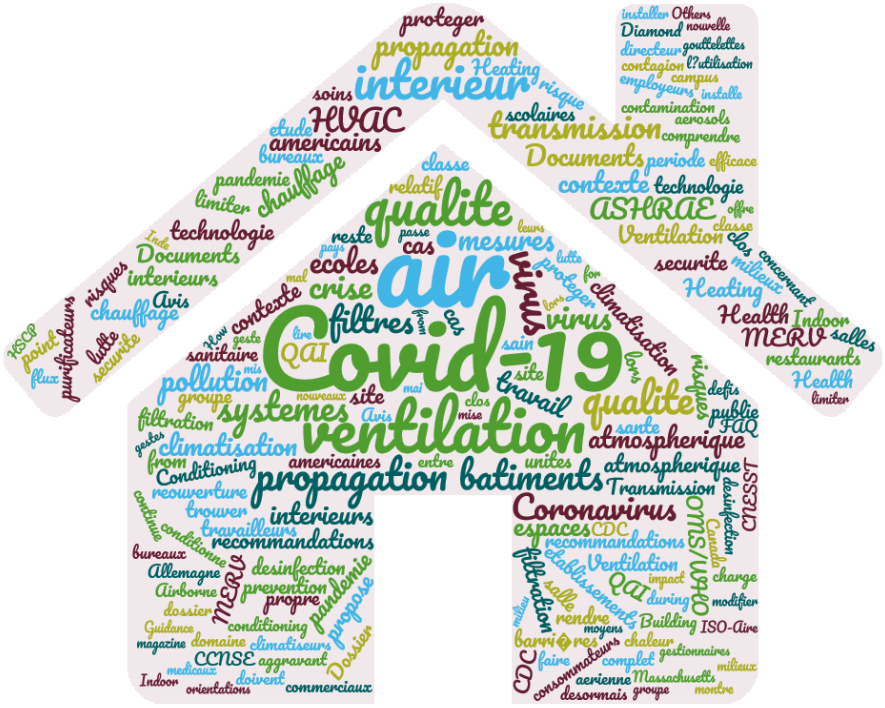

Rapport de veille n° 102

Aéraulique et COVID-19

23/10/2024

Les bulletins de veille sont disponibles pour le personnel de l'INRS sur le portail documentaire de l'INRS.
Pour les lecteurs externes, merci de les consulter sur le portail documentaire public.
L'abonnement vous permet de recevoir une alerte mail lors de la publication d'un nouveau bulletin (bouton « M'abonner »).

Google Scholar, Lens et WoS

Greco, E., Gaetano, A. S., De Spirt, A., Semeraro, S., Piscitelli, P., Miani, A.*, et al.*
AI-Enhanced Tools and Strategies for Airborne Disease Prevention in Cultural Heritage Sites.
Epidemiologia, Vol. **5** n°(2), (2024), 267-274 p.

In the wake of the COVID-19 pandemic, the surveillance and safety measures of indoor Cultural Heritage sites have become a paramount concern due to the unique challenges posed by their enclosed environments and high visitor volumes. This communication explores the integration of Artificial Intelligence (AI) in enhancing epidemiological surveillance and health safety protocols in these culturally significant spaces. AI technologies, including machine learning algorithms and Internet of Things (IoT) sensors, have shown promising potential in monitoring air quality, detecting pathogens, and managing crowd dynamics to mitigate the spread of infectious diseases. We review various applications of AI that have been employed to address both direct health risks and indirect impacts such as visitor experience and preservation practices. Additionally, this paper discusses the challenges and limitations of AI deployment, such as ethical considerations, privacy issues, and financial constraints. By harnessing AI, Cultural Heritage sites can not only improve their resilience against future pandemics but also ensure the safety and well-being of visitors and staff, thus preserving these treasured sites for future generations. This exploration into AI's role in post-COVID surveillance at Cultural Heritage sites opens new frontiers in combining technology with traditional conservation and public health efforts, providing a blueprint for enhanced safety and operational efficiency in response to global health challenges.

****

Niza, I. L., Bueno, A. M., Gameiro Da Silva, M., Broday, E. E.
Air quality and ventilation: Exploring solutions for healthy and sustainable urban environments in times of climate change.
Results in Engineering, Vol. **24**, (2024)

Ensuring sustainability and reducing energy consumption in the built environment is essential for achieving energy efficiency and comfort. To obtain a healthy and sustainable urban environment, indoor air quality and ventilation play a crucial role inside buildings since billions of people live in urban environments worldwide and spend significant time indoors. Considering the relevance of this theme, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was adopted to conduct a review regarding air quality and ventilation and their impacts on urban environments. The search identified 7568 articles related to the topic, of which 103 were selected after applying the criteria defined to answer four research questions. The main findings of this research are: (I) Analysis of design strategies related to indoor air quality shows that ventilation plays a key role in promoting healthy and comfortable conditions; (II) Air distribution involves controlling temperature, velocity, humidity and pollutant concentration, thus creating an indoor environment with low energy consumption and high air quality; (III) The Covid-19 pandemic has emphasized the urgency of addressing Indoor Air Quality (IAQ) and ventilation as crucial strategies in reducing the spread of respiratory viruses; (IV) Climate change and the global energy crisis have imposed significant pressure on the construction industry to design buildings with low energy consumption, especially in developed countries with high levels of energy consumption.

****

Alhussain, H., Ghani, S., Eltai, N. O.
Breathing clean air: Navigating indoor air purification techniques and finding the ideal solution.

