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Bao, J., Kosonen, R., Kilpeläinen, S., Hagström, K., Vasara, J.

## [Airborne infection risk between patients and healthcare staff under different air distribution strategies: A test chamber study.](#)

*Building and Environment*, Vol. **302**, (2026),

Healthcare-associated infections have increased across European hospitals in recent years, raising attention to indoor air quality in healthcare environments. This chamber study investigates strategies to reduce airborne infection risk between patients and healthcare staff in a simulated double-bed patient room by examining the effects of heat gain, airflow rate, air distribution, infector location, and curtain position. Three air distribution methods were evaluated: mixing ventilation (MV), occupant-targeted ventilation (OTV), and wall attachment ventilation (ATT). Virus-laden aerosols were simulated using sulfur hexafluoride (SF<sub>6</sub>) released from a thermal breathing manikin. When the infector was a patient, ATT maintained lower mean concentrations than MV at 40 L/s, whereas the performance of OTV was limited on the near-field side due to spatial constraints. The average contaminant removal effectiveness (CRE) with ATT on the infected side was 42.7% higher than that with MV at 17 W/m<sup>2</sup> and 80 L/s. However, ATT was sensitive to diffuser location, with the lowest CRE observed on the exposed side. When the infector was a staff member, notable concentration fluctuations were observed with ATT on the near-field side, whereas OTV significantly improved dilution effectiveness at 80 L/s. Increasing airflow from 40 L/s to 80 L/s reduced infection probability in the exposed area, with 8 of 12 tests achieving ≥50.0% reduction across the different ventilation configurations. Overall, the findings support the optimized selection of local air distribution systems for practical application and provide insights into improving microenvironmental safety in complex healthcare scenarios.

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Sanpablo, A. I. P., Lecona, D. a. G., Cedeno Laurent, J. G., Peñaloza, A. M., Fresnedo, J. Q.

## [Airborne Risk Stratification in Clinical Spaces via Environmental Modelling and Multivariate Statistics.](#)

XLVIII Mexican Conference on Biomedical Engineering

This study aimed to estimate the risk of airborne SARS-CoV-2 transmission across 44 indoor clinical spaces in a rehabilitation hospital using environmental modeling and multivariate statistics. High-resolution CO<sub>2</sub> measurements, occupancy, and ventilation data were collected, and the Gammaitoni–Nucci model was used to compute individual transmission risk estimates. Six indoor air quality (IAQ) variables were measured: room volume, occupancy, CO<sub>2</sub> concentration, time with CO<sub>2</sub> > 1000 ppm, ventilation, and air replacement time. Among 36 valid observations, the mean CO<sub>2</sub> concentration was 1012.4 ppm (SD = 313.7), the average ventilation rate was 4.4 ACH, and the estimated transmission risk was 28.3% (SD = 18.9). Principal Component Analysis (PCA) revealed that two components explained 68.8% of total variance: PC1 captured ventilation efficiency (high ACH), while PC2 reflected occupancy density and elevated CO<sub>2</sub> levels. Hierarchical clustering identified three distinct IAQ profiles: Cluster 1 (high occupancy, high CO<sub>2</sub>, moderate ventilation), Cluster 2 (low occupancy, poor ventilation, highest risk), and Cluster 3 (high ACH, low CO<sub>2</sub>, low exposure). While traditional service-based comparisons showed no differences, cluster-based analysis revealed significant variations in CO<sub>2</sub> (p < 0.01), ACH (p < 0.01), occupancy (p < 0.01), and transmission risk (p = 0.01). Multiple linear regression identified ACH as the only significant

predictor of airborne risk ( $\beta = -1.25$ ,  $p = 0.01$ ), resulting in a 1.25 percentage point reduction in risk per ACH unit. These findings support the use of IAQ-based clustering as a practical framework for identifying the risk of airborne transmission. Recommendations include maintaining  $ACH \geq 3$  and prioritizing  $CO_2$  monitoring in high-turnover rooms.

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Porporato, D., Luceri, A., Feyles, E., Lembo, D., Donalizio, M., Coto, B., *et al.*

**[Antibacterial and antiviral activities of SiO<sub>2</sub>-Ag and ZrO<sub>2</sub>-Ag nanocomposite coatings deposited on polymeric air filters.](#)**

*Ceram Int*, Vol. **52** n°(14, Part B), (2026), 25286-25296 p.

