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Google Scholar, Lens et WoS

Batista, M., Bulgim, O., Matus, E., Estrella, J., Gittens, R., Molino, J.
Analysis of Indoor CO2 Concentration Using Split Ventilation Systems as an Indicator of COVID-19 Transmission.
American Journal of Applied Sciences, Vol. **20** n°(1), (2023)

We measured the indoor CO2 concentration in occupied areas with ventilation systems that recirculate air without an external air supply. The average time required to achieve the highest probability of contagion was also measured based on the number of participants in the group. Three different experimental groups were evaluated: Group One (G1), which included 5 participants; Group Two (G2), with 10 participants; and Group Three (G3), with 15 participants. Before the measurements, the CO2 concentration was measured to be homogeneous and its sampled value was given by the difference between the indoor and outdoor CO2 measurements (>5000 ppm or 0.5% CO2 in air) averaged over an 8-h work day Time-Weighted Average (TWA.). G1 and G3 group participants performed low-intensity daily office activities, such as reading and talking. In contrast, Group Two (G2) was asked to perform moderate intensity activities, such as frequently lifting 10 kg items and walking quickly. The CO2 concentration was measured with two instruments to compare the outdoor and indoor measurements. Both devices were configured to take one reading every second for 30 min. A mathematical model was developed from the CO2 concentrations measured, the group size, and the retention factor of the mask being worn to determine the probability of inhaled air contaminated with an aerosol of SARS-CoV-2. We concluded that the likelihood of contagion in enclosed areas such as study areas, offices, and meeting rooms, among others, which use ventilation without a circulation of fresh air, is high. Despite proper distancing and masking, there is a 99% chance of contagion in one of the modeled extreme case scenarios in less than 10 min of exposure. The study took place in Albrook, Republic of Panama, which is a tropical developing coastal geographic location where split air conditioning units are widely used and, like many other countries in Latin America, where indoor air quality has only recently started being discussed publicly and enforced.

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Li, S., Qin, F., Dong, Y., Zhou, S., Sun, J.
Assessment of respiratory disease infection risk and natural ventilation intervention countermeasures in teaching spaces: A campus case study.
Journal of Building Engineering, Vol. **70**, (2023)

The risk of indoor respiratory disease transmission can be significantly reduced through interventions that target the built environment. Several studies have successfully developed theoretical models to calculate the effects of built environment parameters on infection rates. However, current studies have mainly focused on calculating infection rate values and comparing pre- and post-optimization values, lacking a discussion of safe baseline values for infection rates with risk class classification. The purpose of this paper is to explore the design of interventions in the built environment to improve the ability of buildings to prevent virus transmission, with a university campus as an example. The study integrates the Wells-Riley model and basic reproduction number to identify teaching spaces with high infection risk on campus and proposes targeted intervention countermeasures based on the analysis of critical parameters. The results showed that teaching buildings with a grid layout pattern had a higher potential risk of infection under natural ventilation. By a diversity of building environment interventions designed, the internal airflow field of classrooms can be effectively organized, and the indoor virus concentration can be reduced. We can find that after optimizing the building mentioned above and environment intervention countermeasures, the maximum indoor virus

infection probability can be reduced by 22.88%, and the basic reproduction number can be reduced by 25.98%, finally reaching a safe level of less than 1.0. In this paper, we support university campuses' respiratory disease prevention and control programs by constructing theoretical models and developing parametric platforms.

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Horne, J., Dunne, N., Singh, N., Safiuddin, M., Esmaeili, N., Erenler, M.*, et al.*
Building parameters linked with indoor transmission of SARS-CoV-2.
Environmental Research, (2023)

The rapid spread of Coronavirus Disease (2019)(COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has emphasized the importance of understanding and adapting to the indoor remediation of transmissible diseases to decrease the risk for future pandemic threats. While there were many precautions in place to hinder the spread of COVID-19, there has also been a substantial increase of new research on SARS-CoV-2 that can be utilized to further mitigate the transmission risk of this novel virus. This review paper aims to identify the building parameters of indoor spaces that could have considerable influence on the transmission of SARS-CoV-2. The following building parameters have been identified and analyzed, emphasizing their link with the indoor transmission of SARS-CoV-2: temperature, relative humidity, ventilation, occupant density, surface finish, HVAC systems, filtration, space compartmentalization, airflow, and air quality. Based on these parameters, it is possible to develop the appropriate remediation tools needed to decrease the transmission risk of SARS-CoV-2 inside occupied buildings. Furthermore, the modifications of the key building parameters have been discussed for controlling the transmission of SARS-CoV-2 in indoor spaces. Understanding the information provided in this paper is crucial to develop effective health and safety measures that will aid in infection prevention.

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Marr, L.
Changing Policies on COVID-19 Transmission.
Am Sci, Vol. **111** n°(5), (2023), 266-269 p.

Despite its top-notch scientific institutions, the United States fared especially poorly during the COVID-19 pandemic. There were many missed opportunities that led to such an epic tragedy. One that has loomed especially large has been confusion around airborne spread of the virus. Precautions such as improving indoor air quality or wearing masks were ignored or downplayed until far too late. Linsey Marr, an engineer who studies aerosols at Virginia Tech, suddenly found her expertise needed in 2020 in the rapidly unfolding public health emergency—and yet she and others in her field were not included among the regulatory scientists working on the guidelines for the World Health Organization and U.S. Centers for Disease Control and Prevention (CDC). Digital features editor Katie L. Burke spoke with Marr about how she and her colleagues worked for years to change policies based on faulty ideas about transmission of the coronavirus. This interview has been edited for length and clarity.

