
# Rapport de veille n° 99

# Aéraulique et COVID-19

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# Google Scholar, Lens et WoS

Graziani, A., Bozza, S., Borghi, M., Mencacci, A., Camilloni, B.
**Circulation and Seasonality of Respiratory Viruses in Hospitalized Patients during Five Consecutive Years (2019–2023) in Perugia, Italy.**
Viruses, Vol. **16** n°(9), (2024)

The emergence of SARS-CoV-2 and the non-pharmacological interventions adopted to counter its spread appear to have led to changes in the normal circulation and seasonality of respiratory viruses. Our study aims to investigate changes related to the circulation of respiratory viruses, not SARS-CoV-2, among hospitalized patients in Perugia, Central Italy, between 2019 and 2023. The samples were collected from individuals who went to the emergency room (ER) or were hospitalized and analyzed using a molecular multiplex test. The results underline that non-pharmaceutical interventions altered the typical seasonal circulation patterns of different respiratory viruses. Those mostly affected were enveloped viruses like influenza viruses that disappeared in 2021; the least impact was recorded for Rhinovirus, which was detected during the pandemic period, maintaining the same seasonality observed in the pre-pandemic period although with a reduction in the number of positive samples. Our data underline the importance of the continuous monitoring of these viruses, especially to understand the timing with which prevention measures, not only non-pharmacological interventions but also the equipment of vaccine doses and monoclonal antibodies, should be adopted to reduce their circulation, particularly in the population at risk of developing severe forms of lower respiratory tract infection.

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Faulkner, C. A., Salsbury, T. I., Abboushi, B., Mouchref, C., Singer, B. C., Sohn, M. D.*, et al.*
**Comparison of effectiveness and energy use of airborne pathogen mitigation measures to meet clean air targets in a prototypical office building.**
Building and Environment, Vol. **257**, (2024)

Organizations such as ASHRAE and the Centers for Disease Control and Prevention (CDC) have proposed guidelines for controlling infectious aerosols in buildings, which can be met through measures such as modified operation of the heating, ventilation, and air-conditioning (HVAC) system or incorporating air-cleaning technologies. However, more research is needed to understand the trade-offs between health, energy, and comfort aspects when designing measures for these guidelines. To address this gap, this paper presents an analysis using new models for air-cleaning technologies, including in-duct and in-room germicidal ultraviolet (GUV) systems and portable air cleaners (PACs). These models are incorporated into an existing prototypical office building model and six measures are designed to meet ASHRAE Standard 241 and CDC clean air targets: MERV 13 HVAC filtration, maximum outdoor air supplied to the building, PACs, and in-duct, upper-room, and whole-room GUV. The measures are simulated for an office building in a cool and humid climate compared against a baseline simulation using MERV 8 filtration. The results show that all measures, except for the maximum outdoor air case, can meet the ASHRAE 241 standard without significant impacts on energy or comfort. The HVAC system measures were not able to meet the CDC target with the default system sizing and lead to significant energy increases, while the in-room measures were able to meet the CDC target with small impacts on energy consumption. This paper consolidates the simulation findings and provides practical guidance for building operators to meet clean air targets while limiting energy and comfort impacts.

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Hung, M.-J., Li, C.-H., Wang, Y.-C., Wang, P.-J.

**Discussion on Radiation Intensity of UVC-LED Different Arrangement Types**.
10th International Conference on Energy Engineering and Environmental Engineering (ICEEEE). Aug 06-08 2024. Singapore, SINGAPORE

Ultraviolet germicidal irradiation (UVGI), due to its characteristics such as mature technology, fast sterilization rate and no secondary pollution for dry disinfection, after the COVID-19 epidemic has been gradually applied to the purification of air conditioning systems such as medical institutions, food hygiene and office buildings and other fields. However, in response to the signing of the "Minamata Convention" for the international ban on mercury in 2013, and UVC-LED has the advantages of no preheating, power saving, small size, long life, non-toxicity, and single band, it has been gradually replaced trend for traditional UV lamps. In view of this, this research uses UV illuminance meter, light source test box, spectrum analyzer and other equipment, a series of experiments were conducted on the radiation intensity of different layout types of UVC-LEDs, the light attenuation with distance, and the characteristics of medium penetration, in order to serve as a reference for the application of environmental disinfection and sterilization on site.