Acute respiratory infections are the most common cause of acute illness globally and have a severe impact on human health and productivity. There is robust evidence of airborne transmission of many respiratory viruses via direct or indirect contact with droplets and aerosol produced by infected individuals, and this transmission route becomes crucial in crowded indoor spaces. Heating, ventilating and air conditioning (HVAC) systems filters can reduce the concentration of virus-carrying droplets, but HVAC systems able to directly inactivate bacteria and viruses are highly desirable to preserve safe indoor air. The aim of the present work was to assess the antibacterial and antiviral properties of silver nanoclusters/silica or zirconia composite coatings deposited onto polymeric air filters against *Staphylococcus epidermidis*, *Staphylococcus aureus* and a panel of representative members of human respiratory viruses, such as human coronavirus OC43 (HCoV-OC43), human rhinovirus A1 (HRV-A1), influenza virus type A (IFVA-H3N2) and adenovirus type -5 (AdV-5) according to standard protocols ISO. Results evidenced that both coatings showed a significant antimicrobial and antiviral activity at variable extent and a good cytocompatibility on all the examined cell lines, demonstrating a broad-spectrum action against selected bacteria and respiratory viruses.

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Bang, J.-I., Sung, M.

**[Disinfection effectiveness of UR-UVGI for airborne bacteria based on equivalent air change rate in a multi-bed patient room.](#)**

12th International Conference on Indoor Air Quality, Ventilation & Energy Conservation in Buildings (IAQVEC 2026)

The prevention of airborne infectious disease transmission in indoor spaces is closely linked to maintaining healthy environments and indoor air quality (IAQ) for occupants. In particular, multi-bed hospital rooms require special attention, as they present higher risks of cross-contamination through bioaerosol dispersion. Ultraviolet Germicidal Irradiation (UVGI) has been recognized as an effective method for microbial inactivation, and its application in healthcare settings offers potential for both infection control and IAQ management. This study evaluates the disinfection performance of Upper-Room UVGI systems in a four-bed patient room mock-up. Bioaerosols were released from a 6-jet nebulizer at one bed to simulate a localized source. Airborne bacteria were sampled at three other beds (representing patient breathing zones) and at the end-terminal of the air handling unit (AHU). Experiments were conducted under 2 and 6  $h^{-1}$ , and three UR-UVGI operational conditions (off, one system on, two systems on). To quantify the UR-UVGI performance, the equivalent air change rate (eACH) was calculated based on the decay of airborne bacterial concentrations over time. In the AHU end-terminal, the eACH under UV off conditions was found to be higher than the set ventilation rate, with values of 7.58  $h^{-1}$  (set 6  $h^{-1}$ ) and 4.85  $h^{-1}$  (set 2  $h^{-1}$ ). UR-UVGI operation increased eACH by approximately 1  $h^{-1}$  at the AHU. In the patient room, UR-UVGI operation led to more significant eACH increases. For the 6  $h^{-1}$  condition, eACH rose from 6.3  $h^{-1}$  (UV off) to 8.6-9.0  $h^{-1}$  (UV on), and for the 2  $h^{-1}$  condition, from 3.7  $h^{-1}$  to 5.4-5.5  $h^{-1}$ . These results confirm the disinfection effect of UR-UVGI within the room; however, discrepancies at the AHU terminal suggest potential influences from surface deposition and duct-related losses. Additionally, variations in eACH were observed depending on the sampling and UR-UVGI locations, suggesting that airflow distribution and

environmental factors should be considered. This highlights the need to assess local ventilation and infection risks near each patient. This study suggests that eACH estimation based on airborne bacterial decay is a valid method for evaluating UR-UVGI effectiveness and can be improved further by accounting for bioaerosol behavior and airflow characteristics.

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Mosleh, R., Shafadeh, M., Majeed, B., Arino, J., Ghasemi, A., Thommes, E. W., *et al.*

**[Dynamics of infectious disease spread between transportation hubs and surrounding communities.](#)**

Infected Disease Modelling, Vol. 11 n°(4), (2026), 1517-1535 p.

Urban transit systems, particularly those in major metropolitan areas, are becoming increasingly interconnected, making it essential to better understand passenger mobility and its implications for the spread of infectious diseases. Respiratory infectious diseases, including COVID-19 (as a case study), can spread rapidly in densely populated urban environments, particularly within public transportation systems. This study investigates the dynamics of infection spread at a subway station, and its surrounding community, focusing on both short-term and long-term transmission. Using two deterministic ordinary differential equation (ODE) models, we simulate disease transmission over a single business day and examine how daily encounters impact infection numbers over the subsequent three months. The short-term model captures localized interactions between transit passengers and community residents, while the long-term model evaluates the cumulative impact of these encounters on community infections. Parameter estimation was performed using ridership data and the least squares method. Results suggest that mobility-related factors, particularly inflow and outflow rates, have a greater impact on controlling disease spread than transmission rates in both short- and long-term dynamics. Reducing inflow eases congestion and lowers encounters in the hub but increases encounters in the community, whereas reducing outflow increases crowding in the hub while decreasing encounters in the community. Joint reductions in inflow and outflow decrease encounters in both settings. In the long term, changes in transmission rates have only a limited effect on peak infections, while reducing outflow notably decreases infections and reducing inflow slightly increases community infections. Overall, simultaneously reducing inflow and outflow is the most effective strategy for limiting encounters in the short term and infections in the long term.