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Rosales, C. M. F., Jiang, J., Lahib, A., Bottorff, B. P., Reidy, E. K., Kumar, V.*, et al.*
Chemistry and human exposure implications of secondary organic aerosol production from indoor terpene ozonolysis.
Science Advances, Vol. **8** n°(8), (2022)

Surface cleaning using commercial disinfectants, which has recently increased during the coronavirus disease 2019 pandemic, can generate secondary indoor pollutants both in gas and aerosol phases. It can also affect indoor air quality and health, especially for workers repeatedly exposed to disinfectants. Here, we cleaned the

floor of a mechanically ventilated office room using a commercial cleaner while concurrently measuring gas-phase precursors, oxidants, radicals, secondary oxidation products, and aerosols in real-time; these were detected within minutes after cleaner application. During cleaning, indoor monoterpene concentrations exceeded outdoor concentrations by two orders of magnitude, increasing the rate of ozonolysis under low (<10 ppb) ozone levels. High number concentrations of freshly nucleated sub-10-nm particles (>= 10(5) cm(-3)) resulted in respiratory tract deposited dose rates comparable to or exceeding that of inhalation of vehicle-associated aerosols.

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Babich, F., Torriani, G., Corona, J., Lara-Ibeas, I.

Comparison of indoor air quality and thermal comfort standards and variations in exceedance for school buildings.

Journal of Building Engineering, Vol. **71**, (2023)

Addressing indoor air quality (IAQ) and thermal comfort issues in school buildings is challenging but relevant. Firstly, their primary occupants are more vulnerable than adults. Secondly, school buildings are often inadequate being too old or designed to prioritise energy-efficiency targets. Thirdly, occupants have often little control over the indoor environmental quality (IEQ). Lastly, the SARS-CoV-2 pandemic highlighted the complexity and vulnerability of existing decision making processes in relation to making timely and well-informed decisions about IEQ threats. Standards and guidelines vary over time and among similar countries despite targeting similar occupants, evaluate IAQ and thermal comfort independently, and do not include any specific adaptations to children. Thus, the aim of this research is to compare different available standards to evaluate IAQ and thermal comfort in school buildings. By analysing with different standards (EN16798, BB101, and ASHRAE 55 and 62.1) the data collected in schools in northern Italy, this research evaluated the consequences of different limits and approaches, and proposed improvements. The conclusions are that (i) thresholds and methods inconsistency within the same standard should be avoided; (ii) upper-and lower-bounded operative temperature scales are the most appropriate means to design and verify thermal comfort in classrooms; (iii) IAQ metrics that give an upper limit per a certain amount of consecutive time might prevent the build-up of indoor pollutants, even with high emissions from the building fabric; (iv) no standard proposes a combined IAQ and thermal comfort analysis which could enable more informed trade-off decisions considering IAQ, thermal comfort, and energy targets.

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Lim, S., Malkawi, A., Norford, L., Ashrae.

Controlling Wind Pressure Around Buildings: Using Automated Multi-Angle Ventilation Louvers for Higher Natural Ventilation Potential.

2023 ASHRAE Winter Conference. February 4-8, 2023 ATLANTA, GEORGIA

Natural ventilation (NV) is an effective means of reducing building energy consumption and enhancing indoor air quality (IAQ) by conveying outdoor air into space. Recently, rising concern about climate change and the COVID-19 aroused interest in raising the potential of NV. However, the uncertainty of airflow around the building, and windows control that rely on the occupant's behavior is a huddle to achieve higher NV potential in conventional buildings. This research proposes an automated multi-angle ventilation louver that can provide a desired and stable airflow into space by controlling the axis position and opening angle, leading to higher NV potential. The louver is designed to open in different directions and angles according to the wind condition to meet the optimized need for cooling and ventilation in the space. The performance of the louver was tested on multiple cases of wind conditions and louver configurations by computational fluid dynamics (CFD) simulations. The airflow data collected from the CFD simulations showed that the louver generates higher NV potential compared to the opening without the louvers. Next, the data was trained by linear regression, and a model was created to predict airflow from various conditions. Based on the model, this

research introduces a simulation tool developed in Rhinoceros and Grasshopper. The simulation tool that is linked to the building energy simulation tool can assist designers and engineers in exploring the potential of NV when utilizing the louvers at different locations, building programs, and building configurations. The tool further indicates louver control and coordination on an hourly basis that can achieve maximized NV potential. Overall, this research expands the applicability of NV in both new and existing buildings by introducing an automated multi-angle ventilation louver and facilitating the use of NV for cooling and ventilating the space. Buildings that are in a disadvantageous location for NV in terms of weather conditions or the surrounding environment might also gain feasibility in utilizing NV by the louver. Further study will optimize the louver design and apply model predictive control (MPC) to the control system. Specifically, a mock-up model will be made to validate the increase of potential, and the control system will be able to predict variations in indoor environments and building surrounding conditions in advance and make an optimized decision.

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Vass, W. B., Nannu Shankar, S., Lednicky, J. A., Yang, Y., Manzanas, C., Zhang, Y., *et al.*
Detection and isolation of infectious SARS-CoV-2 omicron subvariants collected from residential settings.
Aerosol Science and Technology, (2023), 1-12 p.

Airborne transmission of infectious (viable) SARS-CoV-2 is increasingly accepted as the primary manner by which the virus is spread from person to person. Risk of exposure to airborne virus is higher in enclosed and poorly ventilated spaces. We present a study focused on air sampling within residences occupied by individuals with COVID-19. Air samplers (BioSpot-VIVAS, VIVAS, and BC-251) were positioned in primary- and secondary-occupancy regions in seven homes. Swab samples were collected from high-touch surfaces. Isolation of SARS-CoV-2 was attempted for samples with virus detectable by RT-qPCR. Viable virus was quantified by plaque assay, and complete virus genome sequences were obtained for selected samples from each sampling day. SARS-CoV-2 was detected in 24 of 125 samples (19.2%) by RT-qPCR and isolated from 14 (11.2%) in cell cultures. It was detected in 80.9% (17/21) and cultured from 61.9% (13/21) of air samples collected using water condensation samplers, compared to swab samples which had a RT-qPCR detection rate of 10.5% (4/38) and virus isolation rate of 2.63% (1/38). No statistically significant differences existed in the likelihood of virus detection by RT-qPCR or amount of infectious virus in the air between areas of primary and secondary occupancy within residences. Our work provides information about the presence of SARS-CoV-2 in the air within homes of individuals with COVID-19. Information herein can help individuals make informed decisions about personal exposure risks when sharing indoor spaces with infected individuals isolating at home and further inform health departments and the public about SARS-CoV-2 exposure risks within residences.

