Bulletin de veille émissions d'aérosols par l'appareil respiratoire humain N° 36 – Novembre 2026

Objectifs : veille scientifique sur les émissions d'aérosols (gaz et particules) par l'appareil respiratoire humain (nez/bouche).

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 fournis sans garantie d'exhaustivité.

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Fouad M, Rizk M, Alhajry A, Abdelmoez M.

Multi-Scale Computational Fluid Dynamics Investigation of Ventilation-Controlled and Gravity-Controlled Respiratory Aerosol Transport in an Office Environment: Implications for Heating, Ventilation, and Air Conditioning Design and Airborne Infection Mitigation.

Buildings-Basel. 2026;16(21):42.

https://doi.org/10.3390/buildings16214297

This study presents a comprehensive transient Computational Fluid Dynamics-Discrete Phase Model (CFD-DPM) investigation of aerosol and droplet transport in an air-conditioned office containing one infected occupant and three susceptible occupants. The transition from ventilation-controlled to gravity-dominated transport of respiratory aerosols in office settings remains poorly characterized. Continuous emission over 300 s was simulated for particle diameters of 1, 5, 10, and 50 µm. The continuous airflow field was resolved using the pressure-based solver, energy equation, and Shear Stress Transport k-omega turbulence model, validated against experimental temperature and relative humidity data with mean absolute errors of 0.59 degrees C and 1.26% relative humidity, respectively. The airflow model was validated against temperature and relative humidity data only; the discrete-phase predictions were not validated directly against experimental aerosol data. A critical finding is the identification of three distinct transport regimes: Regime I (1-5 µm), characterized by ventilation-dominated behavior with strong airflow coupling, approximately 50% outlet removal, and 38-39% airborne fraction at 300 s; Regime II (10 µm), representing a mixed-transition zone where gravitational effects begin to compete with aerodynamic forces; and Regime III (50 µm), dominated by gravitational settling with 93% deposition and only 1.6% outlet removal at 300 s. The critical transition diameter between ventilation-controlled and gravity-dominated transport was estimated to be approximately 20-30 µm based on interpolation between the 10 µm and

50 & micro;m cases and dimensionless analysis; this estimate requires further validation with intermediate particle sizes. Dimensionless analysis revealed that particles with Stokes numbers below 0.1 remain strongly coupled to the airflow, while those exceeding 1.0 exhibit ballistic trajectories dominated by inertia and gravity. Outlet-2 consistently served as the dominant removal path for all particle sizes, confirming an asymmetric ventilation transport route attributable to the supply jet trajectory and recirculation patterns. Human 2 received the highest body-deposition fraction for aerosol-sized particles (0.287% for 1 & micro;m, 0.123% for 5 and 10 & micro;m at 300 s), identifying this location as a critical exposure zone. For 50 & micro;m droplets, susceptible occupant deposition was negligible (<0.0005%) because gravitational settling deposited most mass on the floor (64.1%) and the infected occupant (25.5%) before far-field transport occurred. These findings establish a quantitative framework for designing ventilation systems that optimize removal of aerosol-sized particles while recognizing the inherent limitations of air extraction for droplet control. The proposed transport-regime classification provides a framework for HVAC engineers, with recommendations for return grille placement, air change rates, and supplementary source-zone controls for large droplets. These recommendations are derived from a single office geometry and ventilation configuration and should be validated across different room layouts, ventilation strategies, and operating conditions before being generalized. The methodology and findings contribute to the growing body of knowledge on airborne infection risk mitigation in occupied spaces, with direct applicability to post-pandemic building design and operation.

Hatif I, Wong K, Tan H, Kek H.

Effects of breathing pathway and phase difference on short-range airborne exposure in a ventilated indoor environment.

