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Aéraulique et COVID-19

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Google Scholar, Lens et WoS

Aleksandar, K., Ana, M., Valentina, G.
679. Needs assessment of ambient co2 monitoring solution.
MECHANICAL ENGINEERING–SCIENTIFIC JOURNAL, Vol. **42** n°(1), (2024), 53-60 p.

Monitoring exhaled CO2 levels in indoor working spaces is crucial for maintaining employees' quality of performance. Hence, preventing excessive levels of exhaled CO2 in any working environment is a key factor relevant for increased cognitive capacity, decreased occurrence of headaches, sleepiness, etc. This paper addresses the need for CO2 monitoring by proposing a novel design of a CO2 monitoring solution, consisting of a device and an appropriate client-oriented data acquisition and presentation software platform. A Needs Assessment is performed to examine the necessity of such a solution on the market. The outcomes of the performed Needs Assessment show that commercial products using WiFi, 4G, standalone with rechargeable battery power supply, and comparable available technologies are missing on the market. Due to the fact that exhaled CO2 concentration acts as an indicator for diseases such as COVID-19, tuberculosis, influenza, SARS, etc., from the perspective of the challenges posed by the COVID-19 pandemic, the novel CO2 monitoring solution can effectively be used for indicative risk prevention of airborne infectious diseases.

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Ammoury, M., Salman, B.
Advancing Sustainability and Resilience of Airports through Deployment of New Technologies in the Aftermath of the COVID-19 Pandemic.
ASCE OPEN: Multidisciplinary Journal of Civil Engineering, Vol. **2** n°(1), (2024)

Airports Council International and the global air transport industry set a net-zero carbon goal for airports by 2050, presenting an opportunity for innovation and creating a sustainable path to recovery amid the COVID-19 pandemic. Yet, there is a lack of information on how US airports perceive sustainability and resilience post-COVID-19. This paper aims to overcome these limitations by investigating the sustainability and resilience management practices in airports while also exploring the potential for leveraging emerging technologies and other solutions. Data collected through interviews with consultants and solution providers and a nationwide survey encompassing 74 geographically diverse airports were categorized by airport size. Statistical analyses were performed to examine the relationship between airport size and technology adoption. The findings of this paper underscore disparities among airports of varying sizes, emphasizing a notable relation between airport size and the adoption of crowd management solutions to mitigate the effects of the pandemic. The study provides important categorical insights into (1) the status of sustainability and resilience management practices; (2) key performance indicators used in monitoring sustainability and resilience grouped under five categories (water conservation, polyfluoroalkyl substances/perfluorooctane sulfonic acid, indoor air quality, energy, and biodiversity and wildlife); (3) airport user recommendations; and (4) drivers and barriers to adopting new technologies. Despite the progress achieved by a few airports, the study reveals that most airports do not possess a formulated strategy to reduce their greenhouse gas emissions. While most airports introduced COVID-19 mitigation solutions, a substantial number of them lack tangible measures to enhance pandemic resilience, and the majority exhibit constrained technological readiness for future disruptions. A comprehensive set of recommendations is provided to aid the aviation sector in preparing for future pandemics, offering insights for operators to navigate challenges and for policymakers to formulate effective policies and grants. This study holds significant potential for developing practical applications within the aviation industry, specifically by guiding airports in attaining the long-term net zero carbon goal and supporting their adoption of pandemic resilience solutions. The research emphasizes the unique opportunity

presented by the COVID-19 pandemic for airports to innovate and redefine sustainable recovery paths. By addressing the information gaps on how US airports perceive sustainability and resilience post-COVID-19, the study provides valuable insights into necessary changes to overcome emerging challenges. The findings underscore certain disparities among airports categorized by size through statistical analyses, offering insights into sustainability and resilience management practices, key performance indicators used in monitoring sustainability and resilience, drivers/barriers to adopting new technologies, and recommendations on adopted technologies. Despite the progress made by some airports, the study reveals a lack of overarching strategies for reducing greenhouse gas emissions, emphasizing the need for tangible measures to enhance pandemic resilience. The paper concludes with a comprehensive set of recommendations to assist airports in preparing for future pandemics. These recommendations are also expected to benefit airport operators and provide insights for policymakers to formulate effective policies, fostering a resilient and sustainable aviation industry.

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Quanta, L., Macias-Jueza, O., Romero-Amorrortua, A., Urrutia-Sustatxab, A., Urrutia-Sustatxab, A., De-Iribasc, J.

Analysis of the impact of new singular ventilation technologies on enhancing indoor air quality in schools.

In: Advances in Energy Research, Materials Science & Built Environment. 2024. 42 p.

Concern about indoor air quality (IAQ) in schools has grown in recent years, especially after the effects of COVID-19 pandemic highlighted its impact on children's health. Existing educational buildings presents limitations for conducting extensive interventions to incorporate ventilation solutions. As a result, simple strategies such as opening windows are employed. While this approach achieves the goal of air renewal, it undermines energy consumption and user comfort.
In this context, it is required to address ventilation in schools from a new perspective, providing innovative technologies that allow quick and simple installation while guaranteeing high standards of air quality, energy efficiency and user comfort. In response to this challenge, a new solution has been developed consisting of autonomous equipment installed inside each classroom and featuring independent intelligent control.
The objective of present study is to evaluate the applicability and the social and economic impact that the widespread implementation of this alternative technology could have compared to conventional methods.
To achieve this, a study was conducted to determine the general characteristics and the specific peculiarities and needs of schools in the Basque Country. The study first approached the topic theoretically through bibliographic references and statistical analysis, and subsequently, fieldwork to assess the reality of existing buildings. Additionally, an air quality monitoring campaign was carried out in pilot schools, conducted in two stages: first without ventilation and later with the new solution. The study evaluated the benefits in terms of improved air quality achieved, as well as the improvements in the implementation and operational processes. These results were extrapolated to Basque educational buildings park, providing an estimation of the potential impact of this new ventilation approach. Highly positive results were yielded in terms of acceptance, feasibility, and ultimately, addressing the identified challenges.

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Mendell, M. J., Chen, W., Ranasinghe, D. R., Castorina, R., Kumagai, K.

Carbon dioxide guidelines for indoor air quality: a review.

