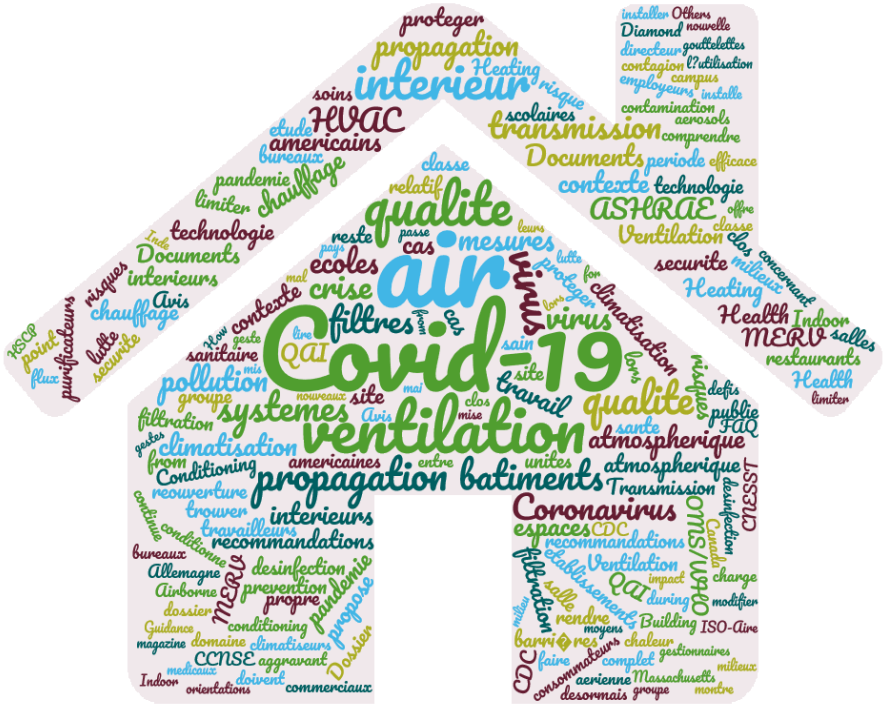

Rapport de veille n° 59

Aéraulique et COVID-19

04/01/2023

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Google Scholar, Lens et WoS

Alegria-Sala, A., Cleries Tardio, E., Casals, L. C., Macarulla, M., Salom, J.
CO2 Concentrations and Thermal Comfort Analysis at Onsite and Online Educational Environments.
International journal of environmental research and public health, Vol. **19** n°(23), (2022)

In building areas with high occupancy, such as classrooms, transmission routes of SARS-CoV-2 are increased when indoor air quality is deficient. Under this scenario, universities have adopted ventilation measures to mitigate contagious environments. However, the lack of adequate equipment or designs in old educational buildings is a barrier to reach minimum requirements. This study aims to quantify the indoor air quality and thermal comfort at universities and compare it to conditions in students' households. In this regard, several classrooms in buildings of the Polytechnic University of Catalonia were monitored for temperature, CO2 concentration and relative humidity. The people who used these classrooms were surveyed about their comfort perceptions. A sample of students was also monitored at their homes where they reported to studying during the exam period. By means of point-in-time surveys, students reported their daily comfort, for comparison with the monitored data. The results show that the recommendations for CO2 concentration, temperature, and relative humidity are not always met in any of the study spaces. These factors are more critical at universities due to the high occupancy. In addition, the surveys highlighted the perception that the environment is better at home than at university.

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Hosseinloo, A. H., Nabi, S., Hosoi, A., Dahleh, M. A.
Data-driven control of COVID-19 in buildings: a reinforcement-learning approach.
arXiv preprint, (2022)

In addition to its public health crisis, COVID-19 pandemic has led to the shutdown and closure of workplaces with an estimated total cost of more than $16 trillion. Given the long hours an average person spends in buildings and indoor environments, this research article proposes data-driven control strategies to design optimal indoor airflow to minimize the exposure of occupants to viral pathogens in built environments. A general control framework is put forward for designing an optimal velocity field and proximal policy optimization, a reinforcement learning algorithm is employed to solve the control problem in a data-driven fashion. The same framework is used for optimal placement of disinfectants to neutralize the viral pathogens as an alternative to the airflow design when the latter is practically infeasible or hard to implement. We show, via simulation experiments, that the control agent learns the optimal policy in both scenarios within a reasonable time. The proposed data-driven control framework in this study will have significant societal and economic benefits by setting the foundation for an improved methodology in designing case-specific infection control guidelines that can be realized by affordable ventilation devices and disinfectants.