The prevalence of airborne pathogens in indoor environments presents significant health risks due to prolonged human occupancy. This review addresses diverse air purification systems to combat airborne pathogens and the factors influencing their efficacy. Indoor aerosols, including bioaerosols, harbor biological contaminants from respiratory emissions, highlighting the need for efficient air disinfection strategies. The COVID-19 pandemic has emphasized the dangers of airborne transmission, highlighting the importance of comprehending how pathogens spread indoors. Various pathogens, from viruses like SARS-CoV-2 to bacteria like Mycobacterium (My) tuberculosis, exploit unique respiratory microenvironments for transmission, necessitating targeted air purification solutions. Air disinfection methods encompass strategies to reduce aerosol concentration and inactivate viable bioaerosols. Techniques like ultraviolet germicidal irradiation (UVGI), photocatalytic oxidation (PCO), filters, and unipolar ion emission are explored for their specific roles in mitigating airborne pathogens. This review examines air purification systems, detailing their operational principles, advantages, and limitations. Moreover, it elucidates key factors influencing system performance. In conclusion, this review aims to provide practical knowledge to professionals involved in indoor air quality management, enabling informed decisions for deploying efficient air purification strategies to safeguard public health in indoor environments.

****

Bk, S.
Building resilience: Examining the impact of cultural behaviour on air quality in British Asian homes.
PLEA 2024: 37th PLEA Conference (Re)thinking resilience, Wroclaw, Poland, 25-28 June 2024

There is a limited understanding of householders' cultural differences, resultant energy behaviour and its impact on indoor air quality. Indoor air quality directly impacts the health and well-being of occupants. The airborne COVID-19 epidemic has highlighted shortcomings of controlled ventilation systems in recent reports. The recently published works including National Design Guide (Jan 2021) are underpinned by the quality of life for the occupants and users of buildings. However, there is a lack of reference to the socio-cultural background of the occupants and how it informs the way we use spaces and hence its impact on indoor thermal comfort, overheating and air quality. The main aim of this research is therefore to develop insights into the realities associated with the social and physical context of one of the key cultural practices, cooking, in kitchens. The impact of cultural behaviour on indoor thermal conditions is examined by studying the impact of cooking on indoor air quality in British-Asian homes in comparison with white British homes through a detailed study of households in Plymouth and Cardiff, UK. This project lays the foundations for larger-scale research working with diverse ethnic minority communities to promote a resilient, inclusive, low-carbon society.

****

Morawska, L.
The burden of disease due to indoor air pollution and why we need to know about it.
Science Bulletin, (2024)

Indoor air pollution is often invisible and undetected by our olfactory sensors, but this is not the only reason for dismissing it as an interesting scientific topic; many areas of invisible, nano-scale science are hot topics. Maybe we do not think much about indoor air because of the long lag between cause and effect, so that we never know if it was the indoor air that made us sick. Or perhaps the perceived safety of our shelters, homes, offices or classrooms makes us blind to their dangers?
So what makes indoor air science so complex? It is the presence of thousands of pollutants in gaseous and particulate phases, which interact with each other through a myriad of physicochemical reactions [3], [4], [5]. It is also the presence of a rich biome of viruses, bacteria, and fungi [6], [7]. These pathogens often thrive in

indoor environments if the building design, its engineering, and the way we operate the whole system provide them with favourable conditions [8]. These pollutants and biological menageries come from all anthropogenic and natural sources that are outside, from sources that we bring or generate inside, and from us—humans are the main source of indoor airborne bacteria and viruses.

****

Li, X., Zhu, L., Zhang, N., Liu, J., Hua, W., Dou, W.*, et al.*
Can the infection risk in elevators be negligible? A comparative study of airborne infection probability in elevators and conference rooms.
Energy and Buildings, Vol. **324**, (2024)

People in crowded and poorly ventilated elevators are at risk of respiratory infection. However, due to the short duration of the elevator ride, the transmission of respiratory diseases in elevators does not get enough attention. To evaluate the infection risk, this study investigated the airborne transmission of respiratory diseases in the hospital elevator by comparison to the conference room. A validated computational fluid dynamics (CFD) model was adopted to simulate airflow, temperature and tracer gas dispersion in the elevator and conference room. We used Wells-Riley model to evaluate the infection probability of the susceptible persons. In addition, the influences of source patient posture and ventilation strategy on the transmission of tracer gas were analyzed. The results showed that the infection probability in the elevator with 5 min (average 2.70%) was higher than that in the conference room with 50 min (average 1.77%). The effects of source patient posture and ventilation strategy on the infection probability in the elevator were more significant than those in the conference room. Local air circulation could gather the tracer gas inside a confined space in the elevator and led to a high infection probability. The infection risk of respiratory diseases in the elevator was non-negligible.

****

Suman, Thera, E. D., Kumar, N.
Chapter 9 - Ventilation and indoor air quality.
In: Health Effects of Indoor Air Pollution. Academic Press; 2024. 223-231 p.

Air pollutants in the vicinity of constructions and buildings are frequently known as indoor air quality (IAQ), especially when they have an impact on the well-being and welfare of human beings staying in the building. Indoor air pollution can be minimized with awareness of how to control various indoor air pollutants and contaminants. As most of our time is spent inside, real-time data and adequate IAQ are crucial for preserving our health and productivity. According to the EPA, interior air is much more polluted than outdoor air because of occupant changes in habits, dust, ineffective or poor maintenance of ventilation systems, and volatile organic compounds present in buildings. People, therefore, require accurate and widespread real-time air quality measurement, especially those whose health is sensitive to poor IAQ. An effort has been made in this chapter to draw a link between ventilation and indoor air pollutants and their quality in the environment. The quality of indoor air is improved by proper ventilation. Ventilation can regulate indoor humidity and airborne pollutants that cause or pose health hazards. Ventilation, or the movement of air into or out of dwellings, is a crucial component of having appropriate IAQ. Ventilation can enhance IAQ by eliminating contaminants from the house and bringing in fresh air from the outside.