Journal of exposure science & environmental epidemiology, (2024)

BACKGROUND: The importance of building ventilation to protect health has been more widely recognized since the COVID-19 pandemic. Outdoor air ventilation in buildings dilutes indoor-generated air pollutants (including bioaerosols) and reduces resulting occupant exposures. Many countries and organizations have advisory guidelines or mandatory standards for minimum ventilation rates (VRs) to maintain indoor air quality (IAQ). Because directly measuring VRs is often difficult, many IAQ guidelines instead specify indoor

concentration limits for carbon dioxide (CO2), using CO2 exhaled by building occupants as an indicator of VR. Although indoor CO2 guidelines are common, the evidence basis for the various CO2 limits has not been clear. OBJECTIVE: To review current indoor CO2 guidelines worldwide and the supportive evidence provided. METHODS: We identified worldwide CO2-based guidelines for IAQ or ventilation, along with any supportive evidence provided. We excluded occupational guidelines for CO2 levels ≥5000 ppm. RESULTS: Among 43 guidelines identified, 35 set single CO2 concentration limits and eight set multi-tiered limits; 16 mentioned no specific human effect to be controlled, 19 specified only odor dissatisfaction, five specified non-infectious health effects, and three specified airborne infectious disease transmission. The most common indoor CO2 limit was 1000 ppm. Thirteen guidelines specified maximum CO2 limits as extended time-weighted averages, none with evidence linking averaged limits to occupant effects. Of only 18 guidelines citing evidence to support limits set, we found this evidence persuasive for eight. Among these eight guidelines, seven set limits to control odor perception. One provided 17 scientifically-based CO2 limits, for specific example space uses and occupancies, to control long-range COVID-19 transmission indoors. IMPACT: Many current indoor carbon dioxide (CO2) guidelines for indoor air quality specified no adverse effects intended for control. Odor dissatisfaction was the effect mentioned most frequently, few mentioned health, and three mentioned control of infectious disease. Only one CO2 guideline was developed from scientific models to control airborne transmission of COVID-19. Most guidelines provided no supportive evidence for specified limits; few provided persuasive evidence. No scientific basis is apparent for setting one CO2 limit for IAQ across all buildings, setting a CO2 limit for IAQ as an extended time-weighted average, or using aone-time CO2 measurement to verify a desired VR.

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Branco, P. T. B. S., Pinto, A. J. S., Sousa, S. I. V.
Characterising indoor air quality in private vehicle cabins under unprecedented traffic conditions during COVID-19 lockdown.
Building and Environment, (2024)

Air pollution negatively impacts human health, yet it is rarely studied inside vehicles. This study aimed to characterise indoor air quality (IAQ) in vehicle cabins, focusing on the concentrations of key pollutants and the influence of various factors on IAQ including vehicle-specific characteristics (self-pollution), traffic intensity, ventilation type, and enclosed spaces like parking garages. It addressed a significant literature gap by using real-world driving data, a multipollutant approach, real-time monitoring, and a detailed log of influencing factors. Additionally, part of the study was conducted during the COVID-19 lockdown, providing an unprecedented opportunity to gather real-world data with reduced traffic emissions. Forty trips were conducted with four diesel vehicles of different ages and emission standards. Concentrations of VOCs, CO, CO_2, NO_2, SO_2, O_3, and PM_1, $PM_{2.5}$, PM_{10}, and TSP were monitored, alongside detailed logbook entries. This study evidenced the formation of O_3 inside vehicle cabins under conditions of high NO_2 and/or VOC concentrations and direct sunlight, a phenomenon not previously reported. Results also showed that IAQ inside vehicle cabins depended largely on vehicle-specific factors, the surrounding environment, and indoor-outdoor air exchange. CO, NO_2, SO_2, and PM levels varied mainly with the external environment and air exchange, while CO_2 levels were influenced primarily by ventilation settings. The concentrations of certain pollutants exceeded reference levels for indoor environments, potentially posing health risks to occupants. Further research is needed to study the pioneer evidence of O3 formation and to develop a comprehensive health risk assessment, thereby contributing to developing specific IAQ guidelines for vehicles.

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Salonen, H., Salthammer, T., Castagnoli, E., Taubel, M., Morawska, L.
Cleaning products: Their chemistry, effects on indoor air quality, and implications for human health.
Environment international, Vol. **190**, (2024)

The use of cleaning and disinfecting products both at work and at home increased during the COVID-19 pandemic. Those products often include surfactants, acids/bases, carcinogens such as chloroform, and endocrine-disrupting chemicals, such as cyclosiloxanes, phthalates, and synthetic fragrances, which may cause harmful health effects among professional cleaners as well as among people exposed at home or in their workplaces. The aim of this study was to synthesize the effects of the commonly used chemical, surface cleaning and disinfecting products on indoor air quality, focusing on chemical and particulate matter pollutants, exposure, and human health in residential and public buildings. We also provide a summary of recommendations to avoid harmful exposure and suggest future research directions. PubMed, Google Scholar, Scopus, and Web of Science (WoS) were used to search the literature. Analysis of the literature revealed that the use of cleaning products and disinfectants increase occupants' exposure to a variety of harmful chemical air contaminants and to particulate matter. Occupational exposure to cleaning and disinfectant products has been linked to an increased risk of asthma and rhinitis. Residential exposure to cleaning products has been shown to have an adverse effect on respiratory health, particularly on asthma onset, and on the occurrence of asthma(-like) symptoms among children and adults. Efforts to reduce occupants' exposure to cleaning chemicals will require lowering the content of hazardous substances in cleaning products and improving ventilation during and after cleaning. Experimentally examined, best cleaning practices as well as careful selection of cleaning products can minimize the burden of harmful air pollutant exposure indoors. In addition, indirect ways to reduce exposure include increasing people's awareness of the harmfulness of cleaning chemicals and of safe cleaning practices, as well as clear labelling of cleaning and disinfecting products.

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Ruiz-Barquero, A., Quesada-Martínez, A. J., Chacon-Cerdas, R., Alfaro-Lopez, A., Bermudez-Campos, W., Loria-Mesen, H.*, et al.*

Design and implementation of a controlled low-cost ventilator for emergency use on ICU patients.

