supply units and configurations are analyzed with the current methodology to quantify the risk of infection, showing a 13% risk reduction when introducing the air purification unit and a 23% reduction when using the same unit but with a more efficient grid configuration.

He, J., Liang, Q., Zhang, S., Yu, M., Xu, H., Cao, M., *et al.*

Quantitative evaluation of temperature and relative humidity effects on 222 nm UVGI air disinfection in a novel wind tunnel system.

Journal of Building Engineering, Vol. **114**, (2025)

Airborne transmission is a significant pathway for pathogen spread, making air disinfection crucial for preventing infectious diseases. Ultraviolet Germicidal Irradiation (UVGI) is widely recognized for air disinfection, and 222 nm UVGI has recently been shown to be safe for human exposure, making it a promising technology. However, the impact of temperature and relative humidity (RH) on 222 nm UVGI's efficacy remains underexplored. This study used a novel wind tunnel testing system and multi-point sampling to examine the effects of temperature and RH on 222 nm UVGI performance, comparing it to traditional 254 nm UVGI. The results revealed that temperature has minimal impact on disinfection efficacy, while RH significantly reduces its effectiveness. At 23 °C, the inactivation rate constants for *Serratia marcescens* were 35.60 cm²/mJ at 30 % RH and 36.81 cm²/mJ at 43 % RH. However, at 55 % and 68 % RH, these values dropped significantly to 9.03 cm²/mJ and 0.00 cm²/mJ, respectively. Furthermore, 222 nm UVGI outperformed 254 nm UVGI in disinfection efficacy. At 23 °C and 30 % RH, the inactivation rate constant for 254 nm UVGI was 15.00 cm²/mJ, much lower than the 35.60 cm²/mJ for 222 nm UVGI. These findings underscore the importance of temperature and RH in optimizing UV-based air disinfection.

Ullah, F., Olatunji, O., Qayyum, S., Tanveer, R.

Role of Ventilation and Spatial Designs in Airborne Disease Transmission Within Residential Aged-Care Facilities.

Designs, Vol. **9** n°(5), (2025)

The global aging population, particularly those aged 60 and above, is increasingly vulnerable to communicable diseases. Building ventilation (BV) plays a key role in residential aged-care (RAC) facilities, where COVID-19 has had a significant impact. This study systematically reviews the published literature to examine the influence of BV systems (BVSS) on airborne disease (COVID-19) transmission in RACs and recommends strategies to protect vulnerable residents. Using the PRISMA framework, articles published in the last decade were sourced from Scopus, Web of Science, and PubMed. Bibliometric analyses revealed

key research clusters on risk factors, transmission, facilities and services, and gender-based and retrospective studies. Australia, the USA, Africa, and the UK have made the most scholarly contributions to this field. Three main research areas emerged: BVS functionality, ventilation's role in COVID-19 transmission, and spatial building design for effective airflow. Findings reveal that inadequate ventilation and poor indoor air quality are major contributors to disease spread, further influenced by ventilation rate, airflow, temperature, humidity, and air distribution. A hybrid ventilation design that integrates natural and mechanical systems with technologies such as HEPA filters, UVGI, and HVAC is recommended in the current study. In addition, building form and layout should incorporate spatial, engineering, administrative, and hierarchical controls in line with sustainable ventilation design guidelines. This study adds to the growing body of knowledge on the roles of ventilation and design in infection control. It offers practical recommendations for architects, RAC managers, government agencies, and policymakers involved in designing and managing RACs to reduce the risk of communicable disease transmission.

Pan, Y., Liu, H., Deng, C., Li, Z., Chen, C.

[A sound-driven digital twin for reducing passengers' exposure to exhaled bioaerosols in an aircraft cabin.](#)

Building and Environment, Vol. **287**, (2026)

Airborne transmission of exhaled bioaerosols poses a significant health risk in enclosed environments such as aircraft cabins, where traditional steady-state and fixed ventilation systems often fail to respond effectively to bioaerosol exhalation events by index passengers. This study introduces a digital twin control system based on real-time sound recognition of coughs to dynamically mitigate passenger-to-passenger bioaerosol transport in an aircraft cabin mockup. The system utilized acoustic sensors distributed throughout the cabin to detect cough events, which were considered as one of the indicators for potential bioaerosol exhalation. Machine learning models were employed to classify and localize these events, serving as input signals for the digital twin framework. To respond to the detected coughs, the system accessed a precomputed database of ventilation strategies derived from computational fluid dynamics (CFD) simulations. These ventilation strategies adjusted the supply air velocity and direction locally to accelerate the removal of bioaerosols exhaled by the index passenger. Experimental validation was conducted in a full-scale seven-row aircraft cabin mockup. The results demonstrated that the sound-driven digital twin dynamic ventilation control system achieved over 80 % reduction in particle concentration in the passengers' breathing zones, without increasing the total ventilation rate or compromising thermal comfort. The proposed system represented a real-time and event-driven solution for effective infection control in aircraft cabin environments. Since the system does not distinguish between coughs produced by healthy and infected individuals, false-positive triggers of ventilation control are expected to occur in real applications. Future work should address this limitation by integrating multiple indicators.