****

Chalin, D., Rochal, S.
Conceptual model of electrostatic non-ionizing air filter.
Phys Scr, Vol. **99** n°(11), (2024)

Many infectious diseases such as SARS-CoV-2, rhinovirus, adenovirus, and influenza are transmitted through small respiratory droplets and various filtration systems are used to reduce the risk of airborne infection. Here, we develop a conceptual model of a filter, which is based on the electrostatic deposition of air droplets potentially containing pathogens. Within the model, we explore the effect of polarization of neutral spherical droplets moving in an air flow past cylindrical electrodes. The strength of electric field they produce is low enough to eliminate corona discharge and minimize air ionization, but high enough to capture the droplets. Based on the proposed model, we calculate the filtration efficiency in a quasi-continuous approximation. Also, we conduct numerical simulations of the deposition of respiratory droplets on a compact periodic array of cylindrical electrodes located at the nodes of a square lattice. The droplets with a radius of 10–20 μm pose the greatest threat in spreading the respiratory infections, and as we demonstrate, the proposed system is very effective in capturing droplets of this size, specifically, for a filter element with a width of about 5 mm, the filtration efficiency exceeds 90%.

****

Chen, Y., Zhuang, W., Gu, Y., Yang, Z.
Correlating surface mold contamination with airborne pollution under mild indoor air disturbance: A case study of Aspergillus niger.
Building and Environment, Vol. **266**, (2024), 112107 p.

Surface mold on building materials constitutes a major indoor pollution source. Indoor airflow disturbances can aerosolize the mold, posing health risks like asthma. However, while studies have explored higher airflow rates typical of air ducts, the relationship between surface mold release and the more common mild indoor airflow conditions (≤1.0 m/s) has not been well established, hindering the understanding of surface-induced mold aerosols. This study addresses this gap by experimentally examining the release dynamics of surface mold under various mild airflow conditions, using Aspergillus niger-contaminated plaster surfaces as examples. The experiments focused on the release intensity (RI) and suspension proportion (SP) of mold across different airflow rates, temperatures, humidity levels, and impact angles. Based on 375 experimental tests, two empirical formulas and two models were established using a hierarchical modeling method to predict the concentration of airborne mold released per disturbance airflow and surface mold-induced indoor air pollution. Results indicate that a substantial amount of surface mold was aerosolized within 0.18 s under mild airflow disturbance, with source concentrations ranging from 1.1 × 105 to 1.5 × 105 CFU/m3 per disturbing airflow, and 30.4 %–85.2 % of the mold remained suspended for 10 min. The empirical formulas were verified to achieve high accuracy, with ±6 % for RI and ±10 % for SP. The predictive models were also validated through new experiments, achieving an accuracy of 5 % for predicting surface mold-induced indoor air pollution levels and the source concentration of airborne mold. This work offers a foundation for predicting indoor mold pollution.

****

Park, J., Lee, K. H., Song, Y. G., Park, H., Lee, K. S.
Development of optimal indoor air disinfection and ventilation protocols for airborne infectious diseases.
PLoS One, Vol. **19** n°(10), (2024)

Since the COVID-19 pandemic, there has been persistent emphasis on the importance of indoor air disinfection and ventilation in isolation units in the hospital environment. Nevertheless, no optimal and concrete disinfection protocol has been proposed to inactivate the viruses as quickly as possible. In this study, we experimentally evaluated various ventilation and disinfection protocols based on the combination of negative-pressure ventilation, ultraviolet (UV) light illumination, and Hypochlorous acid (HOCl) spray against three active virus species in a 3.5 cubic meters isolation unit. This small-size unit has gained attention during the pandemic due to the high demand for compact mobile laboratory systems capable of rapid disease diagnosis. In accordance with the WHO laboratory biosafety guidance, which states that all enclosed units

where diagnostic work is conducted must ensure proper ventilation and disinfection activities, we aim to propose virus removal protocols for units compact enough to be installed within a van or deployed outdoor. The results confirmed the superiority (in terms of virus removal rate and time required) of the virus removal methods in the order of UV light, ventilation, and HOCl spray. Ultimately, we propose two optimal protocols: (i) UV light alone for three minutes, and (ii) UV light with ventilation for three minutes, followed by one-minute ventilation only. The time span of three minutes in the latter protocol is based on the clinical practice such that the medical staffs have a sufficient time to process the samples taken in transition to next patient to care.

****

Song, Z., Deng, L., Liu, X., Zhou, H., Wu, X., Han, Y.*, et al.*
Distribution characteristics and analysis of fungal aerosol concentration and particle size in air-conditioned wards in Wuhan, China.
Ann Agric Environ Med, (2024)

Fungal contamination in the air of hospital wards can affect the health of medical staff, patients, and caregivers. Through systematic analysis of the concentration, types, and particle size distribution characteristics of fungi in the air of wards in Wuhan, China, in 2023, it was found that there was no significant correlation between the concentration of fungi in the air of wards and the disease type and personnel density. The main influencing factors were temperature, humidity, and seasonal changes. The distribution characteristics of fungal particle size in the wards of various departments in winter and summer showed a roughly normal distribution, with the percentage of particle size gradually increasing from stage I to stage III. The proportion from stage III to stage V was generally the highest, while the proportion from stage V to stage VI gradually decreased. There was no significant difference in the median diameter of airborne fungal conidia between different departments in winter and summer, and the median diameter of fungal conidia was less than 3.19 μm. The dominant fungal genus in the wards during winter and summer were basically the same, and there was no significant difference compared to wards in other inpatient buildings. The current study indicates that more attentions should be paid to the increasing of filtration efficiency of fungal conidia particle sized from 1.1~4.7 μm, and appropriate antifungal and sterilization drugs, equipments and methods should be selected in the maintenance of daily hygiene, including the operation and management of the air conditioning systems in the inpatient wards.

