Rapport de veille n° 40

Aéraulique et COVID-19

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Google Scholar et WoS

Armand, P., Tache, J.
3D modelling and simulation of the dispersion of droplets and drops carrying the SARS-CoV-2 virus in a railway transport coach.
Scientific reports, Vol. **12** n°(1), (2022)

Computational fluid dynamics (CFD) modelling and 3D simulations of the air flow and dispersion of droplets or drops in semi-confined ventilated spaces have found topical applications with the unfortunate development of the Covid-19 pandemic. As an illustration of this scenario, we have considered the specific situation of a railroad coach containing a seated passenger infected with the SARS-CoV-2 virus (and not wearing a face mask) who, by breathing and coughing, releases droplets and drops that contain the virus and that present aerodynamic diameters between 1 and 1000m. The air flow is generated by the ventilation in the rail coach. While essentially 3D, the flow is directed from the bottom to the top of the carriage and comprises large to small eddies visualised by means of streamlines. The space and time distribution of the droplets and drops is computed using both an Eulerian model and a Lagrangian model. The results of the two modelling approaches are fully consistent and clearly illustrate the different behaviours of the drops, which fall down close to the infected passenger, and the droplets, which are carried along with the air flow and invade a large portion of the rail coach. This outcome is physically sound and demonstrates the relevance of CFD for simulating the transport and dispersion of droplets and drops with any diameter in enclosed ventilated spaces. As coughing produces drops and breathing produces droplets, both modes of transmission of the SARS-CoV-2 virus in human secretions have been accounted for in our 3D numerical study. Beyond the specific, practical application of the rail coach, this study offers a much broader scope by demonstrating the feasibility and usefulness of 3D numerical simulations based on CFD. As a matter of fact, the same computational approach that has been implemented in our study can be applied to a huge variety of ventilated indoor environments such as restaurants, performance halls, classrooms and open-plan offices in order to evaluate if their occupation could be critical with respect to the transmission of the SARS-CoV-2 virus or to other airborne respiratory infectious agents, thereby enabling relevant recommendations to be made.

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Thuresson, S., Fraenkel, C.-J., Sasinovich, S., Soldemyr, J., Widell, A., Medstrand, P., *et al.*
Airborne SARS-CoV-2 in hospitals – effects of aerosol-generating procedures, HEPA-filtration units, patient viral load and physical distance.
Clinical Infectious Diseases, (2022)

Transmission of covid-19 can occur through inhalation of fine droplets or aerosols containing infectious virus. The objective of this study was to identify situations, patient characteristics, environmental parameters and aerosol-generating procedures (AGPs) associated with airborne SARS-CoV-2 virus.Air samples were collected near hospitalised covid-19 patients and analysed by RT-qPCR. Results were related to distance to the patient, most recent patient diagnostic PCR Ct-value, room ventilation and ongoing potential AGP.In total 310 air samples were collected, and of these 26 (8%) were positive. Of the 231 samples from patient rooms, 22 (10%) were positive for SARS-CoV-2. Positive air samples were associated with a low patient Ct-value (OR 5.0 for a Ct-value <25 vs >25, p=0.01, 95% confidence interval 1.18 to 29.5) and a shorter physical distance to the patient (OR 2.0 for every meter closer to the patient, p=0.05, CI 1.0 to 3.8). A mobile HEPA-filtration unit in the room decreased the proportion of positive samples (OR 0.3, p=0.02, CI 0.12 to 0.98). No association was observed between SARS-CoV-2 positive air samples and mechanical ventilation, high flow nasal cannula, nebulizer treatment or non-invasive ventilation. An association was found with positive expiratory pressure (PEP) training (p<0.01) and a trend towards association for airway manipulation, including bronchoscopies

and in- and extubations.Our results show that major risk factors for airborne SARS-CoV-2 include short physical distance, high patient viral load and poor room ventilation. AGPs, as traditionally defined, seem to be of secondary importance.

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Blinc, A., Ponikvar, J. B., Fras, Z.
Airborne spread of SARS-CoV-2–a commentary by the Division of Internal Medicine, University Medical Centre Ljubljana.
Slovenian Medical Journal, (2022), pp. 1-7

Slovenia is one of the countries that have been most affected by the autumn/winter 2020/21 wave of the COVID-19 pandemic regarding the incidence and excess mortality among the general population as well as regarding the incidence among health care workers and nursing personnel. The World Health Organization has underestimated the importance of the airborne spread of SARS-CoV-2 and the recommended safety measures have not been entirely sufficient. When people breathe, talk, sing, cough, or sneeze, they emit respiratory droplets of various sizes, most of which are always smaller than 1 µm. Respiratory droplets smaller than 5 µm stay airborne in indoor spaces for a long time and travel over distances much longer than 2 m. Thus, an infected person in an indoor environment creates an infectious aerosol that may infect other people without close interpersonal contact. This short review presents the mathematical model and internet application by authors from the Massachusetts Institute of Technology for calculating the safe time before probable airborne infection occurs in indoor spaces. The importance of ventilation, air filtration, air humidity, and air disinfection by ultraviolet light is briefly discussed. The principles of preventing the airborne spread of SARS-CoV-2 are summarized.

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Parvez, M. K., Parveen, S.
Airborne transmission of SARS-CoV-2 disease (COVID-19).
Future Virology, (2022)

Since its first appearance in 2019, SARS-CoV-2 disease (COVID-19) has continued to cause massive devastation, worldwide [1,2]. Emergence of its aggressive mutant strains or genetic variants in Brazil, the USA, the UK, South Africa, India or elsewhere and their subsequent spread in other countries has further worsened the crisis [3]. SARS-CoV-2 generally manifests into fever, cough, nausea, headache, hypoxia or diarrhea and may progress to mild-to-severe pneumonia and death [1]. Fortunately, we have acquired an in-depth knowledge on the epidemiology, manifestations, pathobiology, prevention and treatments modalities of SARS-CoV-2 as well as its 'variants of concern'. In the absence of specific therapeutics, several repurposed drugs are currently under advanced phases of clinical trials or approved for emergency use [4]. Notably, within one and half years of this pandemic, some of the leading vaccines have been granted approval for mass vaccination, worldwide.
Viral transmission rates are often higher in dense than in sparse populations, where social contacts greatly enhance their spread. The 'human-to-human' direct transmission of SARS-CoV-2 through multiple modes, such as naso/oropharyngeal droplets, aerosols and fomites have been confirmed [1]. Therefore, as advised by the international health regulatory authorities, wearing masks, maintaining physical distancing and hand or surface sanitization would limit the risk of infection. In addition, recent data on detection of SARS-CoV-2 in a COVID-19 patient's stool and several water sources, suggest its plausible waterborne spread through fecal–oral route [5,6].