Revista Tecnología en Marcha, (2024)

The worldwide outbreak of the SARS-CoV-2 virus led to a shortage of hospital ventilators worldwide. During recovery, these devices were crucial for patients in Intensive Care Units (ICUs). However, countries like Costa Rica faced difficulties acquiring these devices due to high demand in the world. To address this issue, professionals and students from the Costa Rica Institute of Technology have developed a prototype of a mechanical ventilator. This ventilator incorporates PIDs and Fuzzy Logic algorithms and features a user-friendly graphic interface based on PyQt5/GraphicsView, designed with input from medical experts. The ventilator is easy to assemble and highly portable. Initially, the ventilator successfully underwent testing using advanced patient simulators, namely Gaumard HAL S3201 and Gaumard NOELLE S574.100. Subsequently, it underwent a successful real-world test using animals. The tests involved varying the breathing rate from 10 to 30 breaths per minute, adjusting the tidal volume from 250 to 800 mL with automatic control of a 50 mL increase, and manipulating the I: E ratio from 1:1 to 1:5.

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Mignot, B., Mahmud, T., Heggs, P. J., Ghadiri, M.

A distributed parameter model for the solvent evaporation from a saline droplet including internal solute diffusion and heat conduction.

Aerosol Science and Technology, (2024)

The study of respiratory droplets evaporation and formation of crystalline solid residues has become more and more important with the spread of respiratory diseases such as COVID-19. Evaporation time and droplet sizes greatly influence the dispersion of respiratory aerosols and their subsequent airborne transmission to susceptible hosts. In this study, a saline droplet is used as a surrogate for a respiratory droplet and a mathematical model is developed for its evaporation. Predictions agree well with experimental data reported

in the literature. The model includes partial differential equations (PDEs) for the diffusion of dissolved solute and heat conduction within a saline droplet and water evaporation from the droplet surface. The internal domain of the droplet is discretized in space using the finite volume method, transforming the (PDEs) into a set of ordinary differential equations in time, which are solved using the Rosenbrock method. The calculation terminates when the solute concentration at the droplet surface reaches a value corresponding to a critical supersaturation level for the on-set of crystallization. The radial concentration profiles at different time intervals highlight the solute concentration enrichment at the droplet surface as it dries, by which the rate of solvent evaporation is affected. The model is also applied to a free-falling saline droplet evaporating under room temperature and relative humidity. The outcome reveals a strong dependency of the initial solute concentration on the ratio of initial to final droplet size. Lastly, the capability of the model predictions is demonstrated at a high relative humidity, where condensation occurs, broadening the model's applicability.

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Lu, J., Chen, X., Ding, X., Jia, Z., Li, M., Zhang, M.*, et al.*
Droplet Micro-Sensor and Detection of Respiratory Droplet Transmission.
Advanced Science, (2024)

Abstract Droplet transmission is the primary infection route for respiratory diseases like COVID-19 and influenza, but small and low-cost wearable droplet detection devices are a significant challenge. Herein, a respiratory droplet micro-sensor based on graphene oxide quantum dots (GOQDs) assembled onto SiO2 microspheres by the nebulized natural deposition is presented. Benefiting from the energy dissipation of the microsphere to droplets, the sensor can detect droplets as far as 2 m from coughing. With this sensor, droplet signal variations caused by some factors like distance, speech, angles, and wind directions are explored, and the effectiveness of different protective measures in preventing droplet transmission is evaluated. This droplet detection technology is expected to be utilized for the development of personal detection and protection devices against infectious respiratory diseases.

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Kanagalingam, S., An, H., Chong, M. Y., Panisilvam, J., Wang, P. C., Soh, C. B.*, et al.*
The effect of different uv-c lamp configurations on the inactivation of sars-cov-2 particles in internal duct system a numerical investigation based on computational fluid dynamics.
9th Thermal and Fluids Engineering Conference (TFEC) April, 21-24, 2024, Corvallis, OR, USA

The global pandemic of the SARS-CoV-2 (COVID-19) virus has necessitated the reanalysis of the measures taken to avert the viral dispersion within indoor and outdoor environments. Ventilation systems play a key role in reducing the spread of the virus to the patrons of indoor environments. The application of UV-C lamps within the internal ducting of the ventilation systems has been prevalently applied to subdue the spread of airborne viruses within an indoor environment. Yet, an optimal configuration of the lamps remains elusive to improve the killing rate of the virus. The current study endeavors to fill this research void by attempting to conduct a parametric evaluation based on the various configurations of UV-C lamps within the internal duct system (0.6m by 0.6m by 3m). Computational Fluid Dynamics (CFD) approach has been adopted in this study to capture the flow features of the virus-laden flow over the UV-C lamps within the internal duct. The Euler-Lagrangian approach was applied to model the viral particles flowing within the duct system. The lamp configurations differed by the number of UV-C lamps, the distance, and the orientation between each lamp. From the numerical study, the effect of different lamp configurations on the killing rate of the virus was predicted by assessing the corresponding UV dosage. CFD prediction from this research established that the number and positioning of UV-C lamps have a direct impact on achieving the required UV dosage to diminish the spread of the virus within the internal duct system.

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Wu, Z., Bai, Y., Wu, S., Li, X., Jing, J., Wang, H.
Electrospun sludge extract-based nanofiber filters for enhanced indoor air quality control.
Colloids and Surfaces a-Physicochemical and Engineering Aspects, Vol. **687**, (2024)

Effectively removal of particulate matter is of positive significance to human health, especially in the COVID-19like epidemic. Electrospinning technology has proved to be an effective approach among the various strategies for particulate matter removal. In this study, sludge extract was innovatively incorporated into Polyamide 66 (PA66) nanofiber air filter to enhance the capture ability of submicron particles. After adding sludge extract, hydrophilicity was enhanced and the contents of functional groups such as -C--O were increased. Under the 3 wt % concentration of sludge extract, the filtration efficiencies of PM0.3 and PM0.5 were increased to 94.74% and 95.12%, respectively, which increased 9.06% and 5.48% compared to PA66 samples. Moreover, the addition of sludge extract increased the diameter of the fibers, which enhanced the passive filtering mechanism and reduced the filtration pressure drop. This study provided the concept of "Controlling waste by waste", which synchronously realized the utilization of sludge and the removal of submicron particles, and provides a costeffective and biosafety solution for advanced nanomaterials with excellent performance

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Solehat, S. I., Junaidi, J., As, Z. A.
Environmental Factors and Airborne Bacteria in Inpatient Wards at Ratu Zalecha Hospital.
Global Health & Environmental Perspectives, Vol. **1** n°(2), (2024), 76-85 p.