****

Brock, R. C., Goudie, R. J. B., Peters, C., Thaxter, R., Gouliouris, T., Illingworth, C. J. R.*, et al.*
Efficacy of Air Cleaning Units for preventing SARS-CoV-2 and other hospital-acquired infections on medicine for older people wards: A quasi-experimental controlled before-and- after study.
Journal of Hospital Infection, (2024)

Summary Background Nosocomial infections are costly and airborne transmission is increasingly recognised as important for spread. Air Cleaning Units (ACUs) may reduce transmission but little research has focused on their effectiveness on open wards. Aim Assess whether ACUs reduce nosocomial SARS-CoV-2, or other, infections on older adult inpatient wards. Methods Quasi-experimental before-after study on two intervention-control ward pairs in a UK teaching hospital. Infections were identified using routinely collected electronic health records data during one year of ACU implementation and the preceding year (“core study period”). Extended analyses included 6 months additional data from one ward pair following ACU removal. Hazard ratios (HR) were estimated through Cox regression controlling for age, sex, ward and background infection risk. Time the ACUs were switched on was also recorded for intervention ward 2. Findings ACUs were initially feasible but compliance reduced towards the end of the study (average operation in first vs second half of ACU time on intervention ward 2: 77% vs 53%). 8171 admissions >48hrs (6112 patients, median age 85yrs) were included. Overall, incidence of ward-acquired SARS-CoV-2 was 3.8%. ACU implementation

was associated with a non-significant trend of lower hazard for SARS-CoV-2 infection (HR core study period 0.90, 95% CI 0.53, 1.52; extended study period 0.78, 95% CI 0.53, 1.14). Only 1.5% of admissions resulted in other notable ward-acquired infections. Conclusion ACUs may reduce SARS-CoV-2 infection to a clinically-meaningfully degree. Larger studies could reduce uncertainty, perhaps using a cross-over design, and factors influencing acceptability to staff and patients should be further explored.

****

Al-Rikabi, I. J., Alsaad, H., Carrigan, S., Voelker, C.
The efficiency of portable air cleaners in reducing cross-exposure through respiratory aerosols: Effects of flowrate, location, and unit type.
Building and Environment, Vol. **267**, (2025)

This study evaluates the efficacy of portable air cleaners (PACs) in a controlled climate chamber that simulates an office environment, assessing their impact on respiratory particle transmission between two thermal manikins (representing an infected and an exposed individual) as well as on the noise level in the chamber. The study explores three types of PAC, namely floor-type (PAC1), table (PAC2) and personalized (PAC3) in various locations and operation modes. The particles were generated using an aerosol generator and introduced into the infected manikin's exhalation; the particle concentration at the exposed manikin's breathing zone (BZ) was measured using an aerodynamic particle sizer. The results showed that the PAC2, operating at a flow rate of 97 m^3/h, significantly reduced the intake fraction (IF) by over 90 % within the first hour, proving to be the most effective in minimizing cross-exposure risks while maintaining sound levels within the acceptable limits for office rooms. In contrast, PAC3, with a lower flow rate of 13 m^3/h, reduced IF by only 21.6 % after 60 min. The result also showed that settings with higher flow rates (higher than 134 m3/h) resulted in noise levels above the maximum allowable for office spaces for all tested PACs. Additionally, prolonged operation did not further decrease IF significantly after reaching optimal reduction levels within 30–60 min, depending on the PAC type and settings. Further, the study showed that strategic placement away from direct alignment with occupants' BZ is recommended to optimize aerosol removal and noise management.

****

Annadurai, G., Mathews, A. J., Krishnan, E. N., Gollamudi, S., Simonson, C. J.
Energy recovery ventilators to combat indoor airborne disease transmission: A sustainable approach.
Science and Technology for the Built Environment, (2024), 1-12 p.

Ventilation plays a crucial role in preventing indoor airborne disease transmission. Nevertheless, ventilation increases the energy consumption of HVAC systems. Therefore, energy efficiency measures or alternative methods must be adopted to reduce the energy demand of HVAC systems, which is necessary to achieve sustainability in the building sector. This study proposes a method of utilizing an energy recovery ventilator (ERV) to provide supplementary ventilation to reduce airborne disease transmission. The proposed method is tested for an office building with one source room (with an infected occupant) and two connected rooms (no infection source). The contributions of the present study are (i) the development and verification of a new supplement ventilation method using an ERV to reduce the probability of infection from airborne pathogens and (ii) providing the economic and environmental benefits of the proposed method to promote its adaption by the building managers/HVAC engineers. The results of the present study show that the proposed method can reduce the probability of infection by 10 to 40% and demonstrate that utilizing an ERV is a sustainable and economical method to improve ventilation to reduce indoor airborne disease transmission.

****

Makris, R., Kopic, C., Tawackolian, K., Schumann, L., Kriegel, M.

Experimental comparison of aerosol transmission in displacement ventilation and mixing ventilation in a meeting scenario.
International Journal of Ventilation, (2024), 1-23 p.

The performance of displacement ventilation (DV) and mixing ventilation (MV) in aerosol contamination control was compared. The considered contamination was an aerosol emitted from a person in meeting scenarios of two and four persons. The experiments were carried out in a full-scale room measuring 4.4?m???5.2 m???2.9?m. Particle counting was carried out at 41 measurement points in the room to assess the concentration field of particles in the room and in the inhalation zone. The influence of the supply airflow rate and the number of activated thermal mannequins on the contaminant removal effectiveness were examined. The main conclusion is that the DV system was superior to the MV system in reducing contamination. An enhanced contaminant removal effectiveness of displacement ventilation was observed for all supply air flow rates and increased with higher airflow rates. At lower airflow rates, contamination in the inhalation zone was reduced by 40% compared to mixing ventilation, while at higher flow rates, the reduction surpassed 50%. This study highlights the advantages of displacement ventilation in terms of contamination control, infection prevention and energy efficiency, emphasising the importance of ventilation system selection for indoor environments, particularly those where airborne transmission risks are prevalent. Displacement ventilation outperformed mixing ventilation in aerosol control in a meeting scenario.The contaminant removal effectiveness was superior in the inhalation zone and above exposed mannequins compared to the reference points at the breathing level.A possible flow rate reduction with displacement ventilation can significantly reduce energy costs.Ventilation system choice is crucial for infection control and energy saving. Displacement ventilation outperformed mixing ventilation in aerosol control in a meeting scenario. The contaminant removal effectiveness was superior in the inhalation zone and above exposed mannequins compared to the reference points at the breathing level. A possible flow rate reduction with displacement ventilation can significantly reduce energy costs. Ventilation system choice is crucial for infection control and energy saving.