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Stroom, M., Eichholtz, P., Kok, N.
**Does working from home work? That depends on the home.**
PLoS One, Vol. **19** n°(8), (2024)

Working from home (WFH) has risen in popularity since the COVID-19 pandemic. There is an ongoing debate about the productivity implications of WFH, but the physical climate of the home office has received only limited attention. This paper investigates the effect of home office satisfaction and environment-improving behavior on productivity and burnout tendency for WFH employees. We surveyed over 1,000 Dutch WFH individuals about their home office and perceived WFH performance. We fit logistic regressions and structural equation models to investigate the effect of home office satisfaction and characteristics on self-reported productivity, burnout tendency, and willingness to continue WFH. Our results reveal that individual differences in WFH productivity are explained by heterogeneity in the physical home office environment. Higher satisfaction with home office factors is significantly associated with increased productivity and decreased burnout tendency. We continue by showing that more ventilation during working hours is associated with increased productivity, willingness to continue WFH, and burnout resilience. This effect is fully mediated by satisfaction with the home office. We find that higher home office satisfaction is associated with WFH success and air-quality-improving behavior is associated with higher satisfaction. Our results underline a holistic perspective such that investing in a healthy and objectively measured physical climate is a key aspect of the bright future of working from home. The move from the work office to the home office needs to be accompanied by careful design and investment in the quality of the office and its climate.

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Yang, G., Wang, Y., Chan, K. C., Mui, K. W., Flemmig, T. F., Ng, S. T.*, et al.*
**Effectiveness of air cleaner on mitigating the transmission of respiratory disease in a dental clinic environment.**
Building Simulation, (2024)

In dental clinics with an open floor plan, the risk of patient-to-patient transmission of respiratory disease is a concern. During dental procedures large amounts of bioaerosol are produced and patients cannot wear personal protective equipment. This paper examines how to effectively deploy air cleaner to reduce the infection risk in dental clinics with an open floor plan. Various locations of air cleaners at various clean air delivery rates (CADRs) were investigated. The dispersion of bioaerosol was studied through numerical simulations, and risk assessment was performed by a dose-response method. The findings indicated that dental patients downstream of the background ventilation have a higher infection risk than those to the left

and right of an infected patient (i.e., the source). The lowest infection risks for the adjacent patients were found when the air cleaner was place opposite to the dentists, i.e., on the floor at low CADR levels of 2.2 m3/min or on the bench at CADR levels of 4.4 m3/min or greater. The results of this study indicated that air cleaner can mitigate the risk of patient-to-patient transmission of SARS-CoV-2 in dental clinics with an open floor plan. Background CADR levels determine the optimal placement of air cleaners.

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Zheng, M.

**Enhancing energy efficiency in HVAC systems through precise heating load forecasting and advanced optimization algorithms.**

Multiscale and Multidisciplinary Modeling Experiments and Design, (2024)

The importance of energy-efficient building management strategies has grown in study and practice today. To address the urgency, this study integrates exact heating demand projections with powerful optimization algorithms to provide a complete solution. This research explores the complex task of energy optimization in HVAC systems, requiring careful analysis and creative problem-solving. This study highlights the importance of accurate heating load forecasting in improving HVAC system efficiency, energy conservation, and cost efficiency. The SVR model is fused with 2 complex optimization algorithms, the Coronavirus Herd Immunity Optimizer (CHIO) and the Honey Badger Algorithm (HBA), in a groundbreaking methodology. The main goals are to improve heating load calculations and streamline HVAC system optimization. This study validates the importance of accurate heating load forecasting for cost-effectiveness, energy efficiency, and environmental sustainability in building operations. The SVHB model outperforms other models with a low RMSE value of 0.860 (kW) and a maximum R2 value of 0.993, indicating higher predictive accuracy and explanation. To meet the growing demand for energy-efficient building management, this research combines advanced algorithms with accurate heating load estimates for HVAC systems. These findings highlight the importance of precise heating demand forecasts for both cost-effective building operations and environmental responsibility.

