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Editorial

Architecture for a Post-COVID World

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During the first three months of 2020, COVID-19, the disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), rapidly developed from a localised disease outbreak into a truly global pandemic. With its rapid spread and cross-sectorial impact, sparing no country, the COVID-19 pandemic has proven to be a social and economic disruptor on a global scale not seen since the influenza pandemic of 1918–1919 [1]. At the time of writing this editorial in August 2022, the pandemic is still ranging in numerous countries. Globally, 592.5 million people have been infected so far, with the death toll exceeding 6.5 million [2].

During late 2020 and throughout 2021, many countries, in search of stimuli to maintain or restart their COVID-19-ravaged economies, provided subsidies to the national construction industry, which resulted in numerous new builds and major revitalization projects. Of concern is that most of these were conducted along the lines of 'business as usual', perpetuating designs that were conceptualized before the COVID-19 pandemic. The highly transmittable Delta and Omicron variants of SARS-CoV-2 have shown that even passing, fleeting contact can be sufficient for the virus to spread. This, for example, raised concerns for communal areas in building complexes such as passageways, stairwells and elevators. It also raised concerns for open-plan office designs and classroom settings.

Likewise, public health mandates required infected persons who were not in hospital to self-isolate at home. This posed the question of how this could be best effected while safeguarding the other family members. The various lockdowns, as well as the numerous examples of self-isolation events have shown that traditional dwelling design is ill-suited to meet the demands placed on them by a pandemic situation.

SARS-CoV-2, the virus causing the COVID-19 pandemic, is only one in a line of coronaviruses that has affected humans and, when seen from an epidemiologist's perspective, most certainly will not be the last. Indeed, zoonotic coronaviruses akin to SARS-CoV-2 are currently in existence in various host species [3–5]. Yet, in the public debate there seems to be little consideration whether the existing designs are appropriate for futureproofing human existence in urban and suburban settings.

The papers in this Special Issue address some of these aspects. It is worth noting that the contributions in this issue bring to bear expertise from a range of cultural and design traditions. Represented are authors of Australian, Chinese, Egyptian, German, Iranian, Italian, Korean, Malaysian, Omani, Saudi Arabian, Russian, Sri Lankan, Thai, Turkish, Vietnamese and Yemeni socio-cultural traditions. This breadth underscores both the global nature of the pandemic and the global reach of the responses that will have to be considered and acted upon by the time humanity faces the next pandemic.

While academic and practitioner interest in green and healthy architecture existed before, the global impact of COVID-19 spurred on a variety of research with increasing numbers of papers in 2020 and 2021 [6,7]. Given that SARS-Cov-2 is an airborne virus, spreading primarily through the inhaling of, or contact with, aerosols and droplets, and given that airborne viruses can persist in poorly ventilated spaces, it is not surprising that a central thread common to most papers in this Special Issue are concerns relating to adequate ventilation and air exchange that need to be addressed in any post- COVID design [6–14]. Ducted (reticulated) heating, ventilation and air-conditioning (HVAC) systems, or air-conditioning mechanical ventilation (ACMV) systems in those countries that do not require heating, are prevalent in most office complexes, hotels, medical and educational facilities as well many private homes. While a small amount of fresh external air is added, HVAC and ACMV systems effectively ensure that air is shared between all rooms. While this saves on energy costs, it also facilitates the seamless transmission of pathogens, unless intercepted by High-Efficiency Particulate Air (HEPA) filters. Where installed, such filters are commonly single units located at the air intake of the pump unit or the major air return. They are not located at the individual returns, thus commonly mingle air from several rooms (and sources).

In their paper, Navaratnam et al. discuss a range of engineering controls, such as UV germicidal irradiation, bipolar ionization as well as high-level HEPA filtering [7]. Spennemann argues for the systematic adoption of differentially pressurized room designs that control and direct the airflow, augmented by separate air cycles for communal and private spaces. This would allow for the compartmentalization and thus the relative isolation of private spaces from public circulation areas. Such design can then be augmented by engineering controls [9].

The majority of design solutions are based on engineering controls with closed systems, although external ventilation through window openings is frequently advocated. The paper by Leng et al. builds on the concept of natural ventilation and advocates, where climatologically feasible, for the use of solar (thermal) chimneys (which relies on the convection of air heated by passive solar energy) to be augmented by low-powered ceiling fans [12]. Likewise, the hospital design options discussed by Amran et al. make use of large atria as suppliers of fresh outside air [13], while internal light shafts could function as room exhausts.