****

Linder, A., Zhu, A., Bruns, R., Olsiewski, P., Gronvall, G.
FAR-UV Technology and Germicidal Ultraviolet (GUV) Energy: A Policy and Research Review for Indoor Air Quality and Disease Transmission Control.
Preprints, (2024)

COVID-19 highlighted the challenges of public acceptance of public health measures, including mask-wearing and vaccination. which has spurred interest in engineered approaches to reduce infections. Germicidal Ultraviolet (GUV) Energy has been used for decades in hospital rooms to limit TB transmission, but it is expensive to install in the upper part of rooms where it may be used safely. In contrast, FAR-UV energy is a relatively new, flexible technology that can be set up in rooms for moderate costs, and studies thus far indicate it is efficacious and not damaging to eyes or skin. To examine the state of the field, experts in aerosol biology, infection control, and building engineering from academia, government, and industry were convened to inform policy recommendations for future investments, identify research required, and examine policy options for using these technologies. Despite its high efficacy for deactivating several types of microorganisms and pathogens of concern, before FAR-UV technologies may be widely deployed, additional studies are needed to understand potential adverse effects, as well as the best approaches to use, standardize, and regulate the technology. In some environments, the use of FAR-UV can generate ozone, which can react with volatile organic compounds that may be hazardous to human health, such as respiratory tract irritation. Even with these concerns, the demonstrated effectiveness in disease control of both FAR-UV and longer wavelengths of GUV deserve increased policy attention to reduce risks of indoor disease transmission. While potentially useful to counter disease in high-risk indoor environments, further standardization and regulatory

measures, as well as research into the production of oxidative compounds is necessary before broad adoption of FAR-UV.

****

Najjar, A. A.
Fungi as Indicators of Indoor Air Quality: Their Effects on Human Health and Treatment.
Preprints, (2024)

Indoor air quality (IAQ) is a critical determinant of human health, with fungal contamination posing significant risks. In 2023, a total of 160 samples were collected from 40 selected rooms. These samples were cultured on Sabouraud Dextrose Agar (SDA) medium using a portable air sampler and incubated at 28°C for 7 days. Initial identification of fungal isolates was performed based on their morphology. Suspected isolates underwent further analysis using internal transcribed spacer (ITS) rDNA analysis. The results revealed 11 species across 8 genera in various rooms. The most prevalent fungi were Aspergillus niger (183 CFU) , Penicillium chrysogenum (139 CFU) and Cladosporium halotolerans (135 CFU). On the other hand, Curvularia hawaiiensis and A. ustus were rarely isolated (10 and 19 respectively). Effective treatment involves a combination of preventive measures, such as controlling humidity and ensuring proper ventilation, alongside targeted interventions like antifungal treatments and thorough cleaning. Continuous monitoring and management of indoor environments are essential to reduce fungal contamination, enhance air quality, and protect human health from the harmful effects of airborne fungi. This abstract underscore the importance of addressing indoor fungal contamination to promote safer, healthier living and working spaces.

****

Park, S., Rim, D.
Human exposure to air contaminants under the far-UVC system operation in an office: effects of lamp position and ventilation condition.
Scientific Reports, Vol. **14** n°(1), (2024)

The far-UVC (222 nm) system has emerged as a solution for controlling airborne transmission, yet its effect on indoor air quality, particularly concerning positioning, remains understudied. In this study, we examined the impact of far-UVC lamp position on the disinfection and secondary contaminant formation in a small office. We employed a three-dimensional computational fluid dynamics (CFD) model to integrate UV intensity fields formed by different lamp positions (ceiling-mounted, wall-mounted, and stand-alone types) along with the air quality model. Our findings reveal that the ceiling-mounted type reduces human exposure to airborne pathogens by up to 80% compared to scenarios without far-UVC. For all the lamp positions, O3 concentration in the breathing zone increases by 4–6 ppb after one hour of operation. However, it should be noted that a high concentration zone (> 25 ppb) forms near the lamp when it is turned on. Moreover, ventilation plays a crucial role in determining human exposure to airborne pathogens and secondary contaminants. Increasing the ventilation rate from 0.7 h−1 to 4 h−1 reduces airborne pathogen and secondary contaminant concentrations by up to 90%. However, caution is warranted as higher ventilation rates can lead to elevated O3 indoors, especially under conditions of high outdoor O3 concentrations.

****

Jiang, S., Cai, W., Luo, C., Zhang, F.
The impact of renovation on the air quality in the stadium, and prevention of indoor air pollution.
Environmental Research, Vol. **257**, (2024)

Indoor air quality is a critical factor influencing athletic performance, particularly in professional sports settings, yet its impact remains underexplored. This study utilizes a panel dataset from 2516 Chinese Basketball Association (CBA) matches across 20 cities in China between 2014 and 2019. We integrate daily air

pollution metrics with player efficiency ratings (PER) to investigate the effects of air quality on individual performance. We find that a 10% increase in the air quality index (AQI) corresponds to a 1.4223 decrease in PER, indicating a strong negative effect of poor air quality on player productivity. Different pollutants have varying effects, with some exacerbating the decline in both overall performance and precision in tasks. Notably, older players and international players exhibit greater resilience to air pollution. These insights contribute to the development of a comprehensive index for assessing work efficiency under varying air quality conditions and suggest targeted strategies to mitigate the negative impacts of air pollution in competitive athletic settings.