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Pérez-Díaz, J. L., Del Álamo Toraño, C., Alcamí, A., Vázquez-Calvo, Á., Rodríguez-Caravaca, G., Mendez-Vigo, P., *et al.*

**Experimental assessment of counterfog bioaerosol fast sampler for virus detection and decontamination.**

The European Physical Journal Plus, Vol. **139** n°(9), (2024)

The respiratory system is equipped with several defence mechanisms to protect the body from microorganisms and airborne pathogens. There are situations where the respiratory system can be overwhelmed or compromised and infection happens, especially in individuals with weakened immune systems. Airborne pathogens are a serious risk for human and animal health, as exemplified by the challenges faced during the COVID-19 pandemic. The list includes viruses of varying severity such as Influenza virus, SARS-CoV-2, measles virus, Varicella-Zoster Virus, or Respiratory syncytial virus among others. Smaller particles can remain suspended in the air for longer periods and may reach the lower respiratory tract, including the alveoli in the lungs. The real-time detection of these pathogens in the air presents a significant challenge. The aerosols, especially those carrying viruses, are so small that they often elude conventional air samplers, making it difficult both to detect their presence and to remove them effectively from the air. This work introduces a recent technique designed for rapid aerosol sampling, with a particular emphasis on virus sampling. The system underwent calibration using artificial ϕ29 virus aerosols and was subsequently tested with naturally emitted aerosols of SARS-CoV-2. A series of tests were conducted in diverse settings, including hospitals, farms, offices, and railway cars. The equipment is also capable of swiftly removing bioaerosols from the air, thereby facilitating effective decontamination. The relevance of this technology lies in its capability for swift detection and elimination of viruses and other kinds of aerosols from air, facilitating prompt decision-making during high-risk events.

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Ejaz, M. F., Kilpeläinen, S., Lestinen, S., Kosonen, R.

**Experimental comparison of structural and active protective methods against breath- and cough-borne aerosols in a meeting room.**

Building and Environment, Vol. **265**, (2024)

In this experimental study, the focus is to address the challenges of cross-contamination due to the presence of an infected individual in a meeting room environment. A detailed analysis is performed to identify effective methods to reduce the spread of infectious aerosols generated due to breathing and coughing. Infectious aerosols are simulated using a Paraffin oil-based solution with a respiratory exhalation simulator integrated with a breathing/coughing machine and an atomizer. Filtration-based active strategies such as the room air purifier, personal air purifier, and facemasks (FFP2 and surgical) along their wearing patterns are examined and compared with structural measures such as face shields and partition walls. The impact of the infectors' location on the exposed person is also studied. Facemasks are the most effective protective measure for both examined respiratory activities and provide over 60 % protection. Other mitigating strategies behaved differently for breathing and coughing trials. In the well-mixed room, during breathing, the portable room air purifier designed for clean air delivery rates (CADR) 2.5 times the ventilation rate effectively reduced aerosol spread. A personal air purifier, with a flow rate of 0.02 times the ventilation rate, offered only partial protection to the exposed occupant. Structural partitions showed marginal effectiveness for breathing but were effective during coughing events. The infector's location has little impact on contaminant levels in a well-mixed meeting room, except for a slight increase when seated next to the exposed person. This study provides a valuable reference for using different mitigation strategies in indoor settings.

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Li, H., Zhang, T., Liu, X.

**How to achieve energy efficiency in buildings without compromising indoor air quality: A case study on enthalpy exchangers.**

Science China Technological Sciences, Vol. **67** n°(9), (2024), 2648-2658 p.