A major concern are hospital-acquired diseases, and keeping the air quality at its best is essential to stopping the spread of airborne germs. The purpose of this study was to investigate the relationship, in Class II and Class III inpatient wards at Ratu Zalecha Martapura Regional Hospital, between airborne bacterial counts and physical air quality measures. Seven rooms from each class made up the sample of fourteen rooms used in the cross-sectional analytical survey design. Measuring air temperature, ventilation rate, humidity, light intensity, room construction and sanitation, and airborne bacterial counts was part of the data collecting. The data showed that a number of the rooms did not satisfy the required levels of humidity, air temperature, ventilation rate, or light intensity. Significant correlations were shown by the statistical analysis between the airborne bacterial counts in both ward classes and these physical air quality indicators. Remarkably, there was no discernible relationship between airborne bacterial counts and room construction or sanitation. The report emphasizes the need of keeping the air temperature, ventilation, humidity, and illumination at the right levels in order to reduce the possibility of nosocomial infections and airborne bacterial contamination in hospital inpatient wards.

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Hoskin, Z., Siegel, J. A., Haines, S. R.
Estimating indoor airborne concentrations of SARS-CoV-2 RNA using quantitative filter forensics.
Building and Environment, Vol. **259**, (2024)

This investigation used portable air cleaners (PACs) and quantitative filter forensics (QFF) to assess week-long average airborne concentrations of SARS-CoV-2 RNA in homes occupied with COVID-symptomatic individuals, classrooms, and dining locations throughout Toronto, Canada. PACs were deployed for one week each, and dust from filters was collected via vacuuming. SARS-CoV-2 RNA from filter dust was quantified using reverse transcription-polymerase chain reaction (RT-PCR). RNA quantities and PAC metadata were used to estimate airborne concentrations of SARS-CoV-2 RNA. The highest concentrations of RNA were found in isolation rooms (median concentration = 8.68 RNA copies/m 3). Classrooms had lower concentrations during summer than in fall and winter (median concentration of sampling weeks when RNA was present = 0.02 RNA copies/m 3 and 0.11 RNA copies/m 3 , respectively), which may be attributed to differences in classroom occupancy among

other factors. Limitations include unknown recovery efficiency of RNA from filters and the dynamics of concentrations due to the temporal averaging of QFF. Our results are consistent with previous research highlighting the effectiveness of isolation in preventing distribution of high concentrations of SARS-CoV-2 RNA throughout a home. Overall, QFF is a beneficial tool for environmental sampling of respiratory airborne viral RNA such as SARS-CoV-2 RNA, that can be implemented for long-term sampling in mixed -occupancy environments.

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Kumar, R., Khurana, S.
Examining building energy retrofit effects on indoor environmental quality before the Covid-19 era: a critical assessment.
International Journal of Environmental Science and Technology, (2024)

The sole purpose of a building design has never been energy efficiency, rather it is considered for health, well-being, and comfort of the occupants. These comforts include sound level, light level, ergonomics, aesthetics, odour, thermal comfort, and indoor air quality or collectively to be said as indoor environmental quality. Indoor air pollution can lead to nausea, dizziness, loss of coordination, and even strokes. Additionally, volatile organic compounds are known to be carcinogenic, posing further health risks. When it comes to energy efficiency, it is argued that energy saving is achieved by compromising comfort. However, building professionals believe that indoor environmental quality does not worsen due to energy efficiency retrofit projects. The existing work lacks clarity on the variation in indoor environmental quality levels pre- and post-energy retrofit. This paper drives down to the available research centred around impact of energy efficiency building retrofit projects on indoor environmental quality. In the existing works, both favourable and unfavourable effects were observed. Variations in the concentration of indoor environmental quality has been addressed but the reason behind such variations are not mentioned. Further exploration is crucial to refine best practices, add control strategies and advance our understanding of the long-term implications. This paper emphasizes the dynamic nature of the field striking a harmonious balance among retrofit initiatives, IEQ and occupants' comfort-oriented control strategies remain an insufficiently researched field that requires more investigation and collaborative efforts within the global scholarly community.

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Dias, M., Gomes, B., Pena, P., Cervantes, R., Beswick, A., Duchaine, C.*, et al.*
Filling the knowledge gap: Scoping review regarding sampling methods, assays, and further requirements to assess airborne viruses.
Science of The Total Environment, Vol. **946**, (2024)

Assessment of occupational exposure to viruses is crucial to identify virus reservoirs and sources of dissemination at an early stage and to help prevent spread between employees and to the general population. Measuring workers' exposure can facilitate assessment of the effectiveness of protective and mitigation measures in place. The aim of this scoping review is to give an overview of available methods and those already implemented for airborne virus' exposure assessment in different occupational and indoor environments. The results retrieved from the different studies may contribute to the setting of future standards and guidelines to ensure a reliable risk characterization in the occupational environments crucial for the implementation of effective control measures. The search aimed at selecting studies between January 1st 2010 and June 30th 2023 in the selected databases. Fifty papers on virus exposure assessment fitted the eligibility criteria and were selected for data extraction. Overall, this study identified gaps in knowledge regarding virus assessment and pinpointed the needs for further research. Several discrepancies were found (transport temperatures, elution steps, …), as well as a lack of publication of important data related to the exposure conditions (contextual information). With the available information, it is impossible to compare results between studies employing different methods, and even if the same methods are used, different

conclusions/recommendations based on the expert judgment have been reported due to the lack of consensus in the contextual information retrieved and/or data interpretation. Future research on the field targeting sampling methods and in the laboratory regarding the assays to employ should be developed bearing in mind the different goals of the assessment.

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Li, X., Chen, Z., Tu, J., Yu, H., Tang, Y., Qin, C.
Impact of impinging jet ventilation on thermal comfort and aerosol transmission: A numerical investigation in a densely-occupied classroom with solar effect.
Journal of Building Engineering, Vol. **94**, (2024)

Urgent demands for ensuring safe and healthy spaces for children have been raised due to the post-COVID-19 pandemic. This study numerically modelled a densely populated classroom with 40 students and one teacher across two layouts with different relative vent positions to assess the effectiveness of an emerging ventilation scheme, impinging jet ventilation (IJV), in balancing thermal comfort and controlling indoor transmission. The effect of solar radiation was carefully analysed. Cough-induced contaminants were expelled from the infectious teacher and were traced by the Eulerian-Lagrangian approach. The exposure risk of students was further assessed via the inhalation index (ID) based on the spatial characteristics of the released particles. The thermal comfort was evaluated by the Fanger model. The results demonstrated that IJV with Layout 2 (teacher at the supply inlet and exhaust side) was found more optimal in counterbalancing the occupants' thermal comfort and indoor transmission control. This layout not only aligned better with ASHRAE standards for thermal comfort, showing a reduced vertical thermal gradient but also lowered student exposure risk by 18.9%–135.2%. With solar radiation, heat absorbed by the windows led to non-uniform wall temperature distributions, causing the air near the windows to also exhibit a non-uniform profile. This interaction with the cooler air from the IJV system was found to facilitate contaminant dispersion. This resulted in a 10.3% to 26% increase in students' average exposure risk compared to those without solar radiation cases. This study aimed to investigate the practical applications of IJV system for densely-occupied classrooms.