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Rothenberg, L., Rezaei, R., Krichtafovitch, I., Viosca, A., Ashrae.
Determination of Energy Savings Potential from Varying Power to Ionization Stage of an Electrostatic Air Filter.
2023 ASHRAE Winter Conference. February 4-8, 2023 ATLANTA, GEORGIA

Indoor air quality is increasingly recognized as a serious health hazard in many international environments. During the recent pandemic, this concern was amplified as Covid-19-related mortality closely correlated with poor air quality. Even a comparatively small decline in the Air Quality Index (AQI) can be linked to a sharp mortality increase. Worsening air quality levels are compounded by distinct air-quality issues in different geographical areas. In the face of this serious and wide-ranging threat, the common solution-introducing a high MERV-rated filter-comes up short, as these filters create back pressure that often exceeds the capacity of the HVAC systems in which they are installed. High-backpressure filters also use more energy and require frequent filter changes, making them more expensive to maintain and bad for the environment. This paper describes a new form of electrostatic filtration that is ideal for international markets since it has a uniform

performance, low back pressure, is energy efficient, and can be tuned to perform at a range of filtration levels depending on demand. This is accomplished by varying voltage applied to the ionization stage of the filter. In this study, we operate an electrostatic filter with a variable power source set to vary filtration level according to a variety of operating algorithms and compare the resulting energy use to standard air filters.

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Genjo, K., Nakanishi, H., Oki, M., Imagawa, H., Uno, T., Saito, T.*, et al.*
Development of Adaptive Model and Occupant Behavior Model in Four Office Buildings in Nagasaki, Japan.
Energies, Vol. **16** n°(16), (2023)

A field survey of indoor environmental measurements and questionnaires on thermal sensation, overall comfort, and behaviors was conducted in four office buildings in Japan by visiting each office every month over a duration of more than a year during the coronavirus disease 2019 (COVID-19) pandemic. The indoor environment was measured concurrently. We obtained 1047 votes from office workers in their 20s to 60s. The regression and Griffiths' methods were used to calculate the indoor comfort temperature. A logistic regression analysis was used to develop the occupant behavior model. Over 70% of the occupants found the indoor environment comfortable at a mean comfort temperature of 23.2 to 25.9 & DEG;C. Gender differences were observed in thermal sensation and overall comfort, but a gender difference was observed only in the cooling mode for the indoor comfort temperature. An adaptive model was developed for the office buildings in Nagasaki city to predict the indoor comfort temperature from the outdoor air temperature. The proportions of heating, cooling, and fan usage can be predicted from the outdoor air temperature using a logistic regression analysis. The adaptive model and occupant behavior model are useful for the indoor temperature control of the existing buildings and thermal simulation of the new building design.

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Kanama, N., Ondarts, M., Guyot, G., Outin, J., Golly, B., Gonze, E.
Effect of energy renovation on indoor air quality and thermal environment in winter of a primary school in a highly polluted French alpine valley.
Journal of Building Engineering, Vol. **72**, (2023)

With increasing the COVID-19 pandemic and the time spent indoor, there is a growing research interest in the issue of Indoor Environmental Quality in building including thermal environment and indoor air quality (IAQ). Research and intervention in schools are a particular focus, as children are especially vulnerable to air pollution. The aim of this study is to assess the impact of energy renovation, including the installation of a balanced ventilation system with a filter (F7 type), on the IAQ of a school building located in a polluted outdoor environment. The study is based on measurements of some parameters of thermal environment and IAQ. To this end, two classrooms were chosen for two measurement campaigns. Each campaign covered 2 months in winter in 2018 and 2020 before and after renovation, respectively. The measurements included ventilation airflow rates, temperature, relative humidity, carbon dioxide, and particle concentration (PM2.5). The main result of installing the balanced ventilation was an increase in the air change rate from 0.1 h-1 and 0.05 h-1 before the renovation to 1.5 h-1 and 1.7 h-1 after the renovation, for classroom 1 and classroom 2, respectively. This increase changed the ICONE air stuffiness level from average air stuffiness to fresh air (no air stuffiness). However, this increase resulted in a significant entry of outdoor particles. As consequence, the highest indoor/outdoor concentration ratio (57%) was observed after the renovation. All these results highlights that ventilation performance should be extended to parameters as filtration efficiencies in order to increase IAQ.

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Du, Y., Zhao, F., Tao, R., Liu, B.
Effect of forceful suction and air disinfection machines on aerosol removal.

BMC Oral Health, Vol. **23** n°(1), (2023), 652 p.

Dental procedures involving drilling and grinding can produce a significant amount of suspended aerosol particles (PM) and bioaerosols. This study aims to analyze the size and concentration of aerosol particles generated during drilling and to investigate the effectiveness of two air exchange systems, namely forceful suction (FS) and air disinfection machines (DM), in removing PM.

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Sekartaji, D., Ryu, Y., Novianto, D.
Effect of ventilation patterns on indoor thermal comfort and air-conditioning cooling and heating load using simulation.
City and Built Environment, Vol. **1** n°(1), (2023), 14 p.

Over the past three years, regulations have been implemented to combine natural ventilation (NV) and air conditioning to mitigate the risk of disease transmission, particularly in response to the COVID-19 outbreak. As we know, simultaneous use of NV and air conditioning can make it challenging to achieve indoor thermal comfort. This paper aims to analyze the effect of NV on the air conditioning`s cooling and heating load in a classroom through simulation. A simulation model was developed using EnergyPlus software with an OpenStudio interface software. Simulation results demonstrate that continuous use of NV alongside an air conditioner increases the cooling load from 1.06 to 1.75 times during summer and a 1.54 to 9.49 times heating load increase during winter. On the other hand, intermittent NV every hour results in a cooling load increase from 1.05 to 1.46 times in summer and a heating load increase from 1.13 to 4.63 times in winter. Moreover, employing NV based on the outside air temperature can reduce the cooling load at the air conditioner with set-point 26℃—28℃ from 0.94 to 0.88 times. The outcomes of this study are expected to serve as a reference for determining strategies that effectively combine NV and air conditioning to meet various needs without causing a significant increase in energy consumption. Additionally, the results are expected to be useful for reducing AC energy consumption in extremely hot and cold weather with some strategies of NV application.