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Derk, R. C., Coyle, J. P., Lindsley, W. G., Blachere, F. M., Lemons, A. R., Service, S. K., *et al.*
Efficacy of Do-It-Yourself air filtration units in reducing exposure to simulated respiratory aerosols.
Building and environment, Vol. **229**, (2023)

Many respiratory diseases, including COVID-19, can be spread by aerosols expelled by infected people when they cough, talk, sing, or exhale. Exposure to these aerosols indoors can be reduced by portable air filtration units (air cleaners). Homemade or Do-It-Yourself (DIY) air filtration units are a popular alternative to commercially produced devices, but performance data is limited. Our study used a speaker-audience model to examine the efficacy of two popular types of DIY air filtration units, the Corsi-Rosenthal cube and a modified

Ford air filtration unit, in reducing exposure to simulated respiratory aerosols within a mock classroom. Experiments were conducted using four breathing simulators at different locations in the room, one acting as the respiratory aerosol source and three as recipients. Optical particle spectrometers monitored simulated respiratory aerosol particles (0.3-3mum) as they dispersed throughout the room. Using two DIY cubes (in the front and back of the room) increased the air change rate as much as 12.4 over room ventilation, depending on filter thickness and fan airflow. Using multiple linear regression, each unit increase of air change reduced exposure by 10%. Increasing the number of filters, filter thickness, and fan airflow significantly enhanced the air change rate, which resulted in exposure reductions of up to 73%. Our results show DIY air filtration units can be an effective means of reducing aerosol exposure. However, they also show performance of DIY units can vary considerably depending upon their design, construction, and positioning, and users should be mindful of these limitations.

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Yuksel, A., Arici, M., Krajcik, M., Civan, M., Karabay, H.
Energy consumption, thermal comfort, and indoor air quality in mosques: Impact of Covid-19 measures.
Journal of Cleaner Production, Vol. **354**, (2022)

Restrictions have been imposed on the number of people, the duration of their stay and air conditioning operation in temples to limit the spread of the SARS-CoV-2 pandemic. This work studied how restrictions affected energy consumption, thermal comfort, and indoor air quality (IAQ) in mosques. Energy consumption data on lighting, heating and cooling before and during the pandemic were analyzed in six mosques of various sizes located in Yalova city, Turkey. The annual energy consumption for lighting was reduced during the pandemic in all mosques due to less usage, while the annual heating and cooling costs were raised in one mosque despite their restricted use. Besides, experiments were conducted to assess the effect of pandemic measures on thermal comfort and IAQ by measuring indoor temperature, relative humidity, air velocity, CO2 and PM concentrations in a typical mosque. Keeping the windows open and limiting occupancy improved the IAQ. This was evidenced by the lower average CO2 concentration during the pandemic (428 +/- 40 ppm) than before the pandemic (661 +/- 201 ppm). An acceptable thermal environment was achieved under pandemic measures at night during the summer period. Creating excellent conditions can be difficult without air conditioning even with open windows and prayers performed at night.

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Kapoor, N. R., Kumar, A., Kumar, A., Zebari, D. A., Kumar, K., Mohammed, M. A., *et al.*
Event-Specific Transmission Forecasting of SARS-CoV-2 in a Mixed-Mode Ventilated Office Room Using an ANN.
International journal of environmental research and public health, Vol. **19** n°(24), (2022)