****

Li, P., Koziel, J. A., Paris, R. V., Macedo, N., Zimmerman, J. J., Wrzesinski, D.*, et al.*
Indoor air quality improvement with filtration and UV-C on mitigation of particulate matter and airborne bacteria: Monitoring and modeling.
Journal of Environmental Management, Vol. **351**, (2024)

Indoor air, especially with suspended particulate matter (PM), can be a carrier of airborne infectious pathogens. Without sufficient ventilation, airborne infectious diseases can be transmitted from one person to another. Indoor air quality (IAQ) significantly impacts people's daily lives as people spend 90% of their time indoors. An industrial-grade air cleaner prototype (filtration + ultraviolet light) was previously upgraded to clean indoor air to improve IAQ on two metrics: particulate matter (PM) and viable airborne bacteria. Previous experiments were conducted to test its removal efficiency on PM and airborne bacteria between the inlet and treated air. However, the longer-term improvement on IAQ would be more informative. Therefore, this research focused on quantifying longer-term improvement in a testing environment (poultry facility) loaded with high and variable PM and airborne bacteria concentrations. A 25-day experiment was conducted to treat indoor air using an air cleaner prototype with intermittent ON and OFF days in which PM and viable airborne bacteria were measured to quantify the treatment effect. The results showed an average of 55% reduction of total suspended particulate (TSP) concentration between OFF days (110 μg/m3) and ON days (49 μg/m3). An average of 47% reduction of total airborne viable bacteria concentrations was achieved between OFF days (~3200 CFU/m3) and ON days (~2000 CFU/m3). A cross-validation (CV) model was established to predict PM concentrations with five input variables, including the status of the air cleaner, time (h), ambient temperature, indoor relative humidity, and day of the week to help simulate the air-cleaning effect of this prototype. The model can approximately predict the air quality trend, and future improvements may be made to improve its accuracy.

****

Rodríguez, M., Seseña, S., Valiente, N., Palop, M. L., Rodríguez, A.
Indoor air quality in elderly care centers: A multidisciplinary approach.
Building and Environment, Vol. **262**, (2024)

Studying the indoor air quality (IAQ) of elderly care centers (ECCs) has important implications for ensuring residents' health and safety. This study involves a multidisciplinary analysis of chemical and microbiological pollutants, comfort parameters and potential pathogens in five ECCs to determine the IAQ in the spaces with the longest dwell time, dining room and TV room. In general, the average concentrations of CO, CH2O, and particles were greater in the dining rooms which can be attributed to the dining room's closer location to the kitchen. The layout of these areas plays a significant role, as facilities with kitchens that are not separated from the dining room exhibited poorer IAQ. Certain pathogenic-related microbes (e.g. Cutibacterium, Sphingomonas, Fusobacterium, Malassezia) were identified in air samples. In general, such genera were positively correlated with particles, CH2O and NO2 concentrations and decreased when air purification was applied. Bacterial community composition was similar among rooms and strongly depended on ECC and purification, suggesting that human occupants are the main source of airborne bacteria. Airborne fungal

communities did not depend on ECC or air purification, but particles concentrations were the main explanatory variable for their composition in indoor environments. A moderate non-carcinogenic risk due to inhalation of CH2O (2.69) and PM2.5 (1.44) was observed in the studied ECCs, so natural ventilation is not sufficient to obtain adequate IAQ. The installation of supplementary ventilation systems or the use of air purifiers would be advisable to avoid health risk, especially considering the vulnerability of the residents.

****

S, V. K., S, P. S., K, V. K., S, S., Y, N., S. C, A.
Indoor Air Quality Monitoring System for Healthcare.
2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM). 28 June 2024. Chennai, India

Although several schools, colleges, offices, gyms opened several weeks ago, still many of them are afraid to lead a normal life. One of the vital reasons is the fear of spreading of the virus exhaled by the opposite person, which is present in air we inhale. Unfortunately, we don't have any sensor that will detect the virus in the atmosphere. We have an alternative that is measuring the quality of air present in an indoor space which people inhale. Indirectly, that carbon dioxide suggests that if someone was a carrier of the coronavirus, there's a good chance there's more virus nuclei in the air. In case of such problems, we can install a indoor Air Quality monitoring system with an Arduino UNO. Air quality sensors are that the sensors will detect automatically the quality of air present in the environment. The indoor air quality is a significant factor in maintaining good health. Understanding of the harmful effects induced by indoor air pollution will help us to take all the appropriate preventive measures to reduce the possible health risks at all relevant sources that are known to contribute should be evaluated.

****

Infection Control in the Dental Office in the Era of COVID-19.
Springer, (2024)

This book discusses the treatment of dental patients in the post-COVID pandemic years and the required compliance with recommended infection control practices to ensure the safe delivery of oral health care. The COVID-19 pandemic has had the most dramatic impact on healthcare, inclusive of dentistry, in history. SARS-CoV-2, the virus that causes COVID-19, is a very dynamic virus and each new variant appears to be more transmissible than previous variants. More effective infection control strategies had to be developed to prevent transmission of COVID-19 in the dental office.
Readers will find guidance on the reduction of aerosol in the dental office, information on vaccines, vaccinations and the re-emergence of vaccine preventable diseases. Infection control during implant placement, oral surgical procedures, N2O administration and IV sedation is explained. In addition to SARS-CoV-2, the book provides information on other emerging respiratory diseases such as Influenza,Respiratory Syncytial Virus (RSV) and the emergence of Vaccine Preventable Diseases (Measles, Mumps, Rubella, Polio, HPV) that present significant risk of transmission if proper infection control practices are not followed. The indirect effects of the COVID-19 pandemic are discussed including a significant increase of STDs (syphilis, gonorrhea, chlamydia, herpes, HPV), new blood- borne infections such as HIV, HBV and HCV infections, as well as a significant increase of healthcare acquired infections and superbugs.