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Bueno De Mesquita, P. J., Sokas, R. K., Rice, M. B., Nardell, E. A.
Far-UVC: Technology Update with an Untapped Potential to Mitigate Airborne Infections.
Annals of the American Thoracic Society, (2023)

Clinicians and patients spent the fall and winter of 2022 grappling with the triple surge of SARS-CoV-2, influenza, and RSV. Meanwhile, a host of zoonotic diseases await the inevitable mutations that could fuel human-to-human transmission and the next pandemic. Because respiratory infections are transmitted through shared indoor air, strategies for prevention should embrace the effective modalities for cleaning indoor air. As an analogy, we don’t rely on vaccines to prevent waterborne illness, even though there is a vaccine against cholera - we rely on effective water treatment to provide safe drinking water free of the spectrum of disease-causing microbial agents. We should take a similar engineering approach to shared indoor air spaces.

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Brown, E., Haslam, A., Prasad, V.
Flu advice in the US news media changed during the COVID-19 pandemic but not the evidence.
Eur J Epidemiol, (2023), 1-3 p.

Advice in the United States news media on preventing seasonal influenza appeared to change drastically during the COVID-19 pandemic. Notably, health experts began recommending the use of face masks, six-foot

social distancing, and improved ventilation to prevent getting and spreading the flu. These interventions were introduced in the US during the COVID-19 pandemic as a means of controlling a novel pathogen in the absence of a vaccine and treatments [...]

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Li, N., Xu, C., Yu, C. W. F.
Healthy and resilient HVAC design for public buildings in post COVID-19 pandemic era.
Indoor and Built Environment, (2023)

People spend around 90% of their lifetime in buildings that serve important physiological, psychological and social functions, especially when considering public and occupants' health. Public buildings, such as offices, hospitals, schools, shopping malls, hotels and transportation spaces, are places where people carry out various public activities with relatively large amounts of space and high flows of people, which can easily lead to airborne disease transmission. The outbreak of COVID-19 since 2019 has raised intense focus on the indoor air quality in these public buildings. Even if the COVID-19 pandemic is at an end as announced by the World Health Organization (WHO), conventional heating, ventilation and air conditioning (HVAC) systems in public buildings are still not capable of coping with potential future severe epidemic situations, and a resilient HVAC would be needed to provide a meaningful retrofit measure to cope with the future epidemics.

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Yusop, H., Wan Puteh, S. E.
Housing and Indoor Factor Influencing Spread of COVID-19.
International Journal of Public Health Research, Vol. **13** n°(2), (2023)

There has been growing recognition linking spread of COVID-19 with environmental factors. One of the environmental factors with robust epidemiological literature supporting its role in diseases is the housing or built environment. COVID-19 spread has been found to occur mostly at homes through secondary household transmission. As most people spend more times inside homes during the pandemic, household remains an important site of COVID-19 spread. The aim of this study is to examine how housing and indoor factors affect the transmission and spread of COVID-19. This article summarizes the housing indoor factors involved in COVID-19 transmission, including the role of transmission from contaminated household surfaces. Indoor transmission of COVID-19 is found to be more likely due to contact transmission and close-contact aerosol transmission in a crowded, confined, and poorly ventilated indoor environment, related to poor housing condition. Whilst role of spread through contaminated household surfaces is of low probability. Based on this review, it can be suggested that besides the existing measures including avoiding crowding, close contacts and proper ventilation, specific standards for indoor environmental quality control and housing condition might be required. Housing is a public health issue and healthy housing is of universal concern.

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Awad, H., Ashouri, A., Rizvi, F.
How Building Energy Use Reacted to Variable Occupancy Pre- and Post- COVID-19 Pandemic. Sensitivity Analysis of 35 Commercial Buildings in Canada.
Buildings, Vol. **13** n°(9), (2023)

The COVID-19 pandemic and global shutdown and work-from-home order for non-essential businesses and employees led to a substantial decline in energy usage in the commercial building sector. However, the magnitude of decline was not equivalent to what would be expected for unoccupied spaces. The energy performance of low/unoccupied commercial buildings, particularly in the context of new minimum requirements to maintain indoor air quality, is an intriguing research question. In this study, we developed a numerical model that measures electricity usage sensitivity to occupancy (ESTO) where we compare the

business-as-usual energy performance with unoccupied energy performance. Two years of COVID-time (in addition to a pre-COVID control year) hourly energy use (electricity (plug loads, lighting, and fans), heating, and cooling) using data from 35 commercial buildings (i.e., buildings with HVAC and other building systems typical of commercial rather than residential buildings) are analyzed to quantify those changes. A change point model is used to assess thermal load intensities, change point temperature, and off-season unoccupied baseloads. Finally, we suggest a generic framework for building scoring based on selected performance parameters. Results indicate that the suggested scoring system is robust and replicable and is reliable for ranking buildings within a given portfolio from best- to worst- performing, thus prioritizing buildings that are best candidates for retrofits.

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Pechter, E., Lessin, N.
Measuring Indoor Air Quality Does Not Prevent COVID-19.
NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, (2023)

Boston Public Schools (BPS) closed for in-person learning in March 2020 due to COVID-19 and didn't fully reopen until the 2021–2022 school year. Due to the age of schools and absent ventilation systems, coupled with decades of disinvestment in the infrastructure, BPS entered the pandemic with serious challenges impacting the health of students and staff. These challenges were magnified by an infectious airborne virus. Instead of using this opportunity to improve ventilation systems, BPS opted to invest in an air quality monitoring system. This system only confirmed what was already known—there is poor ventilation in most school buildings. It did not lead to correction of new or long-standing problems. This failure has harmed the BPS community, which includes primarily low-income Black and Brown families. This article describes Boston's school system, its track record of inadequate attention to infrastructure, and explores pitfalls of focusing on evaluation instead of correction.