The emerging novel variants and re-merging old variants of SARS-CoV-2 make it critical to study the transmission probability in mixed-mode ventilated office environments. Artificial neural network (ANN) and curve fitting (CF) models were created to forecast the R-Event. The R-Event is defined as the anticipated number of new infections that develop in particular events occurring over the course of time in any defined space. In the spring and summer of 2022, real-time data for an office environment were collected in India in a mixed-mode ventilated office space in a composite climate. The performances of the proposed CF and ANN models were compared with respect to traditional statistical indicators, such as the correlation coefficient, RMSE, MAE, MAPE, NS index, and a20-index, in order to determine the merit of the two approaches. Thirteen input features, namely the indoor temperature (TIn), indoor relative humidity (RHIn), area of opening (AO), number of occupants (O), area per person (AP), volume per person (VP), CO2 concentration (CO2), air quality index (AQI), outer wind speed (WS), outdoor temperature (TOut), outdoor humidity (RHOut), fan air speed (FS), and air conditioning (AC), were selected to forecast the R-Event as the target. The main objective was to determine the relationship between the CO2 level and R-Event, ultimately producing a model for forecasting

infections in office building environments. The correlation coefficients for the CF and ANN models in this case study were 0.7439 and 0.9999, respectively. This demonstrates that the ANN model is more accurate in R-Event prediction than the curve fitting model. The results show that the proposed ANN model is reliable and significantly accurate in forecasting the R-Event values for mixed-mode ventilated offices.

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Paz Alvarenga, M. O., Monteiro Dias, J. M., Jose De Lavor Araujo Lima, B., Leonidas Gomes, A. S., Queiroz De Melo Monteiro, G.

The implementation of portable air-cleaning technologies in healthcare settings -a scoping review.

The Journal of hospital infection, (2022)

BACKGROUND: The COVID-19 pandemic revealed opportunities to improve prevention practices in healthcare settings, mainly related to the spread of airborne microbes (also known as bioaerosols). AIM: This scoping review aimed to map methodologies used to assess the implementation of portable air cleaners in healthcare settings, identify gaps, and propose recommendations for future research. METHODS: The protocol was registered in the Open Science Framework (OSF) (doi: https://osf.io/8g9ap) and reported following the checklist provided by the Preferred Reporting Items For Systematic Reviews and Meta-Analysis-an extension for Scoping Reviews (PRISMA-ScR) statement. The search strategy was performed in five databases and one grey literature source. FINDINGS: At the last selection phase, 24 articles that fulfilled our inclusion criteria were summarised and disseminated. Out of these, 17 studies were conducted between 2020 and 2022; one of them is a protocol of a multicentre randomised controlled trial. The outcomes measured among the studies include airborne microbes counts, airborne particle concentrations, and rate of infections/interventions. The leading healthcare settings assessed were dental clinics (28%), patient's wards (16%), operating rooms (16%), and intensive care units (12%). CONCLUSION: Most of the devices demonstrated a significant potential to mitigate the impact of bioaerosols. Although some indoor air quality parameters can influence the mechanics of aerosols, only a few studies controlled these parameters in their analyses. Future clinical research should assess the rate of infections through randomized controlled trials with long-term follow-ups and large sample sizes to determine the clinical importance of the findings.

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Scungio, M., Parlani, G., Falcucci, G.

Influence of the ventilation strategy on the respiratory droplets dispersion inside a coach bus: CFD approach.

Journal of Physics: Conference Series, Vol. **2385** n°(1), (2022)

The airborne transmission of the COVID-19 virus was considered the main cause of infection. The increasing concern about the virus spread in confined spaces, characterized by high crowding indexes and an often-inadequate air exchange system, pushes the scientific community to the design of many studies aimed at improving indoor air quality. The risk of transmission depends on several factors such as droplet properties, virus characteristics, and indoor airflow patterns. The main transmission route of the SARS-CoV-2 virus to humans is the respiratory route through small (<100 µm) and large droplets. In an indoor environment, the air exchange plays a fundamental role on the dispersion of the droplets. In this study, an integrated approach was developed to evaluate the influence of the ventilation strategy on the dispersion of respiratory droplets emitted inside a coach bus. There are no specific guidelines and standards on the air exchange rate (AER) values to be respected in indoor environments such as coach buses. The aim of this work is to analyse the influence of ventilation strategy on the respiratory droplet concentration and distribution emitted in a coach bus. Ansys FLUENT was used to numerically solve the well-known transient Navier-Stokes equations (URANS equations), the energy equation and using the Lagrangian Discrete Phase Model (DPM) approach to construct the droplet trajectories. The geometry is representative of an intercity bus, a vehicle constructed exclusively for the carriage of seated passengers. The 3D CAD model represented a coach bus with an HVAC system,