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Albertin, R., Pernigotto, M. G., Gasparella, P. A.

Assessment Of The Covid-19 Contagion Risk In University Classrooms With TRNSYS And TRNFLOW Simulations.
IAQ 2020 : Indoor Environmental Quality Performance Approaches
ASHRAE Topical Conference Proceedings; Atlanta, (2021)

The ongoing covid-19 pandemic has drawn the attention on the importance of providing adequate fresh air to the occupants of the built environment, in particular in educational buildings. Higher ventilation rates and personal protection devices like facial masks are among the strategies and procedures to reduce the infection risk, allowing the fruition of school spaces despite the epidemic progression. Nevertheless, the problem of airborne transmission has been usually dealt with considering each environment alone and assuming steady state conditions. Indeed, the contagion risk among adjacent environments, under dynamic occupancy or with variable ventilation rates has not been discussed in detail.
In order to investigate those aspects, this research focused on a floor with three adjacent classrooms at the campus of the Free University of Bozen-Bolzano, Italy (UNIBZ). The case-study is part of a modern high performance building, served by a mechanical ventilation system and equipped with building automation solutions. Furthermore, two out of three classrooms are part of the UNIBZ Living Labs, where a network of sensors is deployed for the constant monitoring of the indoor environmental conditions.
A TRNSYS and TRNFLOW air flow network model was developed, calibrated and validated against the experimental data collected in the UNIBZ Living Labs. Then, a series of transient scenarios were simulated by varying the probability of windows' opening, mask utilization and ventilation typology. For each scenario and each room, the infection risk was assessed according to the Airborne Infection Risk Calculator tool (AIRC). High risks of infection were found related to poor ventilation, as it can be the case during lectures if windows and doors are kept closed and the mechanical ventilation system is not operating. When open doors are simulated, pathogen propagation in adjacent environments was observed, even if with a lower associated risk if compared to the room where the pathogen source is located.

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Duchaine, C., Roy, C. J.
Bioaerosols and airborne transmission: Integrating biological complexity into our perspective.
The Science of the total environment, (2022)

There is broad consensus that airborne disease transmission continues to be the thematic focus of COVID-19, the complexities and understanding of which continues to complicate our attempts to control this pandemic. Masking used as both personal protection and source reduction predominates our society at present and, other than vaccination, remains the public health measure that will faithfully reduce aerosol transmission and overall disease burden (Gandhi and Marr, 2021). Early in the advent of the COVID-19 pandemic, and especially after preliminary recognition of airborne transmission, there was considerable efforts in the application of computational fluid dynamics (CFD) modeling aerosols as well as risk models calculations, the products of which were detailed in the literature (Morawska et al., 2020; Buonanno et al., 2020a) and even disseminated in media destined for the public. As the respiratory pathway emerged as the dominant exposure pathway for SARSCoV-2 transmission, much of what was promoted from CFD was applied to risk models to estimate community infection and in some cases expected clinical outcome. COVID-19 proved to fit the profile of an obligate respiratory-transmitted pathogen, and the plausibility of using aerosol modeling when silhouetted with emerging COVID-19 epidemiology provided ample evidence for promotion of masking and ventilation optimization as a required public health measure. Masking is often included as a factor in developed risk models and it remains an essentially important part of our response to this airborne threat, and ultimately will agnostically reduce disease burden although efforts to improve ventilation in indoor spaces remain a challenge. Arguably the most important concept in the airborne transmission of infectious agents is the biologically active componentry that comprises the aerosol particle and the functional dynamic nature of particle contents. Specifically, the innate generation, transport, and ultimate deposition/disposition of

bioaerosols; the aerosol particles that nearly exclusively harbor bioactive components, including viruses, when disease agents are transmitted through the air.

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Schimmoller, B., Trovao, N. S., Isbell, M., Goel, C., Heck, B. F., Archer, T. C., *et al.*
Covid-19 Exposure Assessment Tool (CEAT): Easy-to-use tool to quantify exposure based on airflow, group behavior, and infection prevalence in the community.
medRxiv, (2022)

The COVID-19 Exposure Assessment Tool (CEAT) allows users to compare respiratory relative risk to SARS-CoV-2 for various scenarios, providing understanding of how combinations of protective measures affect exposure, dose, and risk. CEAT incorporates mechanistic, stochastic and epidemiological factors including the: 1) emission rate of virus, 2) viral aerosol degradation and removal, 3) duration of activity/exposure, 4) inhalation rates, 5) ventilation rates (indoors/outdoors), 6) volume of indoor space, 7) filtration, 8) mask use and effectiveness, 9) distance between people, 10) group size, 11) current infection rates by variant, 12) prevalence of infection and immunity in the community, 13) vaccination rates of the community, and 14) implementation of COVID-19 testing procedures. Demonstration of CEAT, from published studies of COVID-19 transmission events, shows the model accurately predicts transmission. We also show how health and safety professionals at NASA Ames Research Center used CEAT to manage potential risks posed by SARS-CoV-2 exposures.

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Roaf, S.
COVID-19: Trust, windows and the psychology of resilience.
In: Routledge Handbook of Resilient Thermal Comfort. 2022. pp. 551-581

A population's trust in its government and experts underpins national cohesion. The COVID-19 pandemic saw major protests from crowds over lockdown policies, and many citizens refused vaccination. Much of the concern, stress and anxiety felt during the pandemic related to how safe people perceived themselves to be in the buildings they live and work in. Many feared going to hospital, to work or sending children to school because they believed that they may get COVID indoors there. Were they right? Many modern buildings are conditioned with air-blown Heating, Ventilating and Air-Conditioning (HVAC) systems. Aerosol transmission of the virus is now acknowledged to be the main cause of inter-personal infections. Do HVAC systems actually spread the virus? Do the proposed fixes to disinfecting these systems work in practice? Would opening a window work better for purging viral loads? What do professional bodies advise? Are they to be trusted? Do people rather trust their own common-sense understandings of the psychological stresses, health threats and options they face? Will modified Business-as-Usual approaches be enough? Is radical new design thinking needed for genuinely healthier buildings ? The implications of such questions are discussed and it is concluded that resilient buildings must have opening windows.