Concepts of room ventilation vary in view of two opposing realities. Fundamentally, aerosols emitted by speaking, coughing or sneezing will disperse and then sink. Yet, the majority of HVAC and ACMV systems rely on air returns that are placed in the ceiling (making use of the fact that warm air is displaced upwards) thereby cycling aerosols upwards, back into the breathing zones of people. Engineering solutions advocated by Navaratnam [7] see the installation of ultraviolet germicidal irradiation systems to purify the air of the upper zones in a room. Concepts advocated by Amran et al. [13] and Spennemann [9] propose floor or otherwise low-mounted air returns relying on positive pressure to drawn potentially contaminated air away from people's faces, with the air either expelled to the exterior or passed through filter or other purification systems.

In addition to ventilation, the contributions by Navaratnam et al. [7], Elrayies [14] and Spennemann [9] cover a range of aspects of innovative building design to be considered to future proof new structures. These aspects range from the fundamental to the specific. The underlying principle of future dwelling design sees the compartmentalization of the occupation zones, from the potentially contaminated external space through a decontamination space into the actual home. Additional compartmentalization in the home between guest accessible and private spheres further aids to contain transmission from visitors to the family [9,10,14]. Elrayies further advocates design options that allow one to install, or extract (from cavities), moveable walls that can allow for the compartmentalization of otherwise open plan designs in times of need [14]. Post-COVID design needs to be flexible to adapt buildings and interior spaces to function also in times of a pandemic, and at a lower patron volume if necessary. This applies in particular to stores, shopping malls and hospitality venues. To avoid a repeat of ad hoc measures, which had to be resorted to by many venues during the COVID-19 pandemic, new venue builds, as well internal refits, can incorporate design options that allow to safely operate at lesser capacity.

Within the home, increased home automation and voice activated technology are seen as means to avoid unnecessary touching of surfaces [7,14]. The proposed engineering controls also consider the use of interior surfaces made from materials that reduce survival times of deposited viruses either due to inherent germicidal properties (e.g., copper) or due to designed antimicrobial properties (mixed into paints or polymers) [7,14]. An interesting proposition is the use of indoor plants for biofiltration and purification of air, with its added benefit of biophilic design.

Given that SARS-Cov-2, as well as potential future viruses, can be transmitted via contaminated surfaces, Navaratnam et al., as well as Elrayies, argue for the inclusion of contactless design measures wherever possible [7,14], such as voice-activated elevator, door and light controls, or foot-activated elevator controls [7]. While such technologies can obviate the need for manual interaction with control buttons, care must be exercised not to marginalize or exclude segments of the community. For example, voice activation may exclude people speaking with dialects or accents, people who do not speak the language of the dominate culture (e.g., migrants, tourists), or people who may experience a communication disability. Further, people relying on wheelchairs will not be able to use foot activated controls. Thus, contactless designs must only augment but not replace standard manual controls.

Given the airborne dispersal of SARS-Cov-2, major gatherings were cancelled early in the pandemic, a trend that continued throughout 2020. Affected were not only large festivals and seasonal markets [15], galleries and museums [16,17] but most significantly all schools and universities [18,19] and other educational and training programs [20]. Educational institutions in particular 'pivoted' to an online mode of delivery into people's homes with varied degrees of success and student engagement [21].

As many countries emerged from the period of lockdowns and internal border closures [22], and began to 'live with the virus', tertiary educational institutions began to realize that the nature of academia had changed, utilized the lessons learnt and continued the use of online offerings [19]. This could occur in the form of straight online delivery for smaller cohorts, by merging traditionally on-campus students with distance education cohorts, or in mixed mode settings where lectures would be delivered online but tutorials and practical sessions delivered in face-to-face mode. Other hybrid models saw the use of online delivery for remote students while providing face-to-face interaction for students in a classroom setting (pers. obs.).

The paper by Marey, Goubran and Tarabieh examines the classroom design that such a hybrid dual-mode model of delivery requires [8]. Unlike traditional classrooms, where the acoustics requirements are bi-directional between the students and the teaching staff at the front of the theatre/room, dual-mode delivery requires the voices of the students who are physically present to be audible to those students participating via videoconferencing software. With declining numbers of students physically present on campus due to changing delivery modes, educational institutions, which already have a major investment in brick-and-mortar infrastructure, will understandably be reluctant to invest in new builds. Thus, as Marey, Goubran and Tarabieh outline, refurbishing existing facilities will be required to have upgrades for dual-mode delivery by installing sound-absorbing padding on walls, soft floor coverings (carpets rather than tiles or vinyl) and adequate installation of sound recording equipment, primarily ceiling microphones augmented with portable (lapel) units.