within which an infected subject was present. The positions of exhaust vents and air-conditioning vents were chosen to ensure complete air circulation throughout the bus. The infected subject emitted droplets with a well-defined size distribution and mass through the mouth. The air exchange is provided in two different ways: general ventilation (from air intakes positioned along the bus windows and top side of central corridor) and personal ventilation (with air intakes for each passenger). For the general ventilation a single AER value was set (0.3 m3 s−1). The first results obtained showed a slight particle dispersion in the computational domain due to the airflow rate entered through the HVAC system, but a still elevated level of particle concentration tended to accumulate on the area near to infected subject. Additional analysis was executed to evaluate the beneficial effects linked to further addition of airflow through personal air-conditioning vents placed above every passenger's head. The results show the importance of the use of the ventilation system inside a coach bus, highlighting how the contribution linked to of the personal air exchange rate can lead to a significant reduction of droplet concentration exposure and consequently a reduction of the risk of infection from airborne diseases.

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Huang, J., Jones, P., He, X.
Masks, ventilation and exposure time: A web-based calculator of indoor COVID-19 infection risk.
Frontiers in Built Environment, Vol. **8**, (2022)

Two and half years into the COVID-19 pandemic, there is quite a lot of confusion over public health guidance necessary in order to reduce disease infection risks, from room air ventilation, the use of air cleaners, and type of mask and whether or not to wear a mask. This paper describes the development of a novel web-based calculator for use by the public to assess COVID-19 infection risks between a source and receiver in a typical room. The aim is to inform the disease infection risk in response to varying exposure times, mask-wearing, and viral variant in circulation. The calculator is based on the state-of-the-art research evidence, i.e., a room air ventilation model, mask infiltration efficiencies, room cleaner efficiencies, the quanta emission rates of various viral variants of COVID-19, and the modified Wells Riley equations. The results show that exposure times are critical in determining transmission risk. Masks are important and can reduce infection risk especially over shorter exposure times and for lower source emission quantum. N95 respirators are by far the most effective, especially for Omicron, and the results indicate that N95 respirators are necessary for the more infectious variants. Increasing fresh air ventilation rates from 2ac/h to 6ac/h can have a considerable impact in reducing transmission risk in a well-mixed space. Going from 6 ac/h to 12ac/h is less effective especially at lower exposure times. Venues can be classified in terms of risk, and appropriate high ventilation rates might be recommended for high-risk, speaking loudly and singing, such as classrooms and theatres. However, for low risk, quiet and speaking softly venues, such as offices and libraries, higher ventilation rates may not be required; instead, mechanical ventilation systems in combination with air cleaners can effectively remove small fraction size aerosol particles. The web-based calculator provides an easy-to-use and valuable tool for use in estimating infection risk.

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Peng, Z., Miller, S. L., Jimenez, J. L.
Model Evaluation of Secondary Chemistry due to Disinfection of Indoor Air with Germicidal Ultraviolet Lamps.
Environmental Science & Technology Letters, (2022)

Air disinfection using germicidal ultraviolet light (GUV) has received increasing attention during the COVID-19 pandemic. GUV uses UVC lamps to inactivate microorganisms, but it also initiates photochemistry in air. However, GUV's indoor-air-quality impact has not been investigated in detail. Here, we model the chemistry initiated by GUV at 254 ("GUV254") or 222 nm ("GUV222") in a typical indoor setting for different ventilation levels. Our analysis shows that GUV254, usually installed in the upper room, can significantly photolyze O3,

generating OH radicals that oxidize indoor volatile organic compounds (VOCs) into more oxidized VOCs. Secondary organic aerosol (SOA) is also formed as a VOC-oxidation product. GUV254-induced SOA formation is of the order of 0.1-1 mu g/m3 for the cases studied here. GUV222 (described by some as harmless to humans and thus applicable for the whole room) with the same effective virus-removal rate makes a smaller indoor-air-quality impact at mid-to-high ventilation rates. This is mainly because of the lower UV irradiance needed and also less efficient OH-generating O3 photolysis than GUV254. GUV222 has a higher impact than GUV254 under poor ventilation due to a small but significant photochemical production of O3 at 222 nm, which does not occur with GUV254.