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Franceschini, P. B., Neves, L. O.
A critical review on occupant behaviour modelling for building performance simulation of naturally ventilated school buildings and potential changes due to the COVID-19 pandemic.
Energy and Buildings, Vol. **258**, (2022)

Occupant behaviour (OB) is one of the main causes of the energy performance gap between buildings' performance prediction versus reality, since, due to its uncertainty and unpredictability, it is often oversimplified in the building performance simulation (BPS). Hence, previous studies developed OB models, mainly in the residential and office contexts, in order to predict and represent human behaviour in BPS. Yet,

school buildings are different from other typologies due to contextual factors (e.g., occupants' age, different daily timetables and group rules) and are in a unique position to promote energy efficiency for tomorrow's citizens. Assessing OB in schools can lead to an improvement of the indoor environment, especially in naturally ventilated buildings, where window operation behaviour directly impacts on the air change rates and, consequently, on the indoor air quality. This study addresses the knowledge gap on OB modelling for naturally ventilated (NV) and mixed-mode (MM) school buildings. The reviewed papers were organized in three main themes, namely (i) OB models for BPS of NV and MM buildings, (ii) OB research studies in NV and MM school buildings and (iii) potential changes on OB in school buildings due to the COVID-19 pandemic. The analysis focused on three phases of the OB modelling framework: data collection (pre-processing), model development (processing) and model implementation (post-processing). Important research gaps are identified, such as the reduced number of studies that cover the three phases of the modelling framework within the school buildings context and the need to better investigate the teachers' behaviour and collective actions as important OB drivers in classrooms. Future research topics are also identified, such as which are the potential changes on actions' drivers due to the COVID-19 pandemic in NV classrooms and to what extent they will be durable or ephemeral. (C) 2022 Elsevier B.V. All rights reserved.

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Dacunto, P., Ng, A., Moser, D., Tovkach, A., Scanlon, S., Benson, M.
Effects of location, classroom orientation, and air change rate on potential aerosol exposure: an experimental and computational study.
Environmental Science : Processes & Impacts, (2022)

This study examined the dispersion of potentially infectious aerosols in classrooms by means of both a CO2 tracer gas, and multizone contaminant transport modeling. A total of 20 tests were conducted in three different university classrooms at multiple air change rates (4.4–9.7/h), each with two different room orientations: one with the tracer gas released from six student desks toward the air return, and one with the same tracer gas released away from it. Resulting tracer concentrations were measured by 19 different monitors arrayed throughout the room. Steady-state, mean tracer gas concentrations were calculated in six instructor zones (A–F) around the periphery of the room, with the results normalized by the concentration at the return, which was assumed to be representative of the well-mixed volume of the room. Across all classrooms, zones farthest from the return (C, D) had the lowest mean normalized concentrations (0.75), while those closest to the return (A, F) had the highest (0.95). This effect was consistent across room orientations (release both toward and away from the return), and air change rates. In addition, all zones around the periphery of the room had a significantly lower concentration than those adjacent to the sources. Increasing the ventilation rate reduced tracer gas concentrations significantly. Similar trends were observed via a novel approach to CONTAM modeling of the same rooms. These results indicate that informed selection of teaching location within the classroom could reduce instructor exposure.

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Wang, Q., Zhao, Y., Wang, Y., Zhang, Y., Dong, J.
Enhanced viral inactivation by combined ultraviolet light and heat.
Laser Physics Letters, Vol. **19** n°(4), (2022)

Viral sensitivity to high temperature and ultraviolet (UV) irradiation has been extensively studied. However, there is still little attention paid to study the joint effect of these two physical factors. Since the outbreak of the COVID-19 pandemic has necessitated the advances of disinfection techniques, rapid and effective viral inactivation by combining heat and UV light is worth investigating. This work focuses on developing such a device combining UV light-emitting diode light sources and a heater. Moreover, two UV bands have been studied in this work, namely 280 nm ultraviolet-C (UVC) and 365 nm ultraviolet-A (UVA. A) control system is developed to accurately control both the heating temperature of the device and the irradiance of the dual-

spectral UV light sources. The performance of the device is verified by a series of experimental measurements. More importantly, the disinfection effect of the device has been verified by the experiments based on non-pathogenic carrier virus commonly used in the laboratory. The disinfection doses of the 280 nm UVC and 365 nm UVA light sources under the high temperature synergy have been examined. The experimental results show that when combined with a heating temperature of 60 C-circle, the cumulative UV radiation doses required for sufficient viral inactivation can be greatly reduced.

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Azizi Jalilian, F., Poormohammadi, A., Teimoori, A., Ansari, N., Tarin, Z., Ghorbani Shahna, F.*, et al.*
Evaluation of SARS-CoV-2 in Indoor Air of Sina and Shahid Beheshti Hospitals and Patients' Houses.
Food and Environmental Virology, (2022), pp. 1-9

Side by side air sampling was conducted using a PTFE filter membrane as dry sampler and an impinger containing a suitable culture medium as a wet sampler. Most of the samples were collected from two hospitals and few air samples were collected from private houses of non-hospitalized confirmed COVID-19 patients. The collected air samples were analyzed using RT-PCR. The results indicated that all air samples collected from the hospitals were PCR negative for SARS-CoV-2. While two of four air samples collected from the house of non-hospitalized patients were PCR positive. In this study, most of the hospitalized patients had oxygen mask and face mask, and hence this may be a reason for our negative results regarding the presence of SARS-CoV-2 in indoor air of the hospitals, while non-hospitalized patients did not wear oxygen and protective face masks in their houses. Moreover, a very high concentration of particles in the size range of droplet nuclei (< 5 µm) was identified compared to particles in the size range of respiratory droplets (> 5-10 µm) in the areas where patients were hospitalized. It can be concluded that using face mask by patients can prevent the release of viruses into the indoor air, even in hospitals with a high density of patients.

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Barroso-Arévalo, S., Sánchez-Morales, L., Barasona, J. A., Rivera, B., Sánchez, R., Risalde, M. A.*, et al.*
Evaluation of the clinical evolution and transmission of SARS-CoV-2 infection in cats by simulating natural routes of infection.
Veterinary Research Communications, (2022)

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the causative agent of the current pandemic disease denominated as Coronavirus Disease 2019 (COVID-19). Several studies suggest that the original source of this virus was a spillover from an animal reservoir and its subsequent adaptation to humans. Of all the different animals affected, cats are one of the most susceptible species. Moreover, several cases of natural infection in domestic and stray cats have been reported in the last few months. Although experimental infection assays have demonstrated that cats are successfully infected and can transmit the virus to other cats by aerosol, the conditions used for these experiments have not been specified in terms of ventilation. We have, therefore, evaluated the susceptibility of cats using routes of infection similar to those expected under natural conditions (exposure to a sneeze, cough, or contaminated environment) by aerosol and oral infection. We have also evaluated the transmission capacity among infected and naïve cats using different air exchange levels. Despite being infected using natural routes and shed virus for a long period, the cats did not transmit the virus to contact cats when air renovation features were employed. The infected animals also developed gross and histological lesions in several organs. These outcomes confirm that cats are at risk of infection when exposed to infected people, but do not transmit the virus to other cats with high rates of air renovation.