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Li, Y., Ma, N., Wiedensohler, A., Guo, L., Zhang, C., Zhu, S., *et al.*

**[Effective density of exhaled submicron particles and its impacts on particle indoor airborne transmission.](#)**

Journal of Aerosol Science, Vol. 197, (2026)

Exhaled particles released through human respiratory activities are the main carriers of respiratory pathogens. Among them, smaller aerosol-mode particles with prolonged lifetime play a dominant role in the indoor airborne transmission of respiratory diseases. Morphology of exhaled particles may vary substantially under different drying conditions, further influencing their deposition behavior. However, the impact of the morphology of exhaled particles on their indoor deposition and residence time remains underexplored. As an easily measurable physical parameter, effective density ( $\rho_{eff}$ ) can reflect the morphological characteristics of particles. This work characterized the  $\rho_{eff}$  of exhaled submicron particles generated from artificial saliva (Saliva), lung fluid (Lung), and severe pneumonia lung fluid (Slung). Although  $\rho_{eff}$  of all the three types of particles decreased with increasing particle size, the effects of drying conditions on  $\rho_{eff}$  differed among them. Slung particles exhibited the highest sensitivity of  $\rho_{eff}$  to drying rate, implying pronounced morphology transformations under the studied drying conditions. Incorporating the measured  $\rho_{eff}$  into an indoor deposition model, we found that the volume remaining fraction of exhaled particles was affected by particle morphology and declined markedly over time. The indoor residence time for porous particles emitted from a healthy individual and a pneumonia patient was 4.9 and 5.8 h longer than that for compact particles, respectively. Our findings suggest that particle morphology may influence indoor fate and transmission risk of exhaled particles, underscoring that incorporating the morphology-

induced changes in particle deposition is essential for accurately predicting and modeling the indoor transmission of respiratory diseases.

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Fu, Z., Liu, Q., Shuang, M., Li, J., Wang, Q., Liu, H., *et al.*

### [Evaluation of disinfection efficiency of new high oxygen membrane air disinfecting machine in hospital ward environment.](#)

Scientific Reports, (2026)

To investigate the air disinfection efficacy of a novel high-oxygen membrane air sterilizer in hospital ward environments. Natural bacteria were used as indicator microorganisms, and air disinfection experiments were conducted under both unoccupied and occupied ward conditions to compare the actual disinfection performance between a high-oxygen membrane air sterilizer and a plasma air sterilizer. The relationship between disinfection efficacy and factors such as ward volume, temperature, humidity, initial bacterial load, and personnel movement was analyzed. Under unoccupied conditions, the natural bacterial extinction rate of the high-oxygen membrane air disinfecting machine was 88.4%, significantly higher than the 82.5% of the plasma air disinfecting machine ( $P = 0.019$ ). However, under occupied conditions, there was no statistically significant difference in extinction rates between the two devices (80.0% vs. 78.7%,  $P = 0.165$ ). Additionally, the disinfection efficacy of the high-oxygen membrane air disinfecting machine was not statistically affected by ward volume, temperature, humidity, initial bacterial concentration, or personnel activity (all  $P > 0.05$ ) within the present experimental settings. Although high-oxygen membrane air disinfection technology demonstrates statistically superior disinfection performance in unoccupied environments, the observed efficacy does not currently support its use as a standalone intervention for reducing the airborne infection transmission. Further research in diverse clinical environments is needed to fully assess its potential.

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Singararaj, K., Lawrance, A., Balaji, S., Rajan, H.