The COVID-19 pandemic placed a considerable, additional strain on the public health system of many countries. Numerous communities responded by developing ad hoc, temporary infrastructure in the shape of field hospitals and testing and vaccination centers [23]. Other communities adapted existing hotel and accommodation infrastructure to act as quarantine facilities. Dincer and Gocer discuss the adaptation of such hotels in light of the perceptions and experiences of the quarantined 'guests' [11]. Given that the quarantined 'guests' were confined to their rooms for a mandatory period of 14 days, inadequacies of hotel room design and the suitability of hotels and quarantine facilities quickly became evident. Perceived as most important, and thus most sorely missed where absent, were operable windows, ventilation and natural lighting, with access to the outside environment via balcony or windows an 'acute and fundamental requirement for guests" [11]. While the use of hotel rooms in non-pandemic settings will not be 24/7 as it was for quarantined 'guests', the identified shortcomings in room design should influence future builds of hotels as well as any projected of refurbishing and adapting of existing buildings. Furthermore, the experiences gained in operating such quarantine hotels, with cross-floor contamination due to lack of infection control [11], highlights the need for ventilation systems with strategic pressure differentials [9].

The existing health infrastructure often proved inadequate to deal with the specific challenges posed by the high infectiousness of some strains of SARS-Cov-2. While most hospitals had the provisions for an infectious diseases ward, these wards were conceptualized on the premise of a few highly infectious patients. Consequently, many hospitals were soon overwhelmed, with non-specialized wards being retrofitted, and makeshift screening chambers constructed [23]. The paper by Amran et al. considers the design of future hospitals [13]. Apart from concepts such as making each ward capable of serving as a fully containable infectious diseases ward, the authors advocate a rethinking of the entire hospital layout, having due regard to the hospital workflow while at the time ensuring compartmentalization of ward space, treatment rooms/operating theatres and sections reserved for administrative functions [13].

All architecture, of course, interfaces with the environment in which it is situated. One of the lessons to be drawn from the pandemic was the increased relevance of urban green spaces for the physical and mental health of communities [24,25].

As the paper of Wang and Li on the perception of the restorative effects of urban public spaces shows, urban green spaces have the highest use ratio and the greatest positive influence to public mental health compared to other public spaces such as commercial or sporting facilities [26]. At the same time, Wang and Li also highlight that green space benefits are not universal but that people with mobility issues or those who are time poor can be excluded from the use of urban green spaces [26].

One of the common concerns by civic authorities was that urban green spaces would act as hubs for social interaction during lockdown periods (where open-air exercise of set duration was permitted) without adequate social distancing. Consequently, many civic authorities simply closed urban green spaces for use by the public. There is a need for post-COVID urban design to incorporate concepts for urban green spaces and roadside verges that allow continued use during pandemic times while safeguarding social distancing protocols [26–28]. It must be emphasized that identified demand for urban green spaces in post-COVID planning has a cross-cultural basis and is not confined to specific communities.

The contribution by Khozaei et al. builds on concepts of green design and argues that biophilic design concepts should be incorporated in new hotel developments. People's connections with the restorative effects of nature surrounding the buildings gain in importance at times when personal movements and the ability to visit urban green spaces is curtailed due to epidemiological concerns. In arguing this point, the authors draw on surveys of Iranian university students and their experiences and needs during periods of lock downs. While ideally situated at the interface between urban development and nature spaces [29], such new developments may not always be possible from a practical or a land use planning perspective. Thus, the authors argue, the greening of interior and exterior building spaces through indoor plants and vertical gardening can partly offset the need for adjunct greenspaces [29]. This is echoed by the vertical gardening and air purification concepts advocated by Navaratnam et al. [7].

This concept can be further expanded to the design of new apartment complexes. Both communal and individual green spaces, no matter how small (i.e., balconies) can provide restorative spaces that allow for the connection with the outdoor world reducing the sense of 'imprisonment' that periods of mandated lockdowns can engender. Segmented outdoor spaces in apartment complexes can allow for social interaction while maintaining the social distancing necessary to reduce the probability of transmission [9,28]. The inclusion of public or communal green spaces into residential developments can also offset the potential exclusion of people with mobility issues or those who are time poor from the use of urban green spaces.