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Yan, S., Wang, L., Birnkrant, M. J., Zhai, Z., Miller, S. L.
Multizone Modeling of Airborne SARS-CoV-2 Quanta Transmission and Infection Mitigation Strategies in Office, Hotel, Retail, and School Buildings.
Buildings, Vol. 13 n°(1), (2023)

Airborne transmission of SARS-CoV-2 mostly occurs indoors, and effective mitigation strategies for specific building types are needed. Most guidance provided during the pandemic focused on general strategies that may not be applicable for all buildings. A systematic evaluation of infection risk mitigation strategies for different public and commercial buildings would facilitate their reopening process as well as post-pandemic operation. This study evaluates engineering mitigation strategies for five selected US Department of Energy prototype commercial buildings (i.e., Medium Office, Large Office, Small Hotel, Stand-Alone Retail, and Secondary School). The evaluation applied the multizone airflow and contaminant simulation software, CONTAM, with a newly developed CONTAM-quanta approach for infection risk assessment. The zone-to-zone quanta transmission and quanta fate were analyzed. The effectiveness of mechanical ventilation, and in-duct and in-room air treatment mitigation strategies were evaluated and compared. The efficacy of mitigation strategies was evaluated for full, 75%, 50% and 25% of design occupancy of these buildings under no-mask and mask-wearing conditions. Results suggested that for small spaces, in-duct air treatment would be insufficient for mitigating infection risks and additional in-room treatment devices would be needed. To avoid assessing mitigation strategies by simulating every building configuration, correlations of individual infection risk as a function of building mitigation parameters were developed upon extensive parametric studies.

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Zaniboni, L., Albatici, R.
Natural and Mechanical Ventilation Concepts for Indoor Comfort and Well-Being with a Sustainable Design Perspective: A Systematic Review.
Buildings, Vol. **12** n°(11), (2022)

Current literature and guidelines on sustainable design often debate on the advantages of natural ventilation (NV) and mechanical ventilation (MV) on indoor environment and energy consumption. The present systematic review explores the existing literature comparing NV and MV on the indoor comfort and well-being points of view. The findings emphasize that thermo-hygrometric comfort is the main driver of occupants' ventilation behavior, while ventilation design is mainly led by indoor air quality targets. Moreover, more recent papers (especially after COVID-19 outbreak) emphasize the necessity of a health-based approach, contrasting airborne pathogens transmission. In this sense, MV is more frequently recommended in public spaces, while hybrid ventilation (HV) is often suggested as a solution to both ensure proper indoor conditions and energy savings. The concept of well-being is currently under-explored, as the present literature only refers to comfort. The same happens with topics such as visual, acoustic, and multi-domain comfort, as well as passive techniques such as night cooling, or analysis of specific environments such as healthcare facilities. Current knowledge would benefit from an expansion of future research in these directions. The choice of the

best ventilation solution cannot ignore the context, type, and condition of energy efficient buildings, in order to properly take into account occupants' well-being.

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Navas-Martín, M. Á., Cuerdo-Vilches, T.
Natural ventilation as a healthy habit during the first wave of the COVID-19 pandemic: An analysis of the frequency of window opening in Spanish homes.
Journal of Building Engineering, Vol. **65**, (2023)

Since SARS-CoV-2 spread worldwide in early 2020, many countries established lockdowns for protection. With a main transmission by aerosols, ventilation was promoted. This article analyses natural ventilation of Spanish housing during the spring 2020. An online questionnaire was launched, obtaining for this study 1502 responses. The comparative window opening before and during confinement, and households, dwellings and home activity variables, were analysed. The binary logistic regression model before pandemic indicated that ventilating properly related to: a worse perceived IAQ (OR = 1.56); thermal adaptation measures, especially those that prefer to open/close windows (OR = 1.45); not having heating system (OR = 1.15); and using power to heat water (OR = 1.60). For the confinement period, the model highlighted: being an employee (OR = 1.88); using heavy clothing in the home (OR = 2.36); and again, open/close windows for adaptation (OR = 2.24). According to specific tasks in quarantine, frequent ventilation was boosted by: an increasing use of oven (OR = 14.81); and alteration of work-habits (OR = 2.70), sport-habits (OR = 1.79), and outdoor-activities (OR = 1.60). Thus, an adequate natural ventilation pattern during the quarantine was linked to low environmental comfort in general, by virtue of indoor air quality. This is corroborated by less acoustic-thermal insulation, worse indicators of heating use, and the adaptive response to opening/closing windows when external temperature changed.