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Yang, J., Sun, D., Xia, T., Shi, S., Suo, J., Kuang, H.*, et al.*
Monitoring Prevalence and Persistence of Environmental Contamination by SARS-CoV-2 RNA in a Makeshift Hospital for Asymptomatic and Very Mild COVID-19 Patients.
International Journal of Public Health, Vol. **68**, (2023)

Objective: To investigate the details of environmental contamination status by SARS-CoV-2 in a makeshift COVID-19 hospital.Methods: Environmental samples were collected from a makeshift hospital. The extent of contamination was assessed by quantitative reverse transcription polymerase chain reaction (RT-qPCR) for SARS-CoV-2 RNA from various samples.Results: There was a wide range of total collected samples contaminated with SARS-CoV-2 RNA, ranging from 8.47% to 100%. Results revealed that 70.00% of sewage from the bathroom and 48.19% of air samples were positive. The highest rate of contamination was found from the no-touch surfaces (73.07%) and the lowest from frequently touched surfaces (33.40%). The most contaminated objects were the top surfaces of patient cubic partitions (100%). The median Ct values among strongly positive samples were 33.38 (IQR, 31.69–35.07) and 33.24 (IQR, 31.33–34.34) for ORF1ab and N genes, respectively. SARS-CoV-2 relic RNA can be detected on indoor surfaces for up to 20 days.Conclusion: The findings show a higher prevalence and persistence in detecting the presence of SARS-CoV-2 in the makeshift COVID-19 hospital setting. The contamination mode of droplet deposition may be more common than contaminated touches.

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Li, B., Wang, S.
Multi-objective optimal control of multi-zone VAV systems for adaptive switching between normal and pandemic modes.

Building and Environment, Vol. **243**, (2023)

The recent COVID-19 pandemic has highlighted the need to adapt the control of building HVAC systems to limit disease transmission in indoor environments. However, such operational adjustments may significantly increase energy use, creating a complex trade-off problem between infection risk mitigation and energy efficiency. Moreover, practical constraints, such as maintaining comfortable temperature and humidity levels for occupants and limited system equipment capacity, can limit the flexibility of operational adjustments, further exacerbating the challenge of finding optimal operational solutions. This paper therefore proposes an optimal control strategy for multi-zone VAV systems that adapts to switching between normal and pandemic modes. The strategy considers dual optimization objectives: minimizing system energy use and disease transmission risk, while also considering all practical constraints. Optimal operational parameters can be determined to achieve the best trade-off between these objectives based on pandemic conditions. Additionally, a new metric called "effective fresh air factor" is proposed to quantify the impact of multi-zone VAV systems on disease transmission in building zones. The effectiveness of the proposed strategy is evaluated in a simulated building and air-conditioning environment. Results show that the VAV system has superior ability to reduce transmission risk through operational adjustments, achieving a decrease in disease transmission risk by 25%-75% compared to normal operation.

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Abbaspour, A., Bahadori-Jahromi, A., Amirkhani, S., Janbey, A., Godfrey, P. B., Tahayori, H.*, et al.*
Multi-Zonal Analysis of Indoor Air Quality in a Higher Educational Building in the UK.
Sustainability, Vol. **15** n°(16), (2023)

This study focuses on the indoor air quality (IAQ) in a higher educational building, the London College in the UK. In this regard, indoor CO2 levels, as well as three contaminants with detrimental effects on human health: NO2, PM2.5, and SARS-CoV-2, are investigated. Various IAQ enhancement strategies are analyzed, including increased ventilation, background ventilation, improved airflow through opened doors, and the use of HEPA air cleaners. Results revealed that background ventilation and open doors during occupied periods reduced CO2 concentrations to around 1000 ppm. However, the effectiveness of background ventilation was influenced by outdoor conditions, such as wind speed and direction. The most effective method for reducing PM2.5 levels was installing an air cleaner alongside a commercial kitchen hood, resulting in a 15% greater reduction compared to background ventilation. To control the SARS-CoV-2 level, combining background ventilation or opening the doors with a 16,000 m3/h ventilation rate or using an air cleaner with baseline ventilation resulted in a basic reproductive number below 1. Overall, the research highlights the importance of background ventilation and open doors in enclosed spaces without operable windows for natural airflow. Additionally, the effectiveness of air purifiers in reducing particle and biological contaminant concentrations is demonstrated, providing valuable insights for improving IAQ in educational buildings.

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Yang, H., Luo, X., Chen, B., Xie, H., Huang, L., Shi, Q.*, et al.*
A numerical investigation on indoor air ventilation design and aerosol transportation: a case study in a hospital hall.
SIMULATION, (2023)

The transportation of indoor aerosol particles is closely related to the infection risk of various viruses. When the pandemic of COVID-19 is anticipated to coexist with human beings in the future, the design of airflow distribution in public buildings becomes more vital not only for thermal comfort but also for epidemic prevention through controlling indoor aerosol transportation. In this paper, the conditioning of indoor air in a hospital hall (Chongzhou Traditional Chinese Medicine Hospital in Chengdu, China) is case studied by numerically simulating the indoor thermal comfort and the aerosol transportation process analysis. Simulation

results indicate that thermal comfort can be first achieved by appropriate air supply forms in summer. Under the combined operation of the nozzles, square diffusers, and the breathing plane, with an average velocity of 0.26?m/s, the average temperature, and the average air age are 23.43°C and 949.59?s, respectively. Second, the arrangement of air-exhaust outlets in this hospital hall is also redesigned and simulated with three new schemes of outlets design, of which the floor exhaust scheme is optimal with the fastest aerosol discharge speed (thus the strongest pollutant discharge capacity), i.e., 62% of aerosol particles discharged in 30?s and 99% of particles discharged in 150?s. This study makes a successful attempt to optimize indoor air ventilation for preventing airborne transmission of viruses, e.g., COVID-19, offering a feasible scheme for the air distribution design in densely populated areas such as hospital halls.