****

Morawska, L., Allen, J., Bahnfleth, W., Bennett, B., Bluyssen, P. M., Boerstra, A.*, et al.*
Mandating indoor air quality for public buildings.
Science, Vol. **383** n°(6690), (2024), 1418-1420 p.

If some countries lead by example, standards may increasingly become normalized People living in urban and industrialized societies, which are expanding globally, spend more than 90% of their time in the indoor environment, breathing indoor air (IA). Despite decades of research and advocacy, most countries do not have legislated indoor air quality (IAQ) performance standards for public spaces that address concentration levels of IA pollutants (1). Few building codes address operation, maintenance, and retrofitting, and most do not focus on airborne disease transmission. But the COVID-19 pandemic has made all levels of society, from community members to decision-makers, realize the importance of IAQ for human health, wellbeing, productivity, and learning. We propose that IAQ standards be mandatory for public spaces. Although enforcement of IAQ performance standards in homes is not possible, homes must be designed and equipped so that they could meet the standards.

****

Praet, S., Afzal, M., Mcdonald, M., Willcox, M.
A novel environmental decontamination system to reduce sars-cov-2 transmission risk in indoor sports facilities.
J Sci Med Sport, Vol. **27**, (2024), S24 p.

Despite being fully vaccinated, high-performance athletes are still at risk of developing COVID-19 and infecting other team or staff members. Atomistic simulation studies suggest that low-energy external electric fields can dramatically destabilize spike proteins of coronaviruses and prevent infection of host cells. This study determined the virucidal effect of a novel environmental decontamination system with a photon-mediated electron emitter (PMEE) on both surface-associated and aerosolized coronaviruses. The PMEE system does not produce any detectable ozone or harmful electromagnetic radiation and is safe to be operated around humans.

****

Alam, N., Mohiuddin, M., Sharma, D., Patil, S. P., Warimani, M., Hasan, Z.*, et al.*
Performance Analysis of a HVAC System with a Heat Recovery Wheel for a Hospital Building.
Journal of Engineering Physics and Thermophysics, Vol. **97** n°(5), (2024), 1135-1142 p.

An effective heating, ventilation, and air conditioning system has been designed for a three storey north-oriented hospital building. The heat load of this building was calculated using the Hourly Analysis Program software with regard for the recovery of the energy from the exhaust air stream with the use of a heat recovery wheel reducing the temperature of the supply air stream and lowering the load on the air handling unit in the building. The results obtained show that a heat recovery wheel attached to a heating, ventilation, and air conditioning system makes it possible to improve the indoor air quality with conservation of 30% of the the electrical energy.

****

Ehelepola, N. D. B., Thilakarathna, H. M. A.
Respiratory infection transmission risk and indoor air quality at outpatient departments and emergency treatment units of Sri Lankan teaching hospitals.
PLOS Global Public Health, Vol. **4** n°(2), (2024)

Indoor carbon dioxide (CO2) concentration has been used as a proxy of the degree of ventilation and, by extension, as an indicator of the risk of contracting respiratory infections. No publications exist regarding indoor air quality (IAQ) parameters of Sri Lankan hospitals.We measured the levels of CO2 and seven other IAQ parameters during morning rush hours for three days, in outpatient departments (OPDs) and emergency treatment units (ETUs) of all 21 teaching hospitals of Sri Lanka. We measured the same parameters of outdoor air also. We calculated the mean values of those parameters. We looked for correlations between outdoors

and OPD and ETU levels of selected air quality parameters.The average CO2 levels of outdoors, OPDs and ETUs respectively were 514ppm (ppm = parts per million), 749ppm and 795ppm. The average levels of PM2.5 (particulate matter with diameters <2.5µm) outdoors, OPDs and ETUs respectively, were 28.7µg/m3,32µg/m3 and 25.6 µg/m3. The average levels of PM10 (particulate matter with diameters <10µm) outdoors, OPDs and ETUs respectively, were 49.4µg/m3, 55.5µg/m3 and 47.9 µg/m3. The median levels of formaldehyde outdoors, OPDs and ETUs respectively, were 0.03mg/m3, 0.04mg/m3 and 0.08mg/m3. The median levels of total volatile organic compounds (VOC) outdoors, OPDs and ETUs respectively were 0.12mg/m3, 0.19mg/m3 and 0.38mg/m3.CO2 levels of air in OPDs and ETUs generally were below the national ceilings but above the ceilings used by some developed countries. Outdoors, OPDs and ETUs air contain PM10, PM2.5 levels higher than WHO ceilings, although below the national ceilings. VOC and formaldehyde levels are generally below the national ceilings. Air in OPDs and ETUs is hotter and humid than national ceilings. Outdoor PM10, PM2.5 levels influence OPDs and ETUs levels. We propose methods to reduce the risk of nosocomial respiratory infections and to improve IAQ of Sri Lankan OPDs and ETUs.

****

Kavita, P., Giri, P.
Sources and Transmission of Bio-Contaminants in Indoor Areas.
Airborne Biocontaminants and their Impact on Human Health, (2024), 37 p.