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Pal, A., Biswas, R., Pal, R., Sarkar, S., Mukhopadhyay, A.
A Novel Approach to Preventing SARS-CoV-2 Transmission in Classrooms: A Numerical Study.
Physics of Fluids, (2022)

The education sector has suffered a catastrophic setback due to ongoing COVID-pandemic, with classrooms being closed indefinitely. The current study aims to solve the existing dilemma by examining COVID transmission inside a classroom. In this work, a standard 5m x 3m x 5m classroom is considered where 24 students are seated, accompanied by a teacher. A computational fluid dynamics simulation based on OpenFOAM is performed using a Eulerian-Lagrangian framework. Based on the stochastic dose response framework, we have evaluated the infection risk in the classroom for two distinct cases: (i) certain students are infected (ii) the teacher is infected. If the teacher is infected, the probability of infection could reach 100% for certain students. When certain students are infected, the maximum infection risk for a susceptible person reaches 30 %. The commonly used cloth mask proves to be ineffective in providing protection against infection transmission reducing the maximum infection probability by approximately 26 % only. Another commonly used solution in the form of shields installed on desks have failed to provide adequate protection against infection reducing the infection risk only by 50 %. Furthermore, the shields serves as a source of fomite mode of infection. Screens suspended from the ceiling have been proposed as a novel solution that reduces the infection risk by 90 % and 95 % compared to the no screen scenario besides being completely devoid of fomite infection mode. In the case of screens, the maximum infection risk reached the value of only 0.2 (20 % infection probability) in 1 325s (22 min).

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Nie, Z., Chen, Y., Deng, M.
Quantitative evaluation of precautions against the COVID-19 indoor transmission through human coughing.

Scientific Reports, Vol. **12** n°(1), (2022)

In this work, we focus on the dispersion of COVID-19-laden droplets using the transient computational fluid dynamics (CFD) modeling and simulation of the coughing process of virus carriers in an enclosure room, aiming to set up the basic prototype of popular precautionary strategies, i.e., face mask, upward ventilation, protective screen, or any combination thereof, against the indoor transmission of COVID-19 and other highly contagious diseases in the future. A multi-component Eulerian–Lagrangian CFD particle-tracking model with user-defined functions is utilized under 8 cases to examine the characteristics of droplet dispersion concerning the mass and heat transfer, droplet evaporation, air buoyancy, air convection, air-droplet friction, and turbulent dispersion. The result shows that implementing upward ventilation is the most effective measure, followed by wearing face masks. Protective screens can restrict the movement of the coughing droplets (though it will not reduce viral load). However, applying protective screens arranged with lean can be counterproductive in preventing the spread of COVID-19 when it is inappropriately placed with ventilation. The soundest solution is the combination of the face mask and upward ventilation, which can reduce the indoor infectious concentration by nearly 99.95% compared with the baseline without any precautionary strategies. With the resumption of school and work in the post-epidemic era, this study would provide intelligence-enhancing advice for the masses and rule-makers to curb the pandemic.