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Ugarte-Anero, A., Fernandez-Gamiz, U., Portal-Porras, K., Lopez-Guede, J. M., Sanchez-Merino, G.
Numerical study of different ventilation schemes in a classroom for efficient aerosol control.
Heliyon, Vol. **9** n°(9), (2023)

The air quality is a parameter to be controlled in order to live in a comfortable place. This paper analyzes the trajectory of aerosols exhaled into the environment in a classroom. Three scenarios are investigated; without ventilation, with natural and with mechanical ventilation. A multi-phase computational fluid study based on Eulerian-Lagrangian techniques is defined. Temperature and ambient relative humidity, as well as air velocity, direction and pressure is taken into account. For droplets evaporation, mass transfer and turbulent dispersion have been added. This work tends to be of great help in various areas, such as the field of medicine and energy engineering, aiming to show the path of aerosols dispersed in the air. The results show that the classroom with a mechanical ventilation scheme offers good results when it comes to an efficient control of aerosols. In all three cases, aerosols exhaled into the environment impregnate the front row student in the first 0.5 s. Reaching the time of 4, 2 and 1 s, in the class without ventilation, mechanical and natural ventilation, respectively, the aerosols have been already deposited on the table of the person in the first row, being exposed for longer in the case of no ventilation. Particles with a diameter of less than 20 µm are distributed throughout the classroom over a long period. The air jet injected into the interior space offers a practically constant relative humidity and a drop in temperature, slowing down the process of evaporation of the particles. In the first second, it can be seen that a mass of 0.0025 mg formed by 9 million droplets accumulates, in cases without ventilation and natural ventilation. The room with a mechanical installation accumulated 5.5 million particles of mass 0.0028 mg in the first second. The energy losses generated by natural ventilation are high compared to the other scenarios, exactly forty and twenty times more in the scenario with mechanical ventilation and without ventilation, respectively.

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Niu, D., Zhang, S.
Outdoor thermal condition based-segmented intermittent demand-controlled ventilation for constant-air-volume system.
Building and Environment, Vol. **244**, (2023)

The outdoor air supply is mandatory for healthy built environments but consumes a large amount of building energy. The demand-controlled ventilation method adjusts the outdoor air supply for both indoor air quality and high energy efficiency. However, the conventional demand-controlled ventilation method does not apply to the constant-air-volume ventilation system. Since the constant-air-volume ventilation system is widely used in practice for outdoor air supply, this study proposes a novel demand-controlled ventilation method, i.e., the segmented intermittent demand-controlled ventilation, to improve the energy efficiency of the constant-air-volume ventilation system with indoor air quality. The proposed method intermittently supplies outdoor air to reduce the amount of outdoor air supply for energy saving of ventilation fan while satisfying indoor air quality. Moreover, the proposed method divides the working time into segments and adjusts the outdoor air supply of

each segment according to the outdoor weather for cooling/heating energy saving. This study reveals the detailed mechanisms of energy saving of the proposed method and develops an optimization algorithm to maximize the energy saving of the proposed method with indoor air quality. The proposed method is tested for both cooling and heating scenarios in different climate zones. The results show that compared with the conventional methods and the existing intermittent demand-controlled ventilation, the proposed method achieves weekly energy savings of 18.0%–62.4% and 4.3%–6.8% respectively. The proposed method can contribute to the development of low-carbon and healthy built environments.

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Li, H., Sang, T., Kong, X., Zheng, W., Wang, Z., Li, J.*, et al.*
Performance analysis of interactive cascade ventilation combined with solar energy for the epidemic prevention and control.
Applied Energy, Vol. **349**, (2023)

Increasing low-grade and renewable energy sources in the HVAC systems has become necessary to reduce heating energy consumption. Hence, seeking a new air conditioning system that can be combined with renewable energy is significant to maintain a healthy and comfortable indoor environment with a low cost. This paper proposes a novel air source heat pumps assisted solar hot water with interactive cascade ventilation system (shortened as SWAP-ICV). Taking the traditional air source heat pumps with mixing ventilation system (AP-MV) as a reference, the virus control performance and energy efficiency of SWAP-ICV is investigated through CFD and TRNSYS simulations. The results demonstrate that interactive cascade ventilation under full-fresh air operation mode and normal-epidemic linkage mode can make the annual infection risk reduce by 41.16% and 9.33% compared with mixing ventilation under full-fresh air operation mode. Meanwhile, the proposed system can reduce energy consumption by 59.92% and 69.8% during the normal period and epidemic period by introducing solar energy. The average system COP during the heating season indicates that SWAP-ICV can improve the system efficiency by 1.9-2.58 times than AP-MV system. The conclusions obtained from this research can provide new ideas for the design and operation of air conditioning systems in the post-epidemic era.

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Xu, C., Ren, Y., Li, N., Liu, L., Mei, X., Fan, Y.
Performance of personalized ventilation in mitigating short-range airborne transmission under the influence of multiple factors.
Building Simulation, (2023)

The effectiveness of using personalized ventilation (PV) in mitigating airborne transmission risk was found to be easily affected by multiple factors. The aim of this study was hereby to evaluate the impacts of several important factors on the performance of PV in airborne disease control for closely ranged occupants. Orthogonal experiments were designed for CFD simulations under different levels of four selected factors. Results indicated that the order of significance of these four factors affecting the intake fraction (IF) of the exposed occupant was as follows: mode of PV use > relative distance between occupants > PV airflow volume > background ventilation. The best combination of the four tested factors was PV of 15 L/s for both the infected source and the exposed occupant, with a relative distance of 2 m between them and mixing ventilation, which would yield an IF of merely 0.0246%. The worst combination was PV of 6 L/s for the exposed occupant only, with a relative distance of 0.86 m under displacement ventilation, indicating an elevated IF of 0.2919%. The increase of PV air volume and relative separation distance both contributed to lower exposure risk, but they were not as influential as the mode of PV use. PV integrated with mixing ventilation and utilized for both infected and susceptible occupants were recommended. The findings in this study will be helpful to provide guidance for the implementation of PV in indoor environment for airborne infection control.

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Fatimah, W., Yusoff, M.