Indoor Built Environ. 2026:19.

https://doi.org/10.1177/1420326X261504228

Short-range airborne exposure in indoor environments is strongly influenced by the transient interaction between exhaled and inhaled respiratory flows. This study investigated how breathing pathway (mouth or nose) and inter-individual phase difference affect near-field contaminant transport between two occupants in a ventilated indoor space. A transient CFD model with physiologically realistic sinusoidal breathing boundary conditions was developed to simulate six face-to-face interaction scenarios at a separation distance of 0.75 m. The model was validated against benchmark experimental data for respiratory airflow and tracer-gas dispersion in a displacement-ventilated room. The results showed that synchronized mouth-to-mouth interaction produced the highest contaminant transfer, inhaled dose, and predicted infection risk. By contrast, phase offset, nasal pathways, and opposing jet interaction substantially reduced short-range exposure by weakening direct transport to the target breathing zone. Across the simulated cases, the predicted infection probability decreased by up to 87% relative to the worst-case condition. Overall, the findings show that short-range airborne exposure depends not only on distance, but also on breathing timing and pathway alignment within the indoor breathing microenvironment.

Norvihoho L, Xu Z, Mubashir M, Zhou Z, Guo H.

Numerical investigation of evaporation and hygroscopic equilibrium in multicomponent respiratory droplet surrogates under winter indoor conditions.

Int Commun Heat Mass Transf. 2026;180:12.

https://www.sciencedirect.com/science/article/abs/pii/S0735193326024486?via%3Dihub

Accurate characterization of respiratory droplet evaporation microphysics is critical for assessing indoor airborne transmission risk of seasonal respiratory pathogens, especially in dry heated winter environments. This study numerically investigates evaporation dynamics of four compositionally distinct respiratory fluid surrogates under controlled winter indoor conditions, using large eddy simulation coupled with a multicomponent discrete phase model (DPM). A single 100 mu m droplet is held in stationary levitation to isolate mass-transfer effects from transport and sedimentation. Simulations vary ambient relative humidity (20-60%), temperature (293-303 K), and background airflow (0-0.2 m/s) across pure water, 0.9% isotonic saline, saliva-like, and glycerol-enhanced lower-respiratory-tract surrogates. Analysis of variance confirms relative humidity dominates drying kinetics, accounting for 73.3% of total variance in t95 (time to 95% diameter reduction), followed by ambient temperature at 18.5%. Surrogate composition and weak airflow contribute only 2.2% and 3.2% of variance, respectively; airflow is not statistically significant at the 95% confidence level. Final residual nucleus diameter is determined solely by initial non-volatile solute content and is invariant across all tested conditions, with ratios ranging from 0.196 for saline to 0.363 for glycerol-enhanced mucus. Evaporative cooling reduces surface temperature by 21-25 K at 293 K for all surrogates; solute-laden droplets rewarm to ambient after drying, while pure water droplets remain at wet-bulb temperature. These findings provide a systematic microphysical basis for improving indoor respiratory aerosol transmission models.

Sobhani H, Vanama G, Zhu S, Lai J, Coleman K, Milton D, et al.

Evaluating Individual Infection Risk: The Interplay between Air Mixing Intensities and Occupant Dynamics.

Environ Sci Technol. 2026;60(45):32677–91.

https://doi.org/10.1021/acs.est.6c06663

Aerosol transmission remains a critical route for the spread of respiratory infectious diseases, yet real-time exposure mapping in complex public spaces is computationally demanding. This study presents a robust and adaptable framework for estimating dynamic individual exposure (i.e., viral dose) by integrating high-fidelity computational fluid dynamics (CFD) with computer vision (CV) analysis. By overlaying validated steady-state viral aerosol plumes onto dynamic human interaction data, we evaluated the interplay between airflow patterns and human behaviors under two distinct air change rates (ACH: 25 h(-1) and 3 h(-1)). Each scenario was simulated both with and without MERV-13 filtration. Applications in both a stochastic-movement hotel meeting room and a stationary-occupant office demonstrate that while high turbulence due to high ACH limits the spatial extent of plumes, sustained close proximity in structured settings can result in disproportionately high viral doses for specific individuals. MERV-13 filtration effectively reduced exposure within high-concentration zones. We propose a Reynolds number (Re)-based modeling guideline: steady-state CFD-CV for moderate mixing (900 <= Re <= 2300), a well-mixed assumption for high mixing (Re > 2300), and transient CFD-CV for low mixing (500 <= Re < 900) during breathing and speaking, and steady-state CFD-CV for coughing and sneezing regardless of Re value. This framework supports real-time monitoring and targeted interventions, providing a data-driven foundation for indoor occupant safety.