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Bui, T. T., Shin, M. K., Jee, S. Y., Long, D. X., Hong, J., Kim, M.-G.
Ferroelectric PVDF nanofiber membrane for high-efficiency PM0.3 air filtration with low air flow resistance.
Colloids and surfaces. A, Physicochemical and engineering aspects, Vol. **640**, (2022)

The significant public health concerns related to particulate matter (PM) air pollutants and the airborne transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have led to considerable interest in high-performance air filtration membranes. Highly ferroelectric polyvinylidene fluoride (PVDF) nanofiber (NF) filter membranes are successfully fabricated via electrospinning for high-performance low-cost air filtration. Spectroscopic and ferro-/piezoelectric analyses of PVDF NF show that a thinner PVDF NF typically forms a ferroelectric beta phase with a confinement effect. A 70-nm PVDF NF membrane exhibits the highest fraction of beta phase (87%) and the largest polarization behavior from piezoresponse force microscopy. An ultrathin 70-nm PVDF NF membrane exhibits a high PM0.3 filtration efficiency of 97.40% with a low pressure drop of 51Pa at an air flow of 5.3cm/s owing to the synergetic combination of the slip effect and ferroelectric dipole interaction. Additionally, the 70-nm PVDF NF membrane shows excellent thermal and chemical stabilities with negligible filtration performance degradation (air filtration efficiency of 95.99% and 87.90% and pressure drop of 55 and 65Pa, respectively) after 24h of heating at 120°C and 1h immersion in isopropanol.

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Bluyssen, P. M.

How airborne transmission of SARS-CoV-2 confirmed the need for new ways of proper ventilation.

In: Routledge Handbook of Resilient Thermal Comfort. 2022. pp. 531-550

Since the first outbreaks of COVID-19, research has focused on how to minimize SARS-CoV-2 transmission indoors. SARS-CoV-2 has three identified transmission routes: (1) direct transmission of virus-carrying droplets between people in close proximity, by coughing, sneezing or talking; (2) indirect transmission via deposited, or transmitted, infectious droplets via surfaces; (3) airborne transmission through virus-carrying, small, airborne droplets, also called aerosols, emanating from infected individuals. To reduce direct transmission from large infectious droplets, physical distancing of individuals is promoted, and for indirect transmissions, the cleaning of surfaces, washing of hands and sneezing/coughing in the elbow are advocated. For people who need or tend to come close to (possibly) infected persons, personal protective equipment is used, including facemasks and gloves. For airborne transmission, the use of 'proper' ventilation measures has been recommended to decrease the risk. In this chapter, the background of airborne transmission research is outlined and measures to reduce transmission are discussed. It is concluded that to provide pathogen safe, and comfortable, buildings in the future, we are in urgent need of both a better understanding of how pathogens spread within buildings, and reliable and resilient new ways of ventilating indoor spaces that are flexible, affordable, efficient and effective.

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Li, Y.

Hypothesis: SARS-CoV-2 transmission is predominated by the short-range airborne route and exacerbated by poor ventilation.

Indoor Air, Vol. **31** n°(4), (2021), pp. 921-925

It is currently unclear whether a predominant route exists for the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the pathogen responsible for the coronavirus disease 2019 (COVID-19) pandemic. Following the first reported case of COVID-19 more than 1 year ago in Wuhan, China, more than 100 million people have been infected globally as of early February 2021, and different intervention strategies have been adopted by different countries. A "just-in-case" intervention approach is too extreme, resulting in significant economical and societal losses, while an inadequate approach results in significant infection rates. An adequate intervention strategy demands knowledge of the predominant transmission route(s) of SARS-CoV-2.

It is generally difficult to identify the transmission routes of respiratory infections. Here, we use airborne or (aerosol) inhalation transmission as an example to demonstrate these difficulties. Airborne transmission of SARS-CoV-2 “in specific settings, particularly in indoor, crowded, and inadequately ventilated spaces, where infected person(s) spend long periods of time with others, such as restaurants, choir practices, fitness classes, nightclubs, offices, and/or places of worship” has been acknowledged by the World Health Organization since October 2020.1 Airborne transmission2 refers to the inhalation of air-suspended virus-laden respiratory aerosols by a susceptible person, resulting in infection. These aerosols were previously exhaled by an infected person. Aerosol inhalation can occur over both short and long distances. This definition suggests the need for the following three criteria to be fulfilled to demonstrate airborne transmission.
An infected individual (with or without subsequent clinical disease) releases sufficient number of viable virus-containing aerosols in the expired air and
The expired jet and/or the air in the space are not sufficiently diluted; and a sufficient number of virus in aerosols are still infectious, and the virus-containing aerosols can remain suspended in air long enough to be transported to a susceptible person such that
A susceptible person inhales a sufficient number of aerosols (viable virus) to produce infection,15 with or without subsequent clinical disease.
These three criteria for demonstrating airborne transmission of any respiratory infection due to expired aerosols, with respect to release, transport/dilution, inhalation, and subsequent infection, are similar to postulates 1–4 proposed by Gwaltney and Hendley.3 However, they are difficult to assess, except in animal studies or human challenge studies, in which it is also difficult to separate inhalation exposure from droplet spray and short-range airborne route. A positive demonstration of these criteria in animal studies may not directly translate to humans, while human challenges are difficult to perform due to ethical considerations. In outbreaks with observed infections, direct evidence of these three criteria mostly disappears after the outbreak has been identified. For SARS-CoV-2, the fulfillment of each individual criteria has been demonstrated in separate studies showing SARS-CoV-2 release by COVID-19 patients,4 the presence of viable SARS-CoV-2 particles in the air within a room,5 the infection of patrons in a restaurant who sat 4.5 m from the index case without any close contact, and fomite transmission (unpublished). However, no study has provided evidence that satisfies all of the three criteria. The same statement can be made for large-droplet transmission and fomite transmission. In practice, evidentiary support for long-range airborne transmission may be indicated by the fulfillment of any one of the following conditions.6
An outbreak occurred that could be directly attributed to the lack of ventilation air introduction into, and circulation within, an enclosed space.
The incidence of infection in susceptible hosts was inversely associated with the ventilation rate per person.
A disease outbreak occurred in an enclosed space, most likely due to air transport of infectious droplet nuclei over a distance greater than 2 m.
Some studies have presented evidence that satisfies these less-stringent criteria for SARS-CoV-2 transmission,7 suggesting that airborne transmission of SARS-CoV-2 is likely.
Here, I propose a different approach to demonstrating that SARS-CoV-2 transmission is likely predominated by the short-range airborne route and that long-range airborne transmission is only opportunistic, that is, when ventilation is insufficient.