Bio-contaminants are pollutants in the air, soil, and water that have a biological source. The majority of the elements in the air are microbes, including bacteria, viruses, unicellular organisms, fungi, algae, mites, insect residues/animal dander, and their by-products. Dogs, cats, birds, pollen, smells, allergies, and building materials are the culprits behind these. Physical factors like ventilation, heating (temperature and humidity), carpets, materials, and so forth might exacerbate them. According to reports, even in highly regulated environments like the operating rooms of modern hospitals, bio-contaminants can be found in indoor air anyplace. 90% or more of the time is spent by humans indoors, where they are heavily exposed to biological pollution in places like homes, schools, dormitories, and colonial buildings, such as stores, cars, and workplaces. Even common household items like fans, air conditioners, chillers, and humidifiers contribute significantly to the development and spread of indoor microorganisms. The majority of the time, air conditioners, fans, and ventilation equipment are colonized by fungi, bacteria, and yeasts. A broad overview of indoor airborne bio-contaminants including their sources, mode of transmission, health consequences, associated evaluation methodologies, and prospective management strategies is the aim of the current study.

****

Eldaghar, O., Zhu, Y., Gleich, D.
A spatial hypergraph model where epidemic spread demonstrates clear higher-order effects.
arXiv preprint, (2024)

We demonstrate a spatial hypergraph model that allows us to vary the amount of higher-order structure in the generated hypergraph. Specifically, we can vary from a model that is a pure pairwise graph into a model that is almost a pure hypergraph. We use this spatial hypergraph model to study higher-order effects in epidemic spread. We use a susceptible-infected-recovered-susceptible (SIRS) epidemic model designed to mimic the spread of an airborne pathogen. We study three types of airborne effects that emulate airborne dilution effects. For the scenario of linear dilution, which roughly correspond to constant ventilation per person as required in many building codes, we see essentially no impact from introducing small hyperedges up to size 15 whereas we do see effects when the hyperedge set is dominated by large hyperedges. Specifically, we track the mean infections after the SIRS epidemic has run for awhile so it is in a "steady state" and find the mean is higher in the large hyperedge regime wheras it is unchanged from pairwise to small hyperedge regime.

****

Zavestovskaya, I. N., Fronya, A. A., Tupitsyn, I. M., Gushchin, V. A., Sinyavin, A. E., Russu, L. I.*, et al.*
Spectral Dependence of Bovine Coronavirus Photoinactivation under Irradiation by UV-A, UV-B, and UV-C Light-Emitting Diodes.
Bulletin of the Lebedev Physics Institute, Vol. **51** n°(4), (2024), S345-S350 p.

We report the results of experimental studies on the effect of ultraviolet (UV) radiation in a wide spectral range of 270–405 nm on bovine coronavirus. The sensitivity of bovine coronavirus to UV radiation is determined, a comparative analysis of the data is performed, and action spectra are constructed. It is shown that bovine coronavirus inactivation is possible in the UV-A range, which will make it possible to select safe radiation sources for use in public places in the presence of people.

****

Meehan, P. E., Mishler, O.
Standard, Contact, Droplet, and Airborne.
In: Infection Control in the Dental Office in the Era of COVID-19. Springer Nature Switzerland; 2024. 83-95 p.

As defined by the World Health Organization (WHO), infection control and prevention is an evidence-based approach applied in healthcare settings to prevent the spread of diseases. The concept of minimizing the transmission of infections in healthcare settings is complex, as it incorporates policies and procedures with the goal to reduce the rates of infections. Considering that dentistry and dental care are a unique healthcare delivery setting, this chapter will highlight infection control practices and procedures specific to the field of dentistry.

****

Wu, B. W.
Strategies to improve indoor air quality and air conditioning system efficiency.
National University of Singapore. Thèse 2024

Indoor Air Quality (IAQ) has gained significant traction since the COVID-19 pandemic. Building owners and Facility Managers (FM) are facing pressures from building occupants and authorities to deliver an optimal IAQ that not only preserves the health and well-being of the occupants but also reduces the transmission risk and spread of infectious disease in the indoor environment. On the other hand, there is also an aggressive push towards energy conservation and reduction of carbon emission in the built environment sector. In this aspect, the authorities have aggressively raised the energy efficiency standards through the Green Mark 2021 certification. This created a conundrum because of the conflicting natures between IAQ and energy conservation. The conventional approach to achieve an optimal IAQ is through introducing additional outdoor air to dilute the carbon dioxide C02 and contaminant levels within the indoor environment. However, doing so will create the undesirable outcome of incurring additional energy to cool the outdoor air. ASHRAE 241 has reshaped this mindset by introducing the concept of equivalent clean airflow which comprises of both outdoor air and treated recirculated air. This allows building owners and FM to rely not only on the outdoor air, but also the treated recirculated air, which requires less energy to cool, to deliver an acceptable IAQ to the occupants. ASHRAE 241 has also further defined the additional requirements for an acceptable IAQ, which is to reduce the transmission risk and spread of infectious disease within the indoor environment. The study seeks to develop the framework for assessing the energy efficiency for delivering an acceptable IAQ, which is defined to the requirements of ASHRAE 62.2 and the additional requirements of ASHRAE 241. It applies actual data from an existing modern office building to calculate the energy efficiency of its air-conditioning system based on this framework and also explores the various strategies to drive further improvements to the energy efficiency. This includes efficient air distribution based on actual occupancy patterns so that cooling and equivalent clean airflow are delivered to the appropriate areas and at the appropriate time to the occupants.

This minimizes cooling “over-provisions” and inefficiencies. The second strategy is to optimize the composition of the outdoor air so that it is just sufficient achieve the acceptable IAQ and keep the C02 limit to 700 ppm below outdoor ambient level. By relying less outdoor air and more treated recirculated air to deliver the equivalent clean air, less energy is incurred for cooling. The third strategy is the efficient treatment of the recirculated air by exploring the efficiency of other air filtration technologies other than the conventional mechanical fibrous MERV filters. This study aims to develop the concepts for energy efficiency for an acceptable IAQ and through this, provide building owners and FM the framework to evaluate and develop targeted solutions to enhance the energy efficiency performance of the air-conditioning system in this aspect.

****