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Liu, H., Zhang, Z., Zhang, Y., Zhou, X.
Impact of ventilation efficiency on restraining hazardous toilet plume post-flushing in indoor environments.
Indoor and Built Environment, (2024)

This study analyzed the hybrid ventilation efficiency of indoor toilet plumes generated post-flushing with various designs. Single-sided natural ventilation and hybrid ventilation were numerically investigated to determine the impact of vent locations commonly found in multistorey buildings. An in-situ experiment was performed to identify the size distribution of the plume with time series. A computational fluid dynamics model based on the Reynolds-averaged naiver-Stokes equations and baseline k-? turbulence equations was used to predict aerosol pollutant transmission. The aerosol-laden particles receded gradually impacted by the convection of the ambient source. Besides flush volume, temperature and ventilation scenarios were also related to the generation and droplet transmission. The results indicated that the ventilation rates were generally increased with decreased residence time if the turbulence was not suppressed. This study suggested that appropriate ventilation design could significantly reduce the average particle residence time, in which case it could also reduce the rate of virus infection.

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Gorgels, K. M. F., Mujakovic, S., Stallenberg, E., Hackert, V. H., Hoebe, C. J. P. A.
Implementation and effectiveness of non-pharmaceutical interventions, including mask mandates and ventilation, on SARS-CoV-2 transmission (alpha variant) in primary schools in the Netherlands.
PLoS One, Vol. **19** n°(6), (2024)

There has been a lot of discussion about the role of schools in the transmission of severe acute respiratory coronavirus 2 (SARS-CoV-2) during the coronavirus 2019 (COVID-19) pandemic, where many countries responded with school closures in 2020. Reopening of primary schools in the Netherlands in February 2021 was sustained by various non-pharmaceutical interventions (NPIs) following national recommendations. Our study attempted to assess the degree of regional implementation and effectiveness of these NPIs in South Limburg, Netherlands. We approached 150 primary schools with a structured questionnaire containing items on the implementation of NPIs, including items on ventilation. Based on our registry of cases, we determined the number of COVID-19 cases linked to each school, classifying cases by their source of transmission. We calculated a crude secondary attack rate by dividing the number of cases of within-school transmission by the total number of children and staff members. Two-sample proportion tests were performed to compare these rates between schools stratified by the presence of a ventilation system and mask mandates for staff members. A total of 69 schools responded. Most implemented NPIs were aimed at students, except for masking mandates, which preferentially targeted teachers over students (63% versus 22%). We observed lower crude secondary attack rates in schools with a ventilation system compared to schools without a ventilation system (1.2% versus 2.8%, p<0.01). Mandatory masking for staff members had no effect on the overall crude secondary attack rate (2.0% versus 2.1%, p = 0.03) but decreased the crude secondary attack rate among staff members (2.3% versus 1.7%, p<0.01). Schools varied in their implementation of NPIs, most of which targeted students. Rates of within-school transmission were higher compared to other studies, possibly due to a lack of proper ventilation. Our research may help improve guidance for primary schools in future outbreaks.

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Subarmaniam, D., Hassim, M. H.
Improving indoor air quality for preventing transmission of Covid-19 at bactiguard Malaysia sdn. Bhd and bactiguard South East Asia.
Journal of Energy and Safety Technology (JEST), Vol. **7** n°(1), (2024), 1-13 p.

According to the World Health Organization (WHO), Covid-19 was regarded as pandemic in the year 2020. However, the status had eventually changed to endemic in 2022 since there are still until now, cases being reported in daily basis, but mostly those infected person will only experienced reversible health effects, with almost none resulted to death after all countries applied the vaccination and booster program including Malaysia. Covid-19 spread mostly by close contact and respiratory droplets. Covid-19 is a viral transmission via small airborne microdroplets or known as 'aerosols'. According to current information on the airborne transmission of SARS-CoV-2, inhalation at distances greater than 1-2 m from an infected source. As a result, optimising ventilation and air quality in indoor areas is crucial to reducing this risk of airborne transmission especially in workplace. Appropriate ventilation distribution ensures that appropriate dilution is achieved. Filtration is the most effective way for HVAC systems. Small particles are removed most effectively by HEPA filters. The purpose of this research was to analyse potential transmission of Covid-19 at Bactiguard Malaysia Sdn. Bhd. and Bactiguard Malaysia South East Asia, to evaluate existing ventilation system is sufficient to reduce the risk of airborne transmission and propose ventilation air system through engineering control that will reduce risk of airborne transmission via droplets. The research was equipped with survey questionnaire to assess employee knowledge and awareness against transmission of Covid-19 by offering insight of indoor air properties that can be adapted at Bactiguard Malaysia Sdn. Bhd. and Bactiguard South-East Asia based on statistical analysis performed using SPSS statistical analysis, risk assessment and documentation for continuous monitoring of Covid-19 transmission rate.

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De Jode, M.
Long term monitoring of CO2 levels and ventilation rates in a naturally ventilated residential apartment.

Indoor Environments, Vol. **1** n°(3), (2024)

Indoor CO2 levels became particularly topical during the recent COVID-19 pandemic. In this study a long-term investigation of indoor CO2 levels in a 1970s built residential apartment in single occupancy is presented. Three NDIR CO2 sensors were used to measure CO2 levels over a one-year period. Mean CO2 levels over this period were 1278 ± 504 ppm, with elevated CO2 levels of greater than 2000 ppm not uncommon. Subsequent investigations used the single zone mass balance model and the decay of CO2 in the absence of occupants to estimate the ventilation rates in various configurations. A mean natural ventilation rate of 0.16 ACH was estimated with all windows closed. Opening fan light windows resulted in a mean ventilation rate of 2.86 ACH whereas opening all windows increased the mean ventilation rate to 19.1 ACH. Evidence was observed of the effect of both wind speed and indoor-outdoor temperature difference on the ventilation rates. It was concluded that with all windows closed the natural infiltration rate was insufficient to maintain optimal indoor air quality even in single occupancy. Opening the fan light windows was sufficient to achieve satisfactory indoor air quality but insufficient for the effective inhibition of airborne disease transmission.