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Macgregor, G.
Indoor air quality+ air purification Ventilation can prevent the spread of infectious diseases.
ISSA Today, n°(February), (2022)

Buildings and indoor spaces have been associated with the spread of infectious diseases through the air, such as measles, influenza, tuberculosis, Legionella, and COVID-19. People are often the source of infection, and your chances of being infected depend on the size of the room and the number of people in it. Just as you

might think of a room full of smokers and the smoke they generate, you can also think of viruses and bacteria similarly being released into the air.
According to the Centers for Disease Control and Prevention (CDC), infectious diseases can spread when an infected person coughs, sneezes, talks, or breathes out droplets and tiny particles that contain viruses or bacteria. These droplets and particles can be breathed in by other people or land on their eyes, noses, or mouth. In addition, an infected person can contaminate surfaces they touch. Virus particles and bacteria in the air can settle on and contaminate surfaces. People can get infected by touching their eyes, nose, or mouth with hands that have the virus or bacteria on them.
A study from National Institutes of Health, CDC, University of California, Los Angeles, and Princeton University scientists in The New England Journal of Medicine found that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes COVID-19 was detectable in respiratory droplets in the air for up to three hours. A single cough can expel more bacteria or viruses than a single breath. But if an infected person breathes 22,000 times per day while coughing up to 500 times, then coughing accounts for as little as 7% of the total bacteria or virus emitted by an infected patient.

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Sami, S., Horter, L., Valencia, D., Thomas, I., Pomeroy, M., Walker, B.*, et al.*
Investigation of SARS-CoV-2 transmission associated with a large indoor convention—New York City, November–December 2021.
Morbidity and Mortality Weekly Report, Vol. **71** n°(7), (2022), pp. 243-248

What is already known about this topic?
The SARS-CoV-2 Delta (B.1.617.2) and Omicron (B.1.1.529) variants are highly transmissible. Outbreaks have been reported among vaccinated populations in indoor settings where mask use was limited.
What is added by this report?
Despite multiple introductions as evidenced by detection of at least three sublineages of SARS-CoV-2, this investigation did not find evidence of widespread transmission among a highly vaccinated population at a large event in an indoor setting where mask use was required and monitored.
What are the implications for public health practice?
Implementing multiple prevention measures (vaccinations and boosters, consistent mask wearing, enhanced indoor ventilation, and testing after text notification) can limit the transmission of SARS-CoV-2 at large events, including highly transmissible variants.

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Arjmandi, H., Amini, R., Kashfi, M., Abikenari, M. A., Davani, A.
Minimizing the COVID-19 spread in hospitals through optimization of ventilation systems.
Physics of Fluids, Vol. **34** n°(3), (2022)

The rapid spread of SARS-CoV-2 virus has overwhelmed hospitals with patients in need of intensive care, which is often limited in capacity and is generally reserved for patients with critical conditions. This has led to higher chances of infection being spread to non-COVID-19 patients and healthcare workers and an overall increased probability of cross contamination. The effects of design parameters on the performance of ventilation systems to control the spread of airborne particles in intensive care units are studied numerically. Four different cases are considered, and the spread of particles is studied. Two new criteria for the ventilation system—viz., dimensionless timescale and extraction timescale—are introduced and their performances are compared. Furthermore, an optimization process is performed to understand the effects of design variables (inlet width, velocity, and temperature) on the thermal comfort conditions (predicted mean vote, percentage of people dissatisfied, and air change effectiveness) according to suggested standard values and the relations for calculating these parameters based on the design variables are proposed. Desirability functions that are comprised of all three thermal condition parameters are used to determine the range of variables that result

in thermally comfortable conditions and a maximum desirability of 0.865 is obtained. The results show that a poorly designed ventilation system acts like a perfectly stirred reactor—which enormously increases the possibilities of contamination—and that when air is injected from the ceiling and extracted from behind the patient beds, the infection spread is least probable since the particles exit the room orders of magnitude faster.

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Wijaya, E. S.
Natural Ventilation Optimization Study in Mechanically Ventilated Studio Apartment Room in Surabaya.
Journal of Applied Science and Engineering, Vol. **25** n°(1), (2022), pp. 141-149

After Covid-19, residential has become the main space for every activity, including work, education, and leisure. Therefore, comfort in residential space is crucial to the occupant. As researchers have found traces, that the virus is airborne, the air quality in the residence must be highlighted, especially for people who live in a centralized cooling system residence. When the cooling system is well maintained, there is no significant risk of viral transmission, but not all residential building has HEPA-filters, nor a well-maintained system. This research focuses on the studio room apartment unit, as it has the smallest opening area compared to other room types. A small one-sided opening is not ideal for the wind to move throughout the room. A few design suggestion is simulated under three air-flow speed, to prove that natural ventilation is possible to be adapted, to reach comfort while minimizing the risk of viral transmission. The result is, the indoor wind speed can be enhanced the most at the overall unit area by modifying the fixed window to an operable window, giving upper horizontal opening in the wall across the existing opening, and using gauze doors on both door openings. The furniture layout is proved to affect wind distribution in the room. This research can also serve as an alternative strategy to optimize the use of natural ventilation to decrease energy use for cooling in the tropic area, after the pandemic.

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Afrasiabian, E., Douglas, R., Geron, M., Cunningham, G.
A numerical evaluation of a novel recovery fresh air heat pump concept for a generic electric bus.
Applied thermal engineering, Vol. **209**, (2022)

Since the outbreak of the worldwide COVID-19 pandemic, public transportation networks have faced unprecedented challenges and have looked for practical solutions to address the rising safety concerns. It is deemed that in confined spaces, operating heating units (and cooling) in non-re-circulation mode (i. e., all-fresh air mode) could reduce the airborne transmission of this infectious disease, by reducing the density of the pathogen and exposure time. However, this will expectedly increase the energy demand and reduce the driving range of electric buses. To tackle both the airborne transmission and energy efficiency issues, in this paper a novel recovery heat pump concept, operating in all-fresh air mode, was proposed. The novelty of this concept lies in its potential to be applied to already manufactured/in-service heat pump units as it does not require any additional components or need for redesigning the heating systems. In this concept, the cabin exhaust air is directed to pass through the evaporator of the heat pump system to recover part of the waste heat from the cabin and to improve the efficiency of the system. In this paper, a 0D/1D coupled model of a generic single-deck cabin and a heat pump system was developed in the Simulink environment of MATLAB (R2020b) software. The model was run in two different modes, namely the all-fresh air (as a baseline and a recovery heat pump concepts), and the air re-circulation mode (as a conventional heat pump concept with a 50% re-circulation ratio). The performance of these concepts was investigated to evaluate how an all-fresh air policy could affect the performance of the system, as well as the energy-saving potential of the proposed recovery concept. The performance of the system was studied under different ambient temperatures of -5 °C, 0 °C, and 5 °C, and for low and moderate occupancy levels. Results show that implementing the all-fresh air policy in the recovery and baseline concepts significantly improved the ventilation rate per person by at least

102% and at most 125%, compared to the air-re-circulating heat pump. Moreover, adopting the recovery concept reduced the power demand by at least 8% and at most 11%, compared to the baseline all-fresh air heat pump, for the selected fan and blower flow rates. The presented results in this paper along with the applicability of this concept to in-service mobile heat pumps could make it a feasible, practical, and quick trade-off solution to help the bus operators to protect people and improve the energy efficiency of their service.