### [Impact of hybrid ventilation strategies on mitigating aerosolized respiratory droplet dispersion in kitchen environments.](#)

Scientific Reports, Vol. 16 n°(1), (2026)

The rapid airborne spread of SARS-CoV-2 in food preparation environments highlights the importance of effective ventilation design in kitchens, where confined layouts and multiple emission sources may increase the risk of aerosol exposure. Motivated by this challenge, the present study investigates the dispersion behaviour of cough-generated aerosols and examines the potential influence of hybrid ventilation strategies combining inlet jets, chimney exhaust, and an air curtain. The objective is to investigate the influence of source placement, inlet velocity, and multi-source emissions on aerosol transport patterns within an enclosed kitchen environment. An Eulerian–Lagrangian computational framework was employed to simulate four source configurations together with a dual-source case under mechanically ventilated conditions. The results indicate that source positioning plays a significant role in determining aerosol transport behaviour. The predicted infection risk reached approximately 68% for the dual-source configuration but decreased to about 18% when the emission source was located near the chimney exhaust, and further reduced to approximately 7% with increased inlet velocity. Higher ventilation velocity promoted faster plume removal, with chimney-proximal sources exhibiting more than 97% reduction in mean aerosol velocity. In contrast, offset source configurations resulted in weaker entrainment and prolonged particle suspension. Smaller droplets (10  $\mu\text{m}$ ) were rapidly removed by the ventilation flow, whereas larger droplets (50  $\mu\text{m}$ ) exhibited temporary recirculation before evacuation. These findings provide insight into the relative influence of ventilation configuration and source placement on aerosol transport in kitchen environments. The results should be interpreted within the scope of the simplified modelling framework adopted in the study, but they offer useful guidance for improving ventilation design strategies aimed at reducing airborne exposure in high-occupancy kitchen settings.

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Keerthana, G., M, K., M, T. V., Athul, N., Shalitha.

### **IoT-Enabled Smart Microclimate Control Robot for Sensitive Environments with Real-Time Sensor Monitoring.**

2026 6th International Conference on Pervasive Computing and Social Networking (ICPCSN)

Sensitive areas such as hospitals, neonatal care, elderly care, and laboratories demand precise control over the environment. Conventional HVAC systems control the micro-environment of the entire room. However, this approach results in high power consumption, delayed response, and the inability to control the micro-environment. This paper introduces an autonomous Micro Climate Control Robot that can monitor the micro-environment of the 1.5–2 m radius of the concerned individual. The robot uses multi-modal sensing for micro-environmental control. An ESP32 microcontroller with FreeRTOS is used for real-time control. Moreover, the robot uses a rule-based PID control strategy for micro-environmental control. Simulation results show that the robot improves micro-environmental control, reduces power consumption, and responds quickly to environmental changes. The robot provides an innovative solution for precision air quality management and helps to make it a personalized one which will ensure personalized environment for a particular individual.

Results: Legionella spp. was detected in air conditioning devices of 8 (21%) facilities. No relation was established between knowledge, external education and management with bacterial colonization. Internal training of employees is carried out in three (37.5%) facilities compared to eight facilities in which bacteria were detected ( $p < 0.05$ ). Also, bacteria detected in 4 (40%) facilities where employee absenteeism was associated with respiratory diseases ( $p < 0.05$ ).

Conclusion: The results emphasize the need for a systemic approach to risk management and the improvement of practices that contribute to safer stay of users and employees in the air-conditioned spaces of public facilities in the Sarajevo Canton.

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Pujar, A. S., D. K, S. M.

### **A Low-Cost VOC-Based Electronic Nose System for Real-Time Bacterial Air Quality Assessment.**

2026 International Conference on Recent Advancement in Electrical, Computer and Communication Technologies (IECCT)

Indoor air quality significantly influences human health, especially within enclosed spaces where airborne microorganisms contribute to respiratory illness and infection transmission. Conventional laboratory-based detection techniques require extended turnaround times and specialized infrastructure, rendering them impractical for continuous surveillance. This paper introduces a low-cost, real-time electronic nose (e-nose) platform combining volatile organic compound (VOC) sensing with a hybrid ensemble machine learning framework for indirect microbial risk estimation. The system integrates an ESP32 microcontroller with a Sensirion SGP40 MOX-based VOC sensor and environmental compensation sensors. A heterogeneous ensemble classifier fusing Random Forest, Gradient Boosting, Support Vector Machine, and Multi-Layer Perceptron through soft voting achieves 97.72% classification accuracy across four pathogen categories. Evaluation using Cohen's Kappa ( $\kappa = 0.969$ ), Matthews Correlation Coefficient ( $MCC = 0.969$ ), and macro-averaged AUC (0.993) confirms robust multi-class discrimination. Validation across 15,766+ samples substantiates the system's effectiveness as an early-warning mechanism for indoor microbial contamination at a hardware cost under \$25.

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Takii, A., Ikeda, T., Yamakawa, M., Chung, Y. M., Kim, M.