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Elezaj, S., Beqiri, L., Elezaj, I.
Management of Health and Environment Issues Through Ventilation in Mining Lines: An Operational and Statistical Approach.
Mathematical Modelling of Engineering Problems, Vol. **11** n°(5), (2024)

In the widest practical and technical sense, ventilation systems are nothing more than an appropriate schematic representation of the mine's overall or individual aeration plans, which only include the specific works that are used to circulate air; other works are left out. The study analyzed the serial aeration system, giving concrete examples of serial connection of the workshops in the mines. Furthermore, the study utilized simple parallel analysis in analyzing the systems of two parallel ventilation system of the mine. In addition, the aerodynamic resistance of the ventilation system was analyzed in relation to the emergence of the COVID-19 pandemic; alongside the political, social, and economic concerns brought out by the COVID-19 pandemic. It is observed that the general resistances of the branched ventilation system through parallel branches are smaller than the minimum resistances of each branch. The findings of this study hold significant implications for managing health risks in mines during pandemics. Implementing parallel ventilation branches ensures consistent airflow distribution, minimizing areas of stagnant air where viruses may accumulate. Taking into account the values of the total resistances that are reached in the ventilation systems in the mine, it was concluded that the probability of COVID-19 over time is always decreasing. This was as a result of the medical measures that were applied for the phenomenon in question.

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Chen, W., Wang, Z.-M., Peerless, K., Ullman, E., Mendell, M. J., Putney, D.*, et al.*
Monitoring of Ventilation, Portable Air Cleaner Operation, and Particulate Matter in California Classrooms: A Pilot Study.
Sustainability, Vol. **16** n°(5), (2024)

Interest in improving ventilation and indoor air quality (IAQ) in California schools has grown since the COVID-19 pandemic. This paper presents a field protocol for simultaneous monitoring of usage patterns of in-room portable air cleaners (PACs), indoor and outdoor concentrations and composition of particulate matter (PM), and CO2 as an indicator of outdoor air ventilation rates (VRs). This protocol was implemented for a 7-week pilot study in four occupied California classrooms in 2022. Monitoring results showed that VRs and indoor PM were generally well maintained in the classrooms studied. One classroom had much higher overall VRs, as well as higher average indoor PM2.5 concentrations compared to similar classrooms, suggesting a possible strong impact of window/door opening behavior on both VRs and indoor PM. The actual use patterns of PACs in

these classrooms varied significantly. No clear correlations were observed between PAC use patterns and indoor PM2.5 concentrations in this pilot study, possibly due to low outdoor PM2.5 concentrations and already efficient central filtration (i.e., MERV 13 filters in central ventilation systems). Information gathered through such field monitoring can help schools to understand the actual classroom ventilation and IAQ conditions and best allocate resources to classrooms that need further IAQ improvements.

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Ishigaki, Y., Yokogawa, S.
Monitoring the ventilation of living spaces to assess the risk of airborne transmission of infection using a novel Pocket CO2 Logger to track carbon dioxide concentrations in Tokyo.
PLoS One, Vol. **19** n°(5), (2024)

We employed carbon dioxide (CO2) concentration monitoring using mobile devices to identify location-specific risks for airborne infection transmission. We lent a newly developed, portable Pocket CO2 Logger to 10 participants, to be carried at all times, for an average of 8 days. The participants recorded their location at any given time as cinema, gym, hall, home, hospital, other indoors, other outgoings, pub, restaurant, university, store, transportation, or workplace. Generalized linear mixed model was used for statistical analysis, with the objective variable set to the logarithm of CO2 concentration. Analysis was performed by assigning participant identification as the random effect and location as the fixed effect. The data were collected per participant (seven males, four females), resulting in a total of 12,253 records. Statistical analysis identified three relatively poorly ventilated locations (median values > 1,000 ppm) that contributed significantly ($p < 0.0001$) to CO2 concentrations: homes (1,316 ppm), halls (1,173 ppm), and gyms (1005ppm). In contrast, two locations were identified to contribute significantly ($p < 0.0001$) to CO2 concentrations but had relatively low average values (<1,000 ppm): workplaces (705 ppm) and stores (620 ppm). The Pocket CO2 Logger can be used to visualize airborne infectious transmission risk by location to help guide recommendation regarding infectious disease policies, such as restrictions on human flow and ventilation measures and guidelines. In the future, large-scale surveys are expected to utilize the global positioning system, Wi-Fi, or Bluetooth of an individual's smartphone to improve ease and accuracy.

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Mei, D., Zhang, X., Wang, C., Liu, L., Li, J.
Multi-objective ventilation optimization for indoor air quality, thermal comfort, and energy conservation in the post-pandemic era: A case study for a moving elevator.
Physics of Fluids, Vol. **36** n°(6), (2024)

Cases of respiratory disease transmission in enclosed elevators have been reported frequently. In the post-pandemic era, in order to mitigate the spread of respiratory diseases in moving elevators, a multi-objective genetic optimization method based on a response surface model is used to optimize the elevator ventilation. The ventilation parameters were optimized for three objectives: reducing carbon dioxide concentration, maintaining human thermal comfort, and achieving energy conservation. First, a response surface model is established using the computational fluid dynamics method and the Kriging model to correlate the design variables (air supply velocity in x, y, and z directions and air supply temperature) with the output function (CO2 concentration, average temperature, and average velocity). Subsequently, the Pareto optimal solution set of ventilation parameters was obtained by employing a multi-objective genetic algorithm. Finally, the optimal air supply velocity, angle, and temperature were obtained for both peak periods of elevator traffic (13 passengers) and other situations (4 passengers) when the elevator is moving up and down, which satisfy the objectives of health, comfort, and energy conservation.

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Van Bennekum, T., Colin, M., Krzhizhanovskaya, V., Bonn, D.