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Szałański, P., Cepiński, W.
Prawdopodobieństwo przenoszenia wirusa SARS-CoV-2 drogą powietrzną w pomieszczeniach wentylowanych (Probability of airborne transmission of SARS-CoV-2 virus in ventilated rooms).(en polonais)
Instal, Vol. n°(2), (2022), pp. 23-29

Using the Wells-Riley model, for different types of rooms, the probability of airborne transmission and reproduction number of SARS-CoV-2 coronavirus (together with Delta and Omicron variants) depending on the type of ventilation and outdoor air flow rate were determined. The analyses were carried out for air flows assumed in the literature and Polish regulations for particular types of rooms and for the permissible or standard number of persons occupying them. Various scenarios was also determined and considered assuming typical time of occupancy in particular types of rooms. The influence of safety rules was also determined and the use of protective masks on the COVID-19 disease transmission by air in rooms.

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Albettar, M., Leon Wang, L., Katal, A.
A real-time web tool for monitoring and mitigating indoor airborne COVID-19 transmission risks at city scale.
Sustainable cities and society, Vol. **80**, (2022)

Airborne transmission of aerosols contributes to a large portion of the SARS-CoV-2 spread indoors. This study develops a real-time interactive web-based platform for the public to compare various strategies to curb indoor airborne transmission of COVID-19 in different archetype buildings at a city scale. Although many countries have started vaccination and a gradual re-opening, because of emerging new variants of the virus and the possibility of future pandemics, a lively updated tool for monitoring and mitigation of infection risk is essential. As a demonstration, we evaluated the impacts of six mitigation measures on the infection risks in various building types in a city. It shows that the same strategy could perform quite differently, depending on building types and properties. All strategies are shown to reduce the infection risk but wearing a mask and reducing exposure time are the most effective strategies in many buildings, with around 60% reduction. Doubling the minimum required outdoor air ventilation rate is not as effective as other strategies to reduce the risk. It also causes considerable penalties on energy consumption. Therefore, new building ventilation standards, control actions, and design criteria should be considered to mitigate the infection risk and save energy.

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Giovanditto, F., Soma, D., Vaira, L. A., Pispero, A., Lombardi, N., Ristoldo, F.*, et al.*
Recommendations for a safe restart of elective aerosol-generating oral surgery procedures following the COVID-19 pandemic outbreak: An Italian multicenter study.
Journal of Cranio-Maxillofacial Surgery, (2022)

Among healthcare workers, oral and maxillofacial surgeons are some of the most exposed to coronavirus disease (COVID-19). The aim of this retrospective study was to develop suggestions for continuing the work of oral and maxillofacial surgeons using a safe protocol for elective and urgent aerosol-generating procedures

that could prevent the onset of new clusters. Based on the results obtained and a guidelines review of those Asian countries that had promptly managed the current pandemic, the following safety protocol was developed:

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Taheri, H., Rider, T. R.
A review on architectural guidelines to safely reopen buildings in light of COVID-19 in the United States: establishing future research opportunities.
Architectural Science Review, (2022)

COVID-19 has caused public health and economic crises in many countries including the United States. Engineering control strategies are cited by leading agencies as the second effective recommendation after virus elimination to safer reopen buildings during the pandemic. This paper systematically surveyed and synthesized highly cited architectural guidelines in the U.S. published by leading agencies. As reviewed in this paper, all reviewed architectural strategies agreed on the importance of increasing outdoor air ventilation and maintaining social distancing, without specific consideration of the potential impact of these strategies on other aspects of buildings and occupants. Thus, this paper provides foundational knowledge for future studies around safer buildings during future pandemics and suggests conducting more pre/post-occupancy evaluations that incorporate human-centered studies and building performance analysis, using qualitative and quantitative methods to support various building stakeholders in making more informed decisions around recommendations to positively and holistically impact occupants and buildings.

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Biswas, R., Pal, A., Pal, R., Sarkar, S., Mukhopadhyay, A.
Risk assessment of COVID infection by respiratory droplets from cough for various ventilation scenarios inside an elevator: An OpenFOAM-based computational fluid dynamics analysis.
Physics of Fluids, Vol. **34** n°(1), (2022)

Respiratory droplets-which may contain disease spreading virus-exhaled during speaking, coughing, or sneezing are one of the significant causes for the spread of the ongoing COVID-19 pandemic. The droplet dispersion depends on the surrounding air velocity, ambient temperature, and relative humidity. In a confined space like an elevator, the risk of transmission becomes higher when there is an infected person inside the elevator with other individuals. In this work, a numerical investigation is carried out in a three-dimensional domain resembling an elevator using OpenFoam. Three different modes of air ventilation, viz., quiescent, axial exhaust draft, and exhaust fan, have been considered to investigate the effect of ventilation on droplet transmission for two different climatic conditions (30 & DEG;C, 50% relative humidity and 10 degrees C, 90% relative humidity). The risk assessment is quantified using a risk factor based on the time-averaged droplet count present near the passenger's hand to head region (risky height zone). The risk factor drops from 40% in a quiescent scenario to 0% in an exhaust fan ventilation condition in a hot dry environment. In general, cold humid conditions are safer than hot dry conditions as the droplets settle down quickly below the risky height zone owing to their larger masses maintained by negligible evaporation. However, an exhaust fan renders the domain in a hot dry ambience completely safe (risk factor, 0%) in 5.5 s whereas it takes 7.48 s for a cold humid ambience.

