Bulletin de veille émissions d'aérosols par l'appareil respiratoire humain N° 13 – Octobre 2024

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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Al-Rikabi IJ, Alsaad H, Carrigan S, Voelker C.

Human exposure to respiratory aerosols: Impact of ventilation rates, mixing ventilation configuration, and breathing patterns.

Journal of Building Engineering. 2024;97:110837.

https://www.sciencedirect.com/science/article/pii/S2352710224024057

https://www.sciencedirect.com/science/article/pii/S2352710224024057?via%3Dihub

This study investigates airborne transmission dynamics between occupants in office rooms equipped with mixing ventilation (MV). The primary aim was to assess how different ventilation configurations, air change rates (ACH), breathing patterns, and supply air temperatures influence cross-exposure and infection risks. The experimental setup involved two thermal manikins simulating an infected and an exposed occupant within a climate chamber. The investigated parameters included four ACH levels (1.2, 2, 4 and 6.6 $h^{-}1$, representing four EN 16798–1 ventilation categories), two MV configurations (near-ceiling and near-floor inlets), two breathing patterns (nose and mouth breathing), and two supply air temperatures (19 °C and 21 °C). Carbon dioxide (CO_2) was used as a tracer gas to simulate exhaled aerosols, enabling precise measurements of effectiveness (εv), intake fraction (IF), and infection probability (P). The findings indicate that higher ACH do not uniformly improve εv but are linked to reduced cross-exposure risk. The near-floor inlet MV configuration significantly outperformed the near-ceiling configuration in reducing IF and P by 15–41 % under most investigated scenarios. Additionally, mouth breathing increased IF and P compared to nose breathing, especially at higher ACH (2, 4, and 6.6 $h^{-}1$). The results also showed that lower supply temperatures do not always correlate with higher IF and P, as MV configuration and breathing patterns significantly influence outcomes. This research

provides insights into optimizing ventilation strategies for safer indoor environments, emphasizing the importance of airflow dynamics, breathing patterns, and supply temperature in ventilation design.

Ishii K, Ohno Y, Oikawa M, Onishi N.

Experimental Understanding of the Flow Dynamics of Exhaled Air to Prevent Infection through Aerosol.

In: Shiozawa T, Hirata H, Inoue T, Kanikowska D, Takada H, editors. Gerontology as an Interdisciplinary Science. Singapore: Springer Nature Singapore; 2024. p. 249-62.

https://doi.org/10.1007/978-981-97-2712-4_18

https://link.springer.com/chapter/10.1007/978-981-97-2712-4_18

Since several mass infections of COVID-19 have been reported in dense and enclosed environments, research efforts have been focused on aerosol transmission, which is a major mode of infection. Although the literature has traditionally focused on coughing and sneezing, it has become evident that avoiding exposure to the exhaled aerosols of asymptomatic infected persons is important for preventing infection. However, limited experimental cases have investigated ordinary exhaled air in real-world settings. Therefore, the authors of this study visualize the flow of exhaled aerosols with and without masks and face shields by simulating customer service in a beauty salon. Since the particle shape of the exhaled aerosol, which is problematic for infection, is similar to that of the particles released by e-cigarettes, light from a laser source scattered by e-cigarette smoke was captured by a camera. The results suggest that exhaled air flows according to certain rules under the influence of the temperature boundary layer on the human body surface. Therefore, it is evident that masks and face shields control the flow of exhaled air in such scenarios.

Li KJ, Li RB, Xiao LJ, Feng L, Mu D, Shi X, Gao NP.

Risk assessment of cough droplets in both static and dynamic indoor environments with different ventilation strategies.

Build Environ. 2024;266:21.

https://www.sciencedirect.com/science/article/pii/S0360132324009818?via%3Dihub

In real-life scenarios, occupants typically alternate between sitting and walking in a room. The wake induced by human movement affects the local airflow, enhances local mixing effects, and increases airborne propagation laterally and across long distances. This study aimed to provide a comprehensive comparison of the impact of human movement on the dispersion of coughed droplets in an office under four ventilation strategies (i.e. Mixed Ventilation (MV), Displacement Ventilation (DV), Stratum Ventilation (SV) and Stratum Displacement Ventilation (SDV)). The improved Wells-Riley model was used to calculate the risk of infection for susceptible individuals in both static and dynamic indoor environments under different ventilation strategies. The results showed that different ventilation strategies, as well as the presence or absence of human movement, significantly affected the diffusion of droplets. When there was no human movement or human movement occurred close to the air supply, the risk of infection for susceptible individuals was lowest under SDV, 5.03 x 10-6 and 21.44 x 10-6, respectively. The risk of infection for susceptible individuals during the infection stage was almost linearly related to exposure time when human beings moved away from the air supply, and all four ventilation methods presented a high risk of infection. The SDV has the best performance, followed by

DV, SV, and finally MV for reducing the risk of indoor cross infection. These results can provide a reference for epidemic control in both static and dynamic indoor environments.

Nagy A, Czitrovszky A, Lehoczki A, Farkas Á, Füri P, Osán J, et al.

Creating respiratory pathogen-free environments in healthcare and nursing-care settings: a comprehensive review.

Geroscience. 2024.

https://link.springer.com/content/pdf/10.1007/s11357-024-01379-7.pdf

Hospital- and nursing-care-acquired infections are a growing problem worldwide, especially during epidemics, posing a significant threat to older adults in geriatric settings. Intense research during the COVID-19 pandemic highlighted the prominent role of aerosol transmission of pathogens. Aerosol particles can easily adsorb different airborne pathogens, carrying them for a long time. Understanding the dynamics of airborne pathogen transmission is essential for controlling the spread of many well-known pathogens, like the influenza virus, and emerging ones like SARS-CoV-2. Particles smaller than 50 to 100 µm remain airborne and significantly contribute to pathogen transmission. This review explores the journey of pathogen-carrying particles from formation in the airways, through airborne travel, to deposition in the lungs. The physicochemical properties of emitted particles depend on health status and emission modes, such as breathing, speaking, singing, coughing, sneezing, playing wind instruments, and medical interventions. After emission, sedimentation and evaporation primarily determine particle fate. Lung deposition of inhaled aerosol particles can be studied through in vivo, in vitro, or in silico methods. We discuss several numerical lung models, such as the Human Respiratory Tract Model, the LUng Dose Evaluation Program software (LUDEP), the Stochastic Lung Model, and the Computational Fluid Dynamics (CFD) techniques, and real-time or post-evaluation methods for detecting and characterizing these particles. Various air purification methods, particularly filtration, are reviewed for their effectiveness in healthcare settings. In the discussion, we analyze how this knowledge can help create environments with reduced PM2.5 and pathogen levels, enhancing safety in healthcare and nursing-care settings. This is particularly crucial for protecting older adults, who are more vulnerable to infections due to weaker immune systems and the higher prevalence of chronic conditions. By implementing effective airborne pathogen control measures, we can significantly improve health outcomes in geriatric settings.

Reid JP, Ferro AR, Finn A, Lawler JV, Lednicky JA, Löndahl J, et al.

World Health Organization report removes the aerosol/droplet dichotomy but does not move us forward in infection control strategies.

Aerosol Sci Technol. 2024;58(10):1089-92.

https://doi.org/10.1080/02786826.2024.2387985