Plasma-Assisted Air Cleaning Decreases COVID-19 Infections in a Primary School: Modelling and Experimental Data.
Computational Science – ICCS 2024

We present experimental data and modelling results investigating the effects of plasma-assisted air cleaning systems on reducing transmission of SARS-CoV-2 virus among pupils in a primary school in Amsterdam, the Netherlands. We equipped 4 classrooms (120 pupils) with the Novaerus NV800 ICU air cleaning system, and 8 classrooms (240 pupils) had standard ventilation systems. We found a significantly lower number of infections in classrooms with air cleaning systems in the first two weeks after instalment, suggesting that air cleaning decreases aerosol transmission. In the subsequent weeks, however, infection numbers increased in the Netherlands, and the difference between classrooms with and without air cleaning ceased to be significant. We analyzed the experimental results, performed a Kaplan-Meier survival estimation and developed a SIR-based computational model that simulates the results of this experiment. We performed sensitivity analysis, optimised model parameters, and tested several hypotheses. This research gives the potential for implementing improved air quality measures in public spaces, which could result in better air quality regulations in spaces such as schools.

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Kase, H.
Practical Process for CAP.
Point Path 2024

Wherever there are indoor spaces in which people come together, and there is good ventilation through constant fresh air, the COVID-19 pandemic will end. In such an environment, it will always be possible to live without worrying about COVID-19.
This grand project opens up the way to fulfil our positive dream of bringing about the sustained end of infection. By building a system utilising internet of things (IoT) and artificial intelligence (AI), the burden on individuals can be minimised. If we all share the goal and pursue it in a partnership of enthusiastic cooperation, this dream will surely come true.

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Al-Delfi, A. M. H., Salman, A. S.
The Preventive Indicators for Evaluating the Design of Existing Buildings as Epidemic-Resilient Architecture: A Theoretical Framework.
Journal of Sustainable Architecture and Civil Engineering, Vol. **35** n°(2), (2024), 182-200 p.

The recent outbreak of epidemics created health challenges and emerging requirements that revealed weaknesses and increased alerts about the contribution of the existing buildings' design to increasing the possibility of epidemics' spread. Those risks necessitated focusing on designing more effectively resilient buildings to epidemics. The study focuses on improving the safety aspects of existing building design from an architectural design perspective. Therefore, this study proposes a theoretical framework for a set of preventive indicators to evaluate the existing building design as a resilient architectural system in its response to epidemics. These indicators have been identified and selected based on an extensive examination of the literature and the most effective practices for preventing and controlling epidemics. Those preventive indicators covered all the various aspects of the design of the existing building, including the effectiveness of social distancing, indoor air quality, indoor environmental quality, control engineering and preventive. Using these indicators, architecture professionals and policymakers can evaluate the effectiveness of existing buildings in reducing the spread of epidemics and making the necessary improvements to create a more resilient environment. The proposed preventive indicators aim to contribute to developing epidemic-resilient architecture and promote the creation of healthier and safer living environments for occupants.

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Kim, D., Roy, S., Mcbeth, P., Lee, J.

Quantitative Comparison of Ventilation Parameters of Different Approaches to Ventilator Splitting and Multiplexing.

Crit Care Explor, Vol. **6** n°(7), (2024), e1113 p.

CONTEXT: Amid the COVID-19 pandemic, this study delves into ventilator shortages, exploring simple split ventilation (SSV), simple differential ventilation (SDV), and differential multiventilation (DMV). The knowledge gap centers on understanding their performance and safety implications. HYPOTHESIS: Our hypothesis posits that SSV, SDV, and DMV offer solutions to the ventilator crisis. Rigorous testing was anticipated to unveil advantages and limitations, aiding the development of effective ventilation approaches. METHODS AND MODELS: Using a specialized test bed, SSV, SDV, and DMV were compared. Simulated lungs in a controlled setting facilitated measurements with sensors. Statistical analysis honed in on parameters like peak inspiratory pressure (PIP) and positive end-expiratory pressure. RESULTS: Setting target PIP at 15 cm H2O for lung 1 and 12.5 cm H2O for lung 2, SSV revealed a PIP of 15.67 ± 0.2 cm H2O for both lungs, with tidal volume (Vt) at 152.9 ± 9 mL. In SDV, lung 1 had a PIP of 25.69 ± 0.2 cm H2O, lung 2 at 24.73 ± 0.2 cm H2O, and Vts of 464.3 ± 0.9 mL and 453.1 ± 10 mL, respectively. DMV trials showed lung 1's PIP at 13.97 ± 0.06 cm H2O, lung 2 at 12.30 ± 0.04 cm H2O, with Vts of 125.8 ± 0.004 mL and 104.4 ± 0.003 mL, respectively. INTERPRETATION AND CONCLUSIONS: This study enriches understanding of ventilator sharing strategy, emphasizing the need for careful selection. DMV, offering individualization while maintaining circuit continuity, stands out. Findings lay the foundation for robust multiplexing strategies, enhancing ventilator management in crises.

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Chen, Y., Zhai, Z., Yuan, Z., He, G.

Removal efficiency of restroom ventilation revisited for short-term evaluation.

City and Built Environment, Vol. **2** n°(1), (2024), 6 p.

Ventilation efficiency or contaminant removal efficiency is often evaluated using the ratio between the concentrations in the exhaust air and the room air. This ratio does not truly represent the expectation of ventilation in restrooms, where dynamic airflow fields and sources are more typical. This study focuses on a short-term (10 min) pollutant removal percentage in a residential restroom featuring a dynamic airflow field, particularly with the onset of window-induced stack ventilation during toilet uses. Thirteen ventilation scenarios of a residential restroom were studied using the numerical method that was validated by a mock-up experiment. The scenarios differed in the operation of the exhaust fan and window. Results show that the 10-min pollutant removal percentage of a typical exhaust ventilation system at 10 h-1 air change rate (ACH) is only 68.5%. Under exhaust ventilation, opening the window can introduce both adverse short circuit and favorable stack ventilation depending on the difference between the indoor and outdoor temperatures. As the temperature difference increases from 0 to 12.5 °C, the removal percentage increases from below 50%, a drop due to short circuit, to above 98% thanks to a tripled ventilation rate. The human thermal plume has notable effect on the removal percentage, but its effect can be neglected with the presence of stack ventilation. The hybrid ventilation strategy has impact on perceived air quality and thermal comfort. When the outdoor air is colder, opening the window under exhaust ventilation may increase the current sitting user’s exposure to the self-produced pollutants but can reduce the exposure of the next immediate standing user. In addition, opening the window in cold days will make the toilet user thermally uncomfortable with reduced local temperatures and increased airflow velocities. The study highlights the importance of using the short-term removal percentage to evaluate the performance of restroom ventilation.