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Piscitelli, P., Miani, A., Setti, L., De Gennaro, G., Rodo, X., Artinano, B.*, et al.*
The role of outdoor and indoor air quality in the spread of SARS-CoV-2: Overview and recommendations by the research group on COVID-19 and particulate matter (RESCOP commission).
Environmental Research, Vol. **211**, (2022)

There are important questions surrounding the potential contribution of outdoor and indoor air quality in the transmission of SARS-CoV-2 and perpetuation of COVID-19 epidemic waves. Environmental health may be a critical component of COVID-19 prevention. The public health community and health agencies should consider the evolving evidence in their recommendations and statements, and work to issue occupational guidelines. Evidence coming from the current epidemiological and experimental research is expected to add knowledge about virus diffusion, COVID-19 severity in most polluted areas, inter-personal distance requirements and need for wearing face masks in indoor or outdoor environments. The COVID-19 pandemic has highlighted the need for maintaining particulate matter concentrations at low levels for multiple health-related reasons, which may also include the spread of SARS-CoV-2. Indoor environments represent even a more crucial challenge to cope with, as it is easier for the SARS-COV2 to spread, remain vital and infect other subjects in closed spaces in the presence of already infected asymptomatic or mildly symptomatic people. The potential merits of preventive measures, such as CO2 monitoring associated with natural or controlled mechanical ventilation and air purification, for schools, indoor public places (restaurants, offices, hotels, museums, theatres/cinemas etc.) and transportations need to be carefully considered. Hospital settings and nursing/retirement homes as well as emergency rooms, infectious diseases divisions and ambulances represent higher risk indoor environments and may require additional monitoring and specific decontamination strategies based on mechanical ventilation or air purification.

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Leonardi, A. J., Mishra, A. K.
A Sanitation Argument for Clean Indoor Air: Meeting a Requisite for Safe Public Spaces.
Frontiers in public health, Vol. **10**, (2022)

In public health terms, “sanitation” refers to a public health implementation of hygienic standards and practices meant to address transmissible diseases like Malaria and Cholera in industrial and public settings like factories, schools, and resorts (1). We propose the management of air given the current pandemic with an airborne pathogen (2). Sanitation has had a stable history as a primary focus in the field of public health engineering, responsible for potable water, waste management, and control of mosquito breeding-grounds (1, 3). Since addressed by a sanitation approach, the effective handling of vector media has made outbreaks and epidemics like the cholera outbreak of 1,911 in New York City unrepeated in the USA (1). However, rarely have pathogens been met with mitigations and public health sanitation measures considering airborne transmission, save for sanitariums and open-air schools for Tuberculosis and the “Fresh Air” movement during the 1918 Influenza Pandemic, which were both caused by pathogens spreading by aerosols (4–6). In such a rare, but notable example in 1918, an open-air hospital in Boston was retrospectively found to benefit the staff by reducing Influenza infection (7). Given our current pandemic, we believe such ventilation measures should be readopted and the air should be sanitized.
As new evidence shows airborne pathogens such as SARS-Cov-2 spread via aerosols, we should refine what is a nebulous attribution of responsibility in mitigating the spread of airborne pathogens indoors and assign it under the purview of public health sanitation and engineering in order to effectively manage indoor air (2). A building's ventilation system is critical to maintaining a healthy work environment (8). Humans breathe in many times more air than our food or water intake—around 6 liters/minute (7). Therefore, we argue for the sanitation of air under the domain of public health environmental engineering, and echo the calls for a necessary paradigm shift via measures such as ventilation and filtration (8).

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Alsved, M., Nygren, D., Thuresson, S., Medstrand, P., Fraenkel, C.-J., Löndahl, J.
SARS-CoV-2 in exhaled aerosol particles from covid-19 cases and its association to household transmission.
Clinical Infectious Diseases, (2022)

Covid-19 transmission via exhaled aerosol particles has been considered an important route for the spread of infection, especially during super-spreading events involving loud talking or singing. However, no study has previously linked measurements of viral aerosol emissions to transmission rates.During Feb-Mar 2021, covid-19 cases that were close to symptom onset were visited with a mobile laboratory for collection of exhaled aerosol particles during breathing, talking and singing, respectively, and of nasopharyngeal and saliva samples. Aerosol samples were collected using a BioSpot-VIVAS and a NIOSH bc-251 two-stage cyclone, and all samples were analyzed by RT-qPCR for SARS-CoV-2 RNA detection. We compared transmission rates between households with aerosol-positive and aerosol-negative index cases.SARS-CoV-2 RNA was detected in at least one aerosol sample from 19 of 38 (50%) included cases. The odds ratio of finding positive aerosol samples decreased with each day from symptom onset (OR 0.55, 95CI 0.30-1.0, p=0.049). The highest number of positive aerosol samples were from singing, 16 (42%), followed by talking, 11 (30%), and the least from breathing, 3 (8%). Index cases were identified for 13 households with 31 exposed contacts. Higher transmission rates were observed in households with aerosol-positive index cases, 10/16 infected (63%), compared to households with aerosol-negative index cases, 4/15 infected (27%) (Chi-square test, p=0.045).Covid-19 cases were more likely to exhale SARS-CoV-2-containing aerosol particles close to symptom onset and during singing or talking as compared to breathing. This study supports that individuals with SARS-CoV-2 in exhaled aerosols are more likely to transmit covid-19.

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Dai, R., Liu, S., Li, Q., Wu, H., Wu, L., Ji, C.

A systematic review and meta-analysis of indoor bioaerosols in hospitals: The influence of heating, ventilation, and air conditioning.

Plos One, Vol. **16** n°(12), (2021)

Objectives To evaluate (1) the relationship between heating, ventilation, and air conditioning (HVAC) systems and bioaerosol concentrations in hospital rooms, and (2) the effectiveness of laminar air flow (LAF) and high efficiency particulate air (HEPA) according to the indoor bioaerosol concentrations. Methods Databases of Embase, PubMed, Cochrane Library, MEDLINE, and Web of Science were searched from 1st January 2000 to 31st December 2020. Two reviewers independently extracted data and assessed the quality of the studies. The samples obtained from different areas of hospitals were grouped and described statistically. Furthermore, the meta-analysis of LAF and HEPA were performed using random-effects models. The methodological quality of the studies included in the meta-analysis was assessed using the checklist recommended by the Agency for Healthcare Research and Quality. Results The mean CFU/m(3) of the conventional HVAC rooms and enhanced HVAC rooms was lower than that of rooms without HVAC systems. Furthermore, the use of the HEPA filter reduced bacteria by 113.13 (95% CI: -197.89, -28.38) CFU/m(3) and fungi by 6.53 (95% CI: -10.50, -2.55) CFU/m(3). Meanwhile, the indoor bacterial concentration of LAF systems decreased by 40.05 (95% CI: -55.52, -24.58) CFU/m(3) compared to that of conventional HVAC systems. Conclusions The HVAC systems in hospitals can effectively remove bioaerosols. Further, the use of HEPA filters is an effective option for areas that are under-ventilated and require additional protection. However, other components of the LAF system other than the HEPA filter are not conducive to removing airborne bacteria and fungi. Limitation of study Although our study analysed the overall trend of indoor bioaerosols, the conclusions cannot be extrapolated to rare, hard-to-culture, and highly pathogenic species, as well as species complexes. These species require specific culture conditions or different sampling requirements. Investigating the effects of HVAC systems on these species via conventional culture counting methods is challenging and further analysis that includes combining molecular identification methods is necessary. Strength of the study Our study was the first meta-analysis to evaluate the effect of HVAC systems on indoor bioaerosols through microbial incubation count. Our study demonstrated that HVAC systems could effectively reduce overall bioaerosol concentrations to maintain better indoor air quality. Moreover, our study provided further evidence that other components of the LAF system other than the HEPA filter are not conducive to removing airborne bacteria and fungi.