Post Covid-19 Ventilation Strategies for Shopping Malls in Hot Humid Climate.

CIC 2023: The 2nd International Conference On Civil Infrastructure And Construction. Qatar University. Doha, Qatar, February 5-8, 2023

To date, many strategies have been executed to combat the COVID-19 disease, including the provision of good ventilation in buildings to reduce the spread of the virus. Open or semi-open space with good air exchange between indoor and outdoor provides better condition compared to enclosed space with mechanical ventilation. However, the design of public buildings, especially the shopping malls in hot and humid climate are mostly enclosed, with the high usage of air-conditioning systems. Due to the COVID-19 situation, it is found that the typical approach to shopping mall design needs to be revised and improved. Hence, this study is conducted with the intention to derive an initial idea regarding the new approach of a shopping mall that is able to be less dependent on the mechanical ventilation system. The method conducted for this preliminary study is a semi-structured interview with three respondents that possess experience of involving in shopping mall projects, namely the architect and mechanical engineer. The findings from the interview show that all respondents agreed that a new approach to ventilation systems should be implemented in shopping malls. They also emphasized that for shopping malls located in hot and humid climate, the usage of merely natural ventilation is impractical, especially in providing thermal comfort to the users. Hence, it is recommended to have hybrid ventilation which combines mechanical and natural ventilation systems. This study is significant as it encourages other studies related to the new approach to shopping mall design, especially in the hot and humid climate.

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Rastogi, P., Sobek, O. N., Toledo, L., Fleck, R., Jephson, G., Sharpe, T.*, et al.*

Results from Air Quality Monitoring and Surveys in UK Residences.

In: 2023 ASHRAE WINTER CONFERENCE. February 4-8, 2023 Georgia. Atlanta, GA2023. pp. 355-365.

Air pollution is a persistent issue in dwellings worldwide, costing an estimated 10-25 billion US dollars per year to the United Kingdom's national health service alone. However, it is an "invisible problem" since background pollutants are often imperceptible except during acute pollution events such as wildfires. Although public awareness of ventilation has increased due to the COVID-19 pandemic, there are few tools available to assess its efficacy. Widely available sensor systems that can measure these pollutants tend to be single units with simple apps and little connection to mitigation, whereas different rooms in a house may have different pollution issues with different recommended actions. In this study, we present the results of a measurement study conducted using a multi-room sensor kit in twenty-nine dwellings across the UK. We also analyze the occupants' reaction to the hardware, data, and a prototype alerting system. The study shows broad awareness of air quality in the participants. However, this awareness rarely corresponded to effective mitigation actions or ventilation provision. The concept of alerts was welcomed by participants if accompanied by actionable recommendations. The data showed significant pollution events, as measured by proxies such as total VOC and CO2, occurring almost daily, particularly in households with gas appliances. These incidents were concentrated around particular times of day and behaviors, indicating that the capacity of infiltration and extract ventilation to bring in adequate fresh air was overwhelmed. No significant outdoor pollution was detected in houses, which was expected given their sheltered peri-urban locations. The study highlights the need for comprehensive implementation of measurement, ventilation, and treatment measures in the UK housing stock to reduce the impact of indoor pollution on health.

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Galmiche, S., Charmet, T., Rakover, A., Schaeffer, L., Chény, O., Von Platen, C.*, et al.*

Risk of SARS-CoV-2 Infection Among Households With Children in France, 2020-2022.
JAMA Network Open, Vol. **6** n°(9), (2023)

Understanding the contribution of children to SARS-CoV-2 circulation in households is critical for designing public health policies and mitigation strategies.To identify temporal changes in the risk of SARS-CoV-2 infection in people living with children.This case-control study included online questionnaire responses from French adults between October 2020 and October 2022. Eligible cases were adults with ongoing SARS-CoV-2 infection with an email address on record with the national health insurance system, which centralized all new diagnoses in France. Eligible controls were adults who had never tested positive for SARS-CoV-2 until February 2021, when eligibility was extended to all adults without ongoing SARS-CoV-2 infection.Transmission of SARS-CoV-2 from a child (aged under 18 years) within the household in the descriptive analysis, as reported by the participating case. Sharing household with a child (of any age or broken down by school level) in the case-control analysis.Ongoing SARS-CoV-2 infection diagnosed by reverse transcription-polymerase chain reaction or supervised rapid antigen test (ie, not self-tests).A total of 682 952 cases were included for the descriptive analysis (68.8% female, median [IQR] age, 44 [34-55] years). Among those, 45 108 (6.6%) identified a household child as the source case; this proportion peaked at 10.4% during the Omicron BA.1 wave (December 20, 2021, to April 8, 2022). For the case-control analysis, we matched 175 688 cases (with a 4:1 ratio) for demographic characteristics with 43 922 controls. In multivariable logistic regression analysis, household exposure to children was associated with an increased risk of infection mainly at the end of summer 2021 (receding Delta wave) and during winter 2022 (Omicron BA.1 wave). In subgroup analysis by school level of the child, living with children under the age of 6 was associated with increased odds of infection throughout the study period, peaking at an odds ratio (OR) 1.8 (95% CI, 1.6-2.1) for children looked after by professional in-home caregivers, 1.7 (95% CI, 1.5-1.7) for children in day care facilities, and 1.6 (95% CI, 1.4-1.8) for children in preschool. The ORs associated with household exposure to children aged 6 to 14 years increased during the Delta (August 14, 2021, to December 19, 2021) and Omicron BA.1 waves, reaching 1.6 (95% CI, 1.5-1.7) for primary school children and 1.4 (95% CI, 1.3-1.5) for middle school children. Exposure to older children aged 15 to 17 years was associated with a moderate risk until April 2021, with an OR of 1.2 (95% CI, 1.2-1.3) during curfew in early 2021 (December 4, 2020, to April 8, 2021).The presence of children, notably very young ones, was associated with an increased risk of SARS-CoV-2 infection in other household members, especially during the Delta and Omicron BA.1 waves. These results should help to guide policies targeting children and immunocompromised members of their household.