As a representative heat recovery device, the fixed-plate enthalpy exchanger possesses the advantages of high recovery effectiveness, low pressure drop, and small space occupied. Still, indoor contaminants may transfer to fresh air through the enthalpy exchanger simultaneously, causing cross-contamination risk. However, the cross-contamination risk of the fixed-plate enthalpy exchanger has been under-researched in previous studies. As a result, this study experimentally investigates the energy performance, formaldehyde and ammonia transfer rates of paper-based and membrane-based enthalpy exchangers. The results illustrate that the enthalpy recovery effectiveness of the plate exchangers ranges from 60%–85%. The formaldehyde transfer rate through the exchangers varies from 5%–23%, and the ammonia transfer rate is 0–15%. The high effectiveness and low contaminant transfer rates are conducive to the promising application of the fixed-plate enthalpy exchangers. In addition, the energy reclaimed increases with the increase of the absolute indoor-outdoor enthalpy difference. The formaldehyde and ammonia transfer rates and cross-contamination risk slightly decrease with increasing temperature but significantly increase with increasing humidity. Moreover, the experimental results demonstrate that the contaminant transfer rates through the membrane-based exchanger are lower than those of the paper-based exchanger. This study provides a reference for the fixed-plate enthalpy exchanger design in practical applications.

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Bae, J., Bednar, P., Zhu, R., Bong, C., Bak, M. S., Stainer, S., *et al.*

**Mechanisms of Plasma Ozone and UV-C Sterilization of SARS-CoV-2 Explored through Atomic Force Microscopy.**

ACS Applied Materials & Interfaces, (2024)

Ultraviolet-C (UV-C) radiation and ozone gas are potential mechanisms employed to inactivate the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), each exhibiting distinct molecular-level modalities of action. To elucidate these disparities and deepen our understanding, we delve into the intricacies of SARS-CoV-2 inactivation via UV-C and ozone gas treatments, exploring their distinct molecular-level impacts utilizing a suite of advanced techniques, including biological atomic force microscopy (Bio-AFM) and single virus force spectroscopy (SVFS). Whereas UV-C exhibited no perceivable alterations in virus size or surface topography, ozone gas treatment elucidated pronounced changes in both parameters, intensifying with prolonged exposure. Furthermore, a nuanced difference was observed in virus–host cell binding post-treatment: ozone gas distinctly reduced SARS-CoV-2 binding to host cells, while UV-C maintained the status quo. The results derived from these methodical explorations underscore the pivotal role of advanced Bio-AFM techniques and SVFS in enhancing our understanding of virus inactivation mechanisms, offering invaluable insights for future research and applications in viral contamination mitigation.

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Chillon, S. A., Fernandez-Gamiz, U., Zulueta, E., Ugarte-Anero, A., Blanco, J. M.
**Numerical performance of CO2 accumulation and droplet dispersion from a cough inside a hospital lift under different ventilation strategies.**
Scientific Reports, Vol. **14** n°(1), (2024)

The impact of mechanical ventilation on airborne diseases is not completely known. The recent pandemic of COVID-19 clearly showed that additional investigations are necessary. The use of computational tools is an advantage that needs to be included in the study of designing safe places. The current study focused on a hospital lift where two subjects were included: a healthy passenger and an infected one. The elevator was modelled with a fan placed on the middle of the ceiling and racks for supplying air at the bottom of the lateral wall. Three ventilation strategies were evaluated: a without ventilation case, an upwards-blowing exhausting fan case and a downwards-blowing fan case. Five seconds after the elevator journey began, the infected person coughed. For the risk assessment, the CO2 concentration, droplet removal performance and dispersion were examined and compared among the three cases. The results revealed some discrepancies in the selection of an optimal ventilation strategy. Depending on the evaluated parameter, downward-ventilation fan or no ventilation strategy could be the most appropriate approach.

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Piri, A., Massoudifarid, M., Hwang, J.
**Optimal environmental sampling conditions for electrostatic aerosol-to-hydrosol collection of airborne viruses.**
Journal of Hazardous Materials, Vol. **478**, (2024)

Due to adverse effects of viral outbreaks on human health, accurate detection of airborne pathogens is essential. Among many methods available for bioaerosol sampling, electrostatic precipitation (ESP) has been used to directly collect bioaerosols as hydrosols. The performance of an ESP sampler depends on its design, operational and environmental parameters such as air relative humidity (RH), air temperature, sampling liquid type and liquid temperature. Thus, it is essential to identify and maintain optimal conditions throughout sampling process to operate the sampler at its highest capacity. This study provides crucial insights into parameters that affect the collection efficiency of the aerosol-to-hydrosol ESP sampler and its virus recovery. The results indicate that air temperature does not affect collection efficiency, meanwhile, air RH, sampling liquid temperature, and salt concentration are the main parameters that significantly affect collection efficiency. Likewise, when deionized water is used as sampling liquid, hydrogen peroxide concentration increases proportionally with increasing air RH, resulting in significant decrease of virus viability.