### **Modeling and prediction of airborne infection risk in offices: A comprehensive CFD study and machine learning surrogate approach.**

Results in Engineering, Vol. **30**, (2026)

Airborne transmission of respiratory viruses in office environments remains a critical public health concern. This study aims to quantify how office layout, A/C flow rate, and ventilation influence cough droplet dispersion and infection risk, and to develop a geometry-native surrogate model for rapid risk prediction. Using the supercomputer Fugaku, we conducted 896 simulations combining 32 diverse office layouts with 28 air conditioning and ventilation conditions. A Risk of Infection (RoI) index was defined based on the time-averaged quantity of cough-generated droplets suspended in the inhalation zone. The results revealed that seating arrangements significantly influence exposure risk; wall-facing seats generally exhibited lower and more stable RoI, whereas seats directly under air conditioning outlets showed high volatility depending on airflow settings. To enable rapid risk assessment without computationally expensive CFD, we developed a surrogate model using machine learning. Among ten regression algorithms compared, PointNet, which directly learns from 3D layout geometry, achieved the highest accuracy for the specific configurations investigated in this study. While the superiority of PointNet is demonstrated for this office-based dataset, its broader generalizability remains a target for future multi-facility verification.

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Huang, B. R., Ibrahim, F., Shariffuddin, I. I., Ibrahim, P. a. S., Chang, L.-Y., Joseph, K., *et al.*

[\*\*A Portable, Foldable Negative-Pressure Aerosol-Containment System \(FNPACS\) for Aerosol Control During Aerosol-Generating Procedures.\*\*](#)

Bioengineering, Vol. **13** n°(6), (2026)

Aerosol-generating procedures (AGPs) expose healthcare personnel to airborne pathogens and require portable engineering controls that can be integrated into routine clinical workflows. We developed a portable, foldable negative-pressure aerosol-containment system (FNPACS) combining adaptive fan control, an H14 high-efficiency particulate air (HEPA) filter, and a disposable metal-oxide prefilter in a mobile filtration module. Bench performance was evaluated using pressure-flow testing in accordance with National Environmental Balancing Bureau (NEBB) procedures and International Organization for Standardization (ISO) 14644-3, polyalphaolefin aerosol challenge testing, and smoke visualization, while an exploratory clinical study assessed environmental contamination via real-time reverse-transcription PCR (rRT-PCR) in 11 patients (31 assay analyses). Bench testing demonstrated HEPA filtration efficiencies of 99.994–99.997%, stable negative-pressure generation across fan duty cycles, no detectable downstream breakthrough beyond the HEPA filter under the tested conditions, and effective inward airflow on smoke testing. A Lagrangian discrete phase model (DPM) particle-tracking simulation further characterized size-dependent aerosol-surrogate transport. Under HEPA-ON active-extraction conditions, 73.0–86.1% of simulated 0.3–10  $\mu\text{m}$  water-equivalent particles were transported to the HEPA suction pathway, while 13.9–27.0% were deposited on internal wall surfaces. In the clinical evaluation, SARS-CoV-2 RNA detection on environmental swabs was limited and predominantly low level. The clearest reproducible signal occurred on the top interior surface under HEPA-OFF conditions, whereas HEPA-ON detections were isolated or presumptive high-Ct signals without reproducible confirmation. These findings provide preliminary engineering and usability support for FNPACS as a feasible near-source aerosol-control platform for AGPs. The patient swab component should be interpreted as an exploratory, proof-of-concept assessment rather than confirmatory evidence of clinical containment efficiency because several clinical cases had non-supportive patient-related controls and were therefore not used in the primary containment interpretation.

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Liping, C., Shaodan, L., Yongchen, P., Liang, H., Jiayan, C., Lian, X., *et al.*

[\*\*Three new terpenes with potential antibacterial and anti-COVID-19 activities from the stems of \*Eurya chinensis\* R. Br.\*\*](#)

Natural Product Research, Vol. **40** n°(8), (2026), 2054-2062 p.

The extract of the stems of *Eurya chinensis* R. Br. yielded three new terpenes (1?3) including two diterpenes and one triterpene, named euryachins C?E, as well as three known diterpenes (4?6). The

structures of these novel compounds were elucidated via spectroscopic analysis, especially IR, NMR spectroscopy and HRESIMS data. Besides, all the isolated compounds were evaluated for antibacterial activity against *Escherichia coli*, *Bacillus cereus*, *Staphylococcus aureus* and Methicillin-resistant *S. aureus* (MRSA). Additionally, the inhibitive activity of the isolated compounds against COVID-19 was studied in vitro. As a result, compounds 1-6 were endowed with profound antibacterial activity. Especially, the MIC values of compounds 3 and 5 both were 0.78 µg/mL, the same antibacterial activity as Vancomycin. In the anti-COVID-19 assay, the IC<sub>50</sub> values of compounds 3-5 were ranging from 4 to 8 µM, which were equivalent to the positive control.

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