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Sovatzidi, G., Triantafyllou, G., Dimas, G., Kalozoumis, P. G., Drikakis, D., Kokkinakis, I. W.*, et al.*

Risk Assessment of COVID-19 Transmission on Cruise Ships Using Fuzzy Rules.
Artificial Intelligence Applications and Innovations. AIAI 2024.

Cruise ships constitute a popular means of vacationing for millions of people each year. However, due to the on-board conditions, e.g., densely populated areas, highly transmissible respiratory diseases, such as COVID-19, are a common cause of outbreaks. Hence, accurate assessment of the transmission risk (TR) is crucial. Recent approaches focus on long-term forecasting of such events; however, the limited availability and inconsistency of relevant data poses a challenge for developing short-term and data-driven methods. To this end, this work proposes a novel short-term knowledge-based method implemented through fuzzy rules for assessing the TR in cruise ships. The use of fuzzy rules, developed by domain experts and information extracted from the literature, assists in dealing with the data limitations. In contrast to previous approaches, the proposed method considers information deriving from various sensors and the ship information system in accord with a recently proposed smart ship design. Moreover, the fuzzy TR assessment estimates the confidence of an inferred decision, quantifying the uncertainty regarding its results. Evaluation via agent-based simulations demonstrates the effectiveness of the proposed method across different scenarios.

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Liu, Z., Wang, Y., Jiang, C., He, J., Rong, R., Li, S.*, et al.*
Spatial distribution of bioaerosols and evaluation of four ventilation method on controlling their diffusion in a typical enhanced biosafety level 2 laboratory.
Journal of Hazardous Materials, Vol. **475**, (2024)

Biosafety laboratories are critical in many fields. However, experimenters associated the infection risk from biological aerosols. In this study, by conducting experiments on the release and collection of bioaerosols within a typical BSL-2 + laboratory, the spatial distribution of bioaerosols was tracked. Numerical calculations were employed to obtain and visualize the airflow patterns and aerosol dispersion paths of four ventilation methods. The results indicated that equipment and tables led to uneven airflow distribution within the laboratory. The comparison results of the four evaluation indicators showed that the air age distribution of UU (Upward supply and upward return) mode and CD (Cross-supply and downward return) mode was superior, with air change efficiency values of 0.595 and 0.603, respectively. Additionally, the contaminant removal index of CD mode was 1.48, significantly higher than the other ventilation methods. The statistical results of the contaminant dispersion index also indicated that CD mode was most conducive to diluting aerosols in the spatial environment. The LD (lateral supply and downward return) mode may lead to airflow short-circuiting. The UD (upward supply and downward return) mode can provide balanced protection for laboratory. Overall, CD mode performed the best among the four ventilation methods, followed by UU mode.

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Huang, Q., Syndicus, M., Frisch, J., Van Treeck, C.
Spatial features of CO2 for occupancy detection in a naturally ventilated school building.
Indoor Environments, Vol. **1** n°(3), (2024)

Accurate occupancy information helps to improve building energy efficiency and occupant comfort. Occupancy detection methods based on CO2 sensors have received attention due to their low cost and low intrusiveness. In naturally ventilated buildings, the accuracy of CO2-based occupancy detection is generally low in related studies due to the complex ventilation behavior and the difficulty in measuring the actual air exchange through windows. In this study, we present two novel features for occupancy detection based on the spatial distribution of the CO2 concentration. After a quantitative analysis with Support Vector Machine (SVM) as classifier, it was found that the accuracy of occupancy state detection in naturally ventilated rooms could be improved by up to 14.8 percentage points compared to the baseline, reaching 83.2 % (F1 score 0.84) without any ventilation information. With ventilation information, the accuracy reached 87.6 % (F1 score

0.89). The performance of occupancy quantity detection was significantly improved by up to 25.3 percentage points versus baseline, reaching 56 %, with root mean square error (RMSE) of 11.44 occupants, using only CO2-related features. Additional ventilation information further enhanced the performance to 61.8 % (RMSE 9.02 occupants). By incorporating spatial features, the model using only CO2-related features revealed similar performance as the model containing additional ventilation information, resulting in a better low-cost occupancy detection method for naturally ventilated buildings.

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Carmona, N., Seto, E., Hayward, L., Tan, S., Lee, S., Kemperman, B., *et al.*
Use of Portable Air Cleaners in Washington State Schools: A Qualitative Analysis Based on the Technology Acceptance Model.
Journal of School Health, (2024)

BACKGROUNDThe US government allocated over $2.5 billion in "Elementary and Secondary School Emergency Relief (ESSER)" funds to Washington State for COVID-19 response and ventilation improvements. Despite available funding, gaps persist in supporting schools to successfully use portable air cleaners (PACs). We evaluated PAC needs within King County, Washington and characterized factors influencing schools' purchase and use of PACs.METHODSPublic Health-Seattle & King County (PHSKC) assessed school's ventilation systems and IAQ improvements through a survey (N = 17). Separately, semi-structured interviews (N = 13) based on the technology acceptance model (TAM) were conducted with school personnel. A thematic analysis using inductive and deductive coding was conducted and logistic regression models assessed the predictive capability of the TAM.RESULTSThe PHSKC survey findings informed our recommendations. Positive attitudes, knowledge, and beliefs in ease of use and effectiveness of PACs were facilitators to PAC use. While barriers included a lack of training, education, and concerns about PAC maintenance and sustainability. TAM constructs of perceived usefulness (PU) and perceived ease of use (PEU) were predictive of having the intention to use PACs in schools.CONCLUSIONSThere is a critical need for solutions to circumvent challenges to implementing PACs in schools. This characterization provides insight for promoting PAC use in IAQ-impacted schools.

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Linares-Alemparte, P., García-Ortega, S., Feldman, F., Romero-Fernández, A., Sorribes-Gil, M., Villar-Burke, R.
VIP 48.1: Trends in building ventilation requirements and inspection in Spain.
2024

AIVC's Ventilation Information Paper #48.1 summarizes current knowledge on trends in building ventilation requirements and inspection in Spain. More specifically, the paper aims to cover the following national trends:
IAQ requirements and market,
energy requirements and market,
inspection of ventilation systems,
innovative systems and market, and
impact of the COVID-19 pandemic

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