The value of personal green spaces is identified by the contribution by Tajani et al. is a retrospective work that examines the impact of COVID-19 on the Italian property market [30]. What the paper highlights are the priorities and expectations that prospective homeowners have of their residences in view of their lived experiences under the pandemic-induced lockdowns: domestic spaces became the focal points of daily life and spaces previously deemed significant, such as private gardens or terraces/balconies, became highly desirable attributes. Concomitantly, properties that did not offer these attributes became less desirable and declined in value.

The paper by Amran et al. also draws attention to the fact that some spaces such as hospitals can act as attractants for infected people, both confirmed or asymptomatic, seeking treatment [13]. Rather than erecting ad hoc temporary screening structures [23], new hospital design needs to include the mitigation of potential spillover by reducing or compartmentalizing high risk zones for inadvertent transmission.

Urological wastewater testing has proven to be a powerful tool in the early detection of SARS-Cov-2 circulating in the community [31,32]. While this primarily concerns the upgrading of adequate urban infrastructure through the provision of sampling points, it has been argued that sampling points can also be installed at selected upstream sites. Consequently, designs for new high occupancy dwellings (e.g., apartment blocks, office blocks, hospitals, schools) should provide appropriate sampling chambers that can be activated on short notice [31]. Any refurbishment of older structures should consider the retrofitting of such sampling chambers.

Current building practice includes the scoring of planned structures in relation to national or transnational sustainability rating systems. While exceptions exist, such as the Living Building Challenge [33] or the WELL Building Standard [34] the majority of current systems only inadequately account for parameters of occupant health and underperform in terms of infection-control and associated risk mitigation [35]. In their review of the development of healthy building standards and guidelines in China, Lin et al. note that while the framework has good intentions, the current policy framework is marred by inadequacies in country-specific research underpinning the guidelines [6]. Moreover, a lack of public awareness, coupled with a flawed standards system (including ambiguity in interpretation) and a lack of human-centered design application, produced new builds that are ill-suited for future pandemics [6]. While Chinese healthy building concepts consider green building principles, these are focused on savings in operational energy, water and land use, as well as reducing the carbon footprint embodied in materials [6]. Healthy buildings, perceived as extension of the green buildings concept, focus on the social and mental wellbeing of occupants, but currently tend to overlook the epidemiological aspects that came to the fore as part of the COVID-19 pandemic [6]. This is not confined to China but applies to other countries, pointing to the need for a systemic change and refocusing of planning priorities.

Architectural design does not exist in a vacuum. It is driven by the vision of the architectural practitioners and their ideological standpoint and positioning vis à vis their role in achieving social and environmental justice for the communities for which they are designing spaces of habitation, work, education, health and play. At the same time, these practitioners are restrained, and constrained, by the briefs issued by their clients, who in turn are guided by their own perceptions of economic realities and profit margins which may, in turn, be mandated by shareholders. Realistically, it will be easier to incorporate lessons learnt from COVID-19 into those new builds that are designed 'from scratch.' Largely due to the absence of legacy elements, architectural practitioners can propose and incorporate innovative design elements into new builds, such as office buildings or apartment complexes, that reduce exposure risks and thereby enhance user resilience. Here, architects, future owners and users, as well as socially responsible developers can readily take on proactive roles. Financial institutions underwriting such developments could act as major agents of change as attitudinal shifts with regard to climate change action have shown.

Of considerable concern, however, are new builds of private residences, in particular in housing estates, where developers tend to work off a set of well-established designs which, while allowing for some mix and match of components, are fully designed and fully costed. The average customer will not be aware of the limitations of existing designs in containing or at least reducing the risk of infectious disease transmission, and thus are unlikely to question the adequacy of the designs they are offered in display homes. After all, they will be guided by the designs there are familiar with and which they have been exposed to by their social circles. It can be posited that many, if not most, developers will be reluctant to revisit their existing designs, as this will not only entail the architect's costs of redesign, but will also necessitate completely new costings for building materials, ventilation systems and labor. Thus, it may well fall to the governments at the national, state and local levels to establish new design guidelines and to mandate minimum design standards.

The need for COVID-19-responsive building design is self-evident. With a new pandemic of a zoonotic disease being not a question of if but a question of when, people cannot afford to remain complacent, unless we are happy to accept another death toll in the multiple millions. The experiences of the COVID-19 pandemic have provided us with a unique opportunity for a complete rethink of our approach to habitation. We should embrace this opportunity to not only design pandemic-resistant buildings, but also make to these buildings environmentally and, importantly, socially sustainable by also espousing the principles of universal design.

The papers in this issue have made a start in the conversation we all need to have.

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