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Tandon, P., Leibner, E. S., Hackett, A., Maguire, K., Mashriqi, N., Kohli-Seth, R.

The Third Wave: Comparing Seasonal Trends in COVID-19 Patient Data at a Large Hospital System in New York City.

Critical Care Explorations, Vol. **4** n°(3), (2022)

IMPORTANCE:
The third wave of COVID-19 is unique in that vaccines have been widely available; however, the highly transmissible Delta variant has been the predominant strain. Temporal changes of hospitalized patient characteristics should continue to be analyzed as COVID-19 progresses.
OBJECTIVES:
Compare the demographics and outcomes of hospitalized patients during New York City's third wave of COVID-19 to the first two waves.
DESIGN, SETTING, AND PARTICIPANTS:
Retrospective cohort study across five hospitals within Mount Sinai Health System, a quaternary academic medical system in New York City. Participants were adult inpatients admitted with COVID-19 identified by positive severe acute respiratory syndrome coronavirus 2 polymerase chain reaction at admission or clinical documentation of infection during the three waves of COVID-19.
MAIN OUTCOMES AND MEASURES:
Patient demographics, comorbidities, vaccination status, and outcomes of COVID-19 patients hospitalized at Mount Sinai Health System were examined. Patients admitted during the third wave were notably younger than the first two, were mostly unvaccinated against COVID-19, and there was a higher rate of patients who self-report as Black or African American as compared with the first two waves. The rate of patients requiring ICU level of care remained consistent throughout all three periods; however, the rate of patients requiring invasive mechanical ventilation decreased and inhospital mortality has trended down. Unvaccinated patients in the third wave are significantly younger with lower comorbidity burden than fully vaccinated patients.
RESULTS:
A total of 13,036 patients were included between the 3 waves. In the 3rd wave patients were notably younger, with a lower intubation rate and lower inhospital death rate. In the 3rd wave, 400 (62.9%) were unvaccinated, 236 (37.1%) were fully vaccinated, and 34 (4.8%) were partially vaccinated. Unvaccinated patients had similar rates of intubation and invasive mechanical ventilation compared with vaccinated patients, though inhospital mortality was lower in unvaccinated patients compared with vaccinated patients which may be expected given their lower age and burden of comorbidities.
CONCLUSIONS AND RELEVANCE:
We continue to see improved outcomes in hospitalized COVID-19 patients. Patients that are unvaccinated against COVID-19 are younger and have less reported comorbidities.

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Ratajczak, K.

Ventilation Strategy for Proper IAQ in Existing Nurseries Buildings-Lesson Learned from the Research during COVID-19 Pandemic.

Aerosol and Air Quality Research, Vol. **22** n°(3), (2022)

During the COVID-19 pandemic, many recommendations were made in the field of limiting the transmission of the SARS-CoV-2 virus, from which we can learn a lesson for determining ventilation strategies in strategic types of buildings (those whose closure during a pandemic is harmful to the economy, e.g., nurseries). The research was aimed at identifying recommendations in the field of ventilation and proposing a solution that would be applicable in existing buildings intended for the care of small children, and which would ensure the proper quality of the building environment, at the same time with low costs incurred by the owners. The outside air pollution (PM10) and the climate in winter (low air temperature) were also taken into account. A

strategy was proposed based on the use of decentralized units, dedicated to single rooms, thanks to which the appropriate amount of air is supplied (per person), the air is cleaned and heated in the heat recovery exchanger. It has been shown that the use of heat recovery ensures that the costs of air heating will be significantly lower than during airing. The proposed solutions require two holes in the external wall with a diameter of 160-200 mm (depending on the number of people), which guarantees the technically possible application in existing buildings. The strategy provides suitable conditions for the functioning of nurseries, but can be used in many types of buildings, in cold and temperate climates, where airing of the rooms during winter is not possible, especially in the case of locations where the quality of outdoor air is very poor. The proposed strategy may be applied during a pandemic, but also on a daily basis, because by ensuring the proper quality of indoor air, young children will have healthy and hygienic conditions for development when they are not at home.

Annexes https://aaqr.org/articles/aaqr-21-11-covid2-0337_suppl.pdf
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Glenn, K., He, J., Rochlin, R., Teng, S., Hecker, J. G., Novosselov, I.
Zonal Model of Aerosol Persistence in ICUs: Utilization of Time and Space-resolved Sensor Network.
Department of Mechanical Engineering, Department of Anesthesiology and Pain Medicine, University of Washington 2022

The COVID-19 pandemic heightened public awareness about airborne particulate matter (PM) due to the spread of infectious diseases via aerosols. The persistence of potentially infectious aerosol in public spaces, particularly medical settings, deserves close investigation; however, approaches for rapidly parameterizing the temporospatial distribution of particles released by an infected individual have not been reported in literature. This paper presents a methodology for mapping the movement of aerosol plumes using a network of low-cost PM sensors in ICUs. Mimicking aerosol generation by a patient, we tracked aerosolized NaCl particles functioning as tracers for potentially infectious aerosols. In positive (closed door) and neutral-pressure (open door) ICUs, an aerosol spike was detected outside the room, with up to 6% or 19% of all PM escaping through the door gaps, respectively. The outside sensors registered no aerosol spike in negative-pressure ICUs. The K-means clustering analysis of temporospatial data suggests three distinct zones: (1) near the aerosol source, (2) room periphery, and (3) immediately outside the room. These zones inform two-phase aerosol plume behavior: dispersion of the original aerosol spike throughout the room, and evacuation phase where “well-mixed” PM decayed uniformly. Decay rates were calculated for 4 ICUs in positive, neutral, and negative mode, with negative modes decaying the fastest. This research demonstrates the methodology for aerosol persistence monitoring in medical settings; however, it is limited by a relatively small data set. Future studies need to evaluate medical settings with high risks of infectious disease, assess risks of airborne disease transmission, and optimize hospital infrastructure.

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