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Xu, F., Gao, Z.
Study on indoor air quality and fresh air energy consumption under different ventilation modes in 24-hour occupied bedrooms in Nanjing, using Modelica-based simulation.
Energy and Buildings, Vol. **257**, (2022)

COVID-19 has forced people to spend more time working and studying at home; in particular, people who share an apartment stay in their respective bedrooms almost all day. This study investigated the impact of ventilation modes on the indoor air quality (IAQ) of 24-hour occupied bedrooms and provided ventilation suggestions for people who stay in their bedrooms for a long time during the pandemic compared with the study of traditional apartment ventilation. In addition, the fresh air energy consumption of different ventilation modes was compared to help residents save energy. In summer, a window-opening ratio of 25% (0.3 m(2)) could effectively improve IAQ. However, it is not recommended to use natural ventilation in winter because the outdoor PM2.5 concentration is too high. Moreover, the fresh air energy consumption for the automatic control window-opening ratio was 1/5 of that for a window-opening ratio of 25%. In the whole summer, it can save 196.1 kWh compared to a fixed window-opening ratio of 25%. Fresh air systems could greatly improve IAQ and lower energy consumption regardless of the season. However, the automatic-control window-opening ratio mode has lower energy consumption, which is approximately 0.37 times that of fresh air systems in summer.

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Ding, E., Zhang, D., Hamida, A., García-Sánchez, C., Jonker, L., De Boer, A. R.*, et al.*
Ventilation and thermal conditions in secondary schools in the Netherlands: Effects of COVID-19 pandemic control and prevention measures.
Building and Environment, Vol. **229**, (2023)

During the COVID-19 pandemic, the importance of ventilation was widely stressed and new protocols of ventilation were implemented in school buildings worldwide. In the Netherlands, schools were recommended to keep the windows and doors open, and after a national lockdown more stringent measures such as reduction of occupancy were introduced. In this study, the actual effects of such measures on ventilation and thermal conditions were investigated in 31 classrooms of 11 Dutch secondary schools, by monitoring the indoor and outdoor CO2 concentration and air temperature, both before and after the lockdown. Ventilation

rates were calculated using the steady-state method. Pre-lockdown, with an average occupancy of 17 students, in 42% of the classrooms the CO2 concentration exceeded the upper limit of the Dutch national guidelines (800 ppm above outdoors), while 13% had a ventilation rate per person (VRp) lower than the minimum requirement (6 l/s/p). Post-lockdown, the indoor CO2 concentration decreased significantly while for ventilation rates significant increase was only found in VRp, mainly caused by the decrease in occupancy (average 10 students). The total ventilation rate per classrooms, mainly induced by opening windows and doors, did not change significantly. Meanwhile, according to the Dutch national guidelines, thermal conditions in the classrooms were not satisfying, both pre- and post-lockdown. While opening windows and doors cannot achieve the required indoor environmental quality at all times, reducing occupancy might not be feasible for immediate implementation. Hence, more controllable and flexible ways for improving indoor air quality and thermal comfort in classrooms are needed.

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Panaras, G., Gropca, R., Papadopoulos, G.

Ventilation requirements and energy aspects: the case of hospitals.

IOP Conference Series : Earth and Environmental Science, Volume 1123, 3rd International Conference on Environmental Design (ICED2022) 22/10/2022 - 23/10/2022 Athens, Greece

Energy building design today aims to ensure thermal comfort and indoor air quality; this concern has been increased, given the recent SARS-CoV-2 pandemic. The proposed work investigates the effect of increased natural ventilation on energy requirements, ensuring low CO2 levels and acceptable Indoor Air Quality (IAQ) in general. The case of hospitals was chosen because of the stringent IAQ requirements they raise as a result of the burdened (physical, chemical, biological) indoor environment, as well as the vulnerable health of the patients. The current energy analysis was carried out in patient wards, waiting rooms, and operating rooms. The proposed correlation between IAQ and energy is infrequent in the relevant literature, especially for the case of hospitals. Different scenarios regarding the ventilation mode are examined, including pure natural ventilation, natural ventilation combined with air cleaners, as well as mechanical ventilation. According to the results, improvement of the air quality leads to higher energy demand; this is the case of mechanical ventilation, noting that not properly designed natural ventilation techniques may lead to high energy consumption, without ensuring acceptable IAQ. Air cleaners can contribute towards better environment, potentially decreasing ventilation requirements; the issue of fresh air adequacy has to be examined though. The demonstrated methodological analysis and results can help the designer to investigate the efficiency of different ventilation modes, involving the effect of thermal envelope, geometrical and operation parameters, towards the energy requirements minimization and IAQ quality maximization.

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