

RESIDENTIAL ARCHITECTURE IN A POST-PANDEMIC WORLD: IMPLICATIONS OF COVID-19 FOR NEW CONSTRUCTION AND FOR ADAPTING HERITAGE BUILDINGS

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ABSTRACT

COVID-19 has highlighted the disruptive, cross-sectorial effects a sudden-onset pandemic has on a globally interconnected world. A particularly insidious component is the high percentage of asymptomatic cases allowing the virus to seed undetected. The design of residential architecture will need to adapt to the new reality that COVID-19 will not be the last coronavirus epidemic. This paper discusses the implications of COVID-19 for new residential construction. It argues for a containment space, separating the largely uncontrollable external environment from the internal threat-reduced residential space, for a separation of visitor entertainment areas and private sleeping areas, as well as the design of a spatially separated master bedroom that can double as a self-isolation space if the need arises. The implications of this new design on existing housing stock are also discussed. The advocated concepts are novel and advance the design considerations for future residential developments.

KEYWORDS

COVID-19, pandemics; environmental control, adaptive architecture, compartmentalisation

INTRODUCTION

The emergence of COVID-19, the coronavirus disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (WHO, 2020b), in January 2020, and its rapid development into a global pandemic has been chronicled in the global media. At the time of writing, it is still raging on several continents. COVID-19 is not a 'Black Swan' event as the emergence of a coronavirus was predicted by public health professionals (Inayatullah, 2020) following the outbreaks of SARS in 2004 (Cunha and Opal, 2014) and MERS in 2012 (Cunha and Opal, 2014). The rapid spread, global reach, intensity and cross-sectorial impact of COVID-19, however, has no predecessor. Even the last pandemic, the influenza ('Spanish flu') epidemic of 1918–1920, while global and severe, cannot serve as a template as the world at that time was not as interconnected, and the economy was not as globalised as it is in 2020.

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During COVID-19, personal and elective international and domestic air travel was either terminated or restricted to repatriation flights (Lau et al., 2020b, Lau et al., 2020a) with flow-on effects to the tourism industry (Gössling et al., 2020, Lau et al., 2020a) and the communities and conservation organisations that rely on tourism income (Newsome, 2020). The associated reduction in air cargo volume (Suau-Sanchez et al., 2020), as well as overall shipping (Depellegrin et al., 2020, March et al., 2020) resulted in disruptions to global as well as national supply chains, not only of manufacturing parts (Ivanov and Dolgui, 2020) and health care material (Govindan et al., 2020, Ranney et al., 2020), but also of food production (Bennett et al., 2020, White et al., 2020) and food distribution (Rizou et al., 2020, Hobbs, 2020), which in part was fuelled by panic buying (Lau et al., 2020a). In consequence, COVID-19 acted as a disruptor affecting labour markets, in particular expatriate workers (Karim et al., 2020, Uvais et al., 2020), with cascading effects on remittances (Bisong et al., 2020), and thus local economies in countries of origin (Murakami et al., 2020). The disruption caused by COVID-19 also resulted in a range of environmental side effects, such as reduced air pollution (Dantas et al., 2020, Muhammad et al., 2020), reduced pressures on wildlife (Rutz et al., 2020) and changes to urban soundscapes (Parker and Spennemann, 2020, Spennemann & Parker, 2020).

Common to all attempts at curtailing the spread of COVID-19 were limitations in personal freedom of movement, social distancing, and messaging on personal hygiene. All of these proved effective in particular when executed in conjunction with each other. At each national level, government reactions to curb or slow the progress of COVID-19 have involved, to various degrees and duration, the reduction of international arrivals to repatriation flights, limitations to domestic travel, the temporary shut-down of non-essential businesses, and the restriction of human movement during periods of 'lockdown' (Moloney and Moloney, 2020, Chinazzi et al., 2020). That lockdown found different levels of expression (Askitas et al., 2020), ranging from limiting movement to accessing food, health care and limited daily exercise (Australia) (Shakespeare-Finch et al., 2020) to only being allowed to leave the house for food and health care every second day (gender separated, Panama) (Woskie and Wenham, 2020) or not at all (youth under 20, Turkey) (Kanbur and Akgül, 2020). Once the lockdown conditions were eased, people resumed prior activity patterns (Parker and Spennemann, subm.-b), even though the pandemic still ranged in various parts of the world and despite that fact a second and third wave often has and may still occur.