Consequently, for ESP samplers similar to our study, the following conditions are recommended: air RH of 55–65%, air and sampling liquid temperature of 37 °C, and a mixture of 10–20 mM ascorbic acid in PBS as sampling liquid.

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Xie, H., Jia, H., Ji, J., Qian, Y., Meng, H., Li, J.*, et al.*
**Performance analysis of a novel air filtration and sterilization PV-Trombe wall.**
Building and Environment, Vol. **265**, (2024)

Bioaerosols have received widespread attention since the outbreak of Coronavirus Disease 2019 owing to their harmful effect on public health. To deal with indoor bioaerosols in an energy-saving method, an air filtration and sterilization PV-Trombe wall was proposed in this study. An experiment rig concerning thermal sterilization of aerosolized Klebsiella pneumoniae was set up to test its feasibility and effectiveness at different exposure temperature and residence time. With the experimental data, an inactivation model was derived based on the first kinetic model and Arrhenius equation. Besides, a mathematic model concerning heat and mass transfer was established for simulating the system performance at different conditions. The results reveal that: (1) The survival ratio of bioaerosols was 0.848, 0.689, 0.493 and 0.257 for the exposure temperature of 45 degrees C, 60 degrees C, 73 degrees C and 85 degrees C at the residence time of 6.5 s (2) the survival ratio predicted by the inactivation model corresponded well with the experimental results and the root mean square error was 0.041. (3) The electrical and thermal efficiencies were 0.134 and 0.218 while the indoor bacterial concentration was reduced by over 60 % with bacterial quantity of filter maintained at a low level. (4) The increase of air velocity could significantly improve the purification performance.

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Zhao, Y., Russell, A., Ambrose, K., Wassgren, C. R.
**Prediction of Air Purifier Effectiveness for Eliminating Exhaled Droplets in a Confined Room.**
Processes, Vol. **12** n°(9), (2024)

High-efficiency particulate air (HEPA) filter purifiers are a recommended method for eliminating respiratory airborne droplets. In this study, the movement of airborne droplets exhaled by occupants in an unventilated, two-bed dormitory room with an air purifier was simulated using computational fluid dynamics. The air was modeled using an Eulerian scheme while the droplets were modeled using a Lagrangian method. The airborne droplet number, the rate at which droplets are removed, and the rate at which droplets accumulate were calculated. A larger HEPA flow rate increased the droplet removal efficiency, with most of the droplets settling on boundary surfaces. Of particular note, the air purifier location within the room had a significant impact on reducing the droplet exchange between two occupants and improving the droplet elimination efficiency.

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Guo, H., Gong, P., Sun, T., Wang, X., Zhang, H.
**Research on the Key Technology of a Fluorescence Detection Device Using the RT-LAMP Method for Instant Detection.**
Micromachines, Vol. **15** n°(8), (2024)

As of 31 October 2023, there have been 771,795,258 confirmed cases of COVID-19 globally. Developing simple, portable, and reliable testing devices has become increasingly important. This paper presents a point-of-care testing (POCT) device for COVID-19 based on the dual-excitation fluorescence RT-LAMP method, which is derived from the principles of RT-LAMP-based COVID-19 detection kits available in the market. The key design solutions of the device were simulated and modeled. Key performance metrics such as detection repeatability and linearity were validated. Comparative experiments with the RT-qPCR detection method were conducted to verify the accuracy and reliability of the device. Additionally, the device's detection sensitivity

and accuracy were assessed. Experimental results show that the repeatability coefficient of variation (CV) value is ≤0.09%; the linearity R2 for the FAM channel is 0.9977 and that for the HEX channel is 0.9899; it exhibits good anti-interference performance, with negligible cross-channel interference; the temperature stability is ±0.062 °C, the temperature accuracy is less than 0.2 °C, and there is no significant temperature overshoot during the heating process. Compared with the real-time quantitative PCR (RT-qPCR) instrument, the positive agreement rate is 100% and the negative agreement rate is 95.0%. This research provides a foundational basis for the development of equipment for the prevention of infectious diseases and clinical diagnostics.