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Xu, Y., Chen, J., Cai, J., Li, S., He, Q.
Simulation-based trade-off modeling for indoor infection risk of airborne diseases, energy consumption, and thermal comfort.
Journal of Building Engineering, Vol. **76**, (2023)

The transmission of airborne diseases indoors represents a significant challenge to public health. While enhancing ventilation can mitigate infection risks, it simultaneously escalates building energy consumption and alters human thermal comfort. There is limited understanding about the intricate interplay among 1) human health measured as exposure to pathogens and infection risk, 2) building energy consumption as a result of different heating, ventilation, and air conditioning (HVAC) control strategies, and 3) human thermal comfort in different climate zones. This research developed a modeling framework to evaluate the trade-offs among health, energy, and human thermal comfort and conducted simulations using school building data, considering a variety of parameters in temperature, humidity, and ventilation control. Key findings revealed that indoor temperature profoundly influences infection risk, energy consumption, and thermal comfort. Ventilation rate governs the variations of infection risks and building energy usage, while indoor relative humidity demonstrated negligible impacts. Notably, thermal comfort and low infection risk can be concurrently realized, albeit at the expense of high energy consumption. Comparing the optimal and worst

environment settings in a typical U.S. climate zone, a 43% decrease in infection risks and a 61% increase in thermal comfort are observed, accompanied by an over 70% increase in energy consumption. The influences and trade-offs among infection risks, energy consumption, and thermal comfort are additionally modulated by climate characteristics.

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Correia, A., Ferreira, L. M., Coimbra, P., Moura, P., De Almeida, A. T.
Smart Thermostats for a Campus Microgrid: Demand Control and Improving Air Quality.
Energies, Vol. **15** n°(4), (2022)

Achieving nearly zero-energy buildings (nZEB) is one of the main objectives defined by the European Union for achieving carbon neutrality in buildings. nZEBs are heavily reliant on distributed renewable generation energy sources, which create new challenges associated with their inherent intermittency. To achieve nZEB levels, demand management plays an essential role to balance supply and demand. Since up to two-thirds of the total consumed energy in buildings is dispended for Heating, Ventilation and Air Conditioning (HVAC) operations, intelligent control of HVAC loads is of utmost importance. The present work aims to offer a solution to improve a building microgrids' flexibility by shifting thermal loads and taking advantage of room thermal inertia. Innovation is present in using the internet of things to link several decentralized local microcontrollers with the microgrid and in the applicability of different control algorithms, such as the pre-emptive heating/cooling of a room. The developed solution relies on smart thermostats, which can be integrated into a building management system, or in a microgrid, and are capable of fulfilling the occupants' need for comfort while complementing the building with needed power flexibility. The equipment is capable of controlling several HVAC systems to guarantee thermal and air quality comfort, as well as coordinate with a building/microgrid operator to reduce energy costs by shifting thermal loads and enacting demand control strategies. The smart thermostat uses an algorithm to calculate room inertia and to pre-emptively heat/cool a room to the desired temperature, avoiding peak hours, taking advantage of variable tariffs for electricity, or periods of solar generation surplus. The smart thermostat was integrated into a university campus microgrid and tested in live classrooms. Since the work was developed during the COVID-19 pandemic, special attention was given to the air quality features. Results show that smart HVAC control is a viable way to provide occupant comfort, as well as contribute to the integration of renewable generation and increase energy efficiency in buildings and microgrids.

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Mccarthy, J. E., Dewitt, B. D., Dumas, B. A., Omnium, L. L. C., Bennett, J. S.
A Superposition Model of Droplet and Aerosol Risk in the Transmission of SARS-CoV-2.
Authorea Preprints, (2023)

Considering three viral transmission routes— fomites, droplets, and aerosols— two routes have been the focus of debate about the relative role of droplets and aerosols in SARS-CoV-2 infection. We seek to quantify infection risk in an enclosed space via short-range and long-range airborne transmission to inform public health decision making. Data from five published studies were analyzed to predict relative exposure at distances of 1 m and farther, mediated by droplet size divided into two bins: $\geqq 8$ μm (medium and large droplets that we call “droplets”) and < 8 μm (small droplets that we call “aerosols”). The results at 1 m from an infectious individual were treated as a boundary condition to model infection risk at shorter and longer distance. At all distances, infection risk was treated as the sum of exposure to aerosols and droplets. It was assumed that number of virions is proportional to particle volume. The largest infection risk occurred close to the infectious individual, and out to approximately 1m, droplets and aerosols both contributed. Farther away, the largest risk was due to aerosols. For one model, droplet exposure disappeared at 1.8 m. Policy concerning physical distancing for meaningful infection reduction relies on exposure as a function of distance, yet within

this construct particle size determines respiratory deposition. This two-fold distance effect can be used to evaluate measures such as plexiglass barriers, masking, and ventilation.

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San Buenaventura, J. R.
 # WorkItOut: The Gym as A Place For Work-From-Home (WFH) Fitness Enthusiasts in the Era of COVID-19.
College of Arts and Sciences, UP Manila. Thèse 2023

This study aims to identify the different features of the gym that, despite changes in its sociocultural milieu and the financial constraints brought by COVID-19, keep it a desirable “space” for people to achieve their fitness goals there. Utilizing a phenomenological case study approach and criteria-based purposive and snowball selection, 15 work-from-home (WFH) fitness enthusiasts, classified as gym owners or managers, gym coaches or personal trainers, and regular gym-goers eagerly shared their experience in the gym before and after the lockdown and were recruited through the Pilipino Body Builders Group (PBBG) Facebook group. Analyzing their narratives along with the observations on two commercial gyms using Scott (2011)’s notion of a “reinventive institution” and the trifecta of area studies, the study shed light on the potential and limitations of the gym as a social and exercise space and spotted the changes in the perceived gym culture of the participants brought by the pandemic. Among the significant improvements in the gym that have resulted from the pandemic scenario is realizing the value of enough space, sanitation, and ventilation. By uncovering the characteristics of this gym, this study gave an idea of its importance as an area not just in the lives of WFH fitness enthusiasts, but also as an institution that plays a vital role in a health crisis.

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