Critical here is that even if COVID-19 will eventually be contained by the application of vaccines, a high level of immunisation, upwards of 70%, will be required to achieve herd immunity (Kwok et al., 2020). This percentage may be difficult to achieve in some countries due to both economic constraints (Wong et al., 2020), and general scepticism (Thunstrom et al., 2020), as well as outright antagonism towards vaccinations ('antivaxxer movement') (Hensher et al., 2020) and government mandated immunisation and healthcare directives ('QAnon' and conspiracy theorists) (Thomas and Zhang, 2020) fuelled by prevaricating and equivocating media (Simonov et al., 2020). Thus, it can be predicted that flare ups of COVID-19 will continue to plague humanity for several years to come. But even when COVID-19 is eventually controlled akin to the common influenza, epidemiologists predict that it will not be the last of the pandemics (Peeri et al., 2020). Other zoonotic coronaviruses akin to SARS-CoV and MERS-CoV are currently in existence in various host species (Ye et al., 2020), some of which are almost certain to emerge as a threat to humans (Wang et al., 2020).

Thus, from a planning perspective, lessons can and should be drawn from COVID-19

which should inform office architecture (Megahed and Ghoneim, 2020, D'alessandro et al., 2020), urban transport (Musselwhite et al., 2020), urban open space planning (Honey-Rosés et al., 2020, Mehta, 2020) as well as community and sporting event planning (Ludvigsen and Hayton, 2020). Some of the literature on the topic has been at a very generic level only. This paper will consider some implications on the design of future residential architecture.

Lessons from COVID-19

From an epidemiological perspective, transmission of COVID-19 can be person-to-person and person-to-surface-to-person. The primary mode of transmission of SARS-CoV-2 and similar coronaviruses will be through aerosols emitted into the air through an infected person not only during coughing, but also talking (Anfinrud et al., 2020, Alsved et al., 2020) and breathing (Alsved et al., 2020), in particular during physical exercise (Jang et al., 2020). The duration of the suspension of the aerosol, which can range from 0.5 to up 3 hours, is subject to droplet size (Kohanski et al., 2020) and humidity of the ambient air (Feng et al., 2020) (Van Doremalen et al., 2020). The dispersal range of these aerosols is governed by a combination of droplet size, airflow and humidity (Feng et al., 2020, Ahlawat et al., 2020).

Primary infection pathways are the mucous surfaces of the nose, mouth and throat (Gengler et al., 2020), but also the eyes, either through direct aerosol exposure, or through self-infection when touching eyes with fingers that carry a virus load picked up from surfaces (Qing et al., 2020). Onwards dispersal of coronaviruses occurs when viral particles are transferred to the infected person's hands (via coughing/sneezing) and from there deposited on surfaces that the person touches, such as light switches, taps, faucets, door and cupboard handles etc. (Dietz et al., 2020).

Dispersal of SARS-CoV-2 has been shown to be facilitated by airflow in office environments, bars, and meeting spaces as well as public transport systems with restricted or directional airflow (Kohanski et al., 2020, Morawska et al., 2020). In addition to direct person-to-person transmission, which makes up the bulk of events, these environments are conducive to person-to-surface-to-person transmission. In environments restricted or directional airflow, aerosols emitted by infected persons will disperse and contrate in the airspace. In consequence, as these aerosols sink, they will deposit on surfaces, which are subsequently touched by the occupants (e.g. keyboards, chair arm rests, door handles etc.), as well as on participant's hair, skin and clothing.

The SARS-CoV-2 virus, as well as its allies SARS-CoV, MERS-CoV, have been shown to survive for prolonged periods on various surfaces (Chin et al., 2020). Residence times of almost 7 hours have been reported in the literature for SARS-CoV-2 deposited on plastics (Van Doremalen et al., 2020), and almost 6 hours for deposition on stainless steel (Van Doremalen et al., 2020). For MERS, viable virus was found after 48 hours, even though total load decreases rapidly, given a half-life of 0.5 to 1hr (Van Doremalen et al., 2013). Degradation of the deposited virus depends on the nature of the substrate, ambient temperature and the extent of ambient humidity, with dry surfaces and lower temperatures extending the viability horizon (Otter et al., 2016). Viable SARS-CoV could be detected on plastics for up to six days (Chan et al., 2011, Rabenau et al., 2005).