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Palacin, J., Rubies, E., Clotet, E.
**A Retrospective Analysis of Indoor CO2 Measurements Obtained with a Mobile Robot during the COVID-19 Pandemic.**
Sensors, Vol. **24** n°(10), (2024)

This work presents a retrospective analysis of indoor CO2 measurements obtained with a mobile robot in an educational building after the COVID-19 lockdown (May 2021), at a time when public activities resumed with mandatory local pandemic restrictions. The robot-based CO2 measurement system was assessed as an alternative to the deployment of a net of sensors in a building in the pandemic period, in which there was a global stock outage of CO2 sensors. The analysis of the obtained measurements confirms that a mobile system can be used to obtain interpretable information on the CO2 levels inside the rooms of a building during a pandemic outbreak.

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Dam, D., Chen, M., Rees, E. E., Cheng, B., Sukkarieh, L., Mcgill, E.*, et al.*
**Risk factors associated with the intensity of COVID-19 outbreaks in Canadian community settings: a retrospective analysis of outbreak-level surveillance data.**
BMC Public Health, Vol. **24** n°(1), (2024)

The severity of COVID-19 outbreaks is disproportionate across settings (e.g., long-term care facilities (LTCF), schools) across Canada. Few studies have examined factors associated with outbreak severity to inform prevention and response. Our study objective was to assess how outbreak severity, as measured using outbreak intensity and defined as number of outbreak-associated cases divided by outbreak duration, differed by setting and factors known to influence SARS-CoV-2 transmission.

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Galmiche, S., Charmet, T., Rakover, A., Chény, O., Omar, F., David, C.*, et al.*
**Risk of SARS-CoV-2 infection in professional settings, shops, shared transport, and leisure activities in France, 2020–2022.**
BMC Public Health, Vol. **24** n°(1), (2024)

The aim of the study was to identify settings associated with SARS-CoV-2 transmission throughout the COVID-19 pandemic in France.

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Cheng, P., Jia, W., Liu, L., Yen, H.-L., Li, Y.
**What sizes of droplets contribute to long-range airborne transmission?**
Indoor Environments, Vol. **1** n°(4), (2024)

The size range of respiratory droplets contributing to long-range airborne transmission of infections determines the targeted intervention methods. However, the exact size range remains unknown, and the influencing parameters are also undetermined. Here, we investigated the size-resolved transport and fate of respiratory droplets in four reported venues of COVID-19 outbreaks. We utilised a transient number balance model, a set of expired droplet size distributions, existing formulas for size-resolved settling rates and filtration efficiencies, and a deposition model from the International Commission on Radiological Protection. This enabled us to obtain the size-resolved concentrations of exhaled droplets in indoor air, the size-resolved number of droplet nuclei in the inhaled air, and the number of droplets deposited throughout the respiratory tract. The newly defined airborne transmission size range of expired droplets depends on the effective dilution flow rate of the infection venue under consideration. Three criteria were proposed for determining the sizes of droplets involved in long-range airborne transmission. The airborne transmission droplets typically featured an initial diameter of 0.1–4–6 µm, with an hourly volume generation rate of 0.38–0.42 nL/h per index case in the four venues. This newly estimated volume of airborne transmission droplets provides an essential input into the viral load method for estimating the infectious quanta generation rate. Practical significance Our size-resolved estimation reveals that only a tiny fraction of expired infectious droplets within an airborne transmission size range survives after the removal effects of ventilation, settling, deactivation, and filtration, as well as the transient dilution effect. These droplets remain in indoor air, potentially contributing to long-range airborne transmission. The airborne transmission size range depends on the size-dependent dilution capacity of a room.

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