While COVID-19 impacted on all age groups, persons with compromised immune systems, high blood pressure, diabetes and obesity seem to be disproportionately affected (Radzikowska et al., 2020, Zheng et al., 2020) as are persons in the age brackets of over 70 years (Palaiodimos et al., 2020, Price-Haywood et al., 2020).

Implications for New Construction

One of the critical components of residential structures should be a design that allows for whole-of-life-stage uses by the occupants. Universal design has long been advocated across many sectors (Story, 1998, Goldsmith, 2000), but the uptake has been slow, not only due to slightly greater costs (mainly due to the low production volume of wider doors compared to ‘standard’ doors and the like) (Malik and Mikołajczak, 2019) but also due to a lack awareness of architects (Ergenoglu, 2015) and a reluctance by housing designers and developers to rethink their designs, rather than to modify existing concepts (Hartje, 2004, Bringolf, 2011).

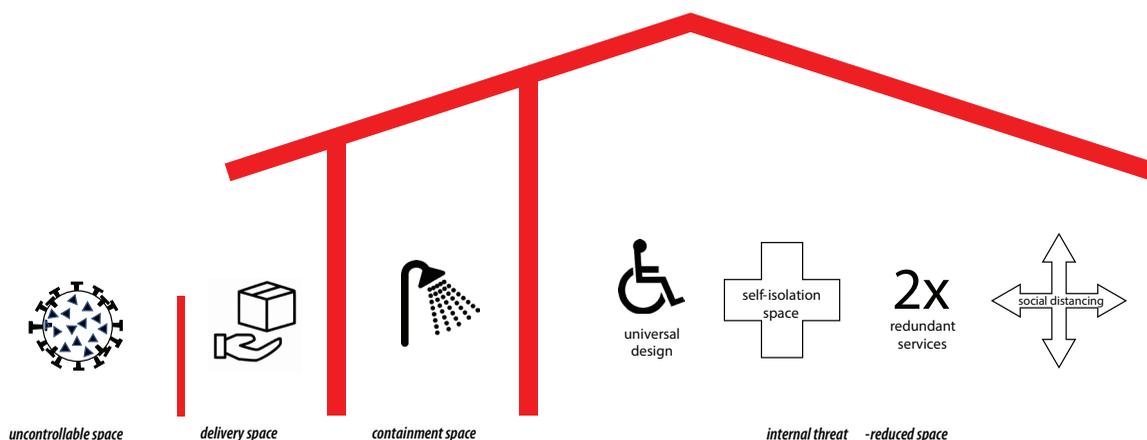
A future proofing of new residential builds in the post-COVID environment must embrace the principles of universal design and incorporate the lessons from COVID-19. Thus, the residence needs to be fully functional under ‘normal’ usage, with an added ability to function in a pandemic environment, both to buffer the occupants from the uncontrollable external world, and, if an occupant is infected or required to self-isolate, to allow for internal containment while at the same time permitting the remainder of the occupants to function as normally as possible. It is likely to be impossible to fully prevent the introduction of a virus into the inner sanctum of the residential space. Thus the aim of the design has to be to minimise the likelihood of transmission through structural, physical and practical means (Morawska et al., 2020). Conceptually, therefore, the building has to account for four spaces: the largely uncontrollable external space; a space with restrict-able access, for example for home deliveries; a containment space designed to reduce an accidental introduction of a virus load into the home; and the threat-reduced domestic habitation space (Figure 1).

There are multiple options for delivery spaces. These can range from an open unprotected space just outside the front door to large parcel-locker style mailbox systems mounted into the front fence with access codes sent electronically to the delivery services (Behnke, 2019).

The containment space

At present, most recent residential designs eschew the use of a formal entrance corridor (Figure 6), with most housing designs favouring varying degrees of open plan living (Dowling, 2008). In a pandemic environment this creates a permeable zone that commingles the exterior and interior. To pandemic-proof residential buildings, buffer or containment space needs to be

FIGURE 1. Conceptual framing of operational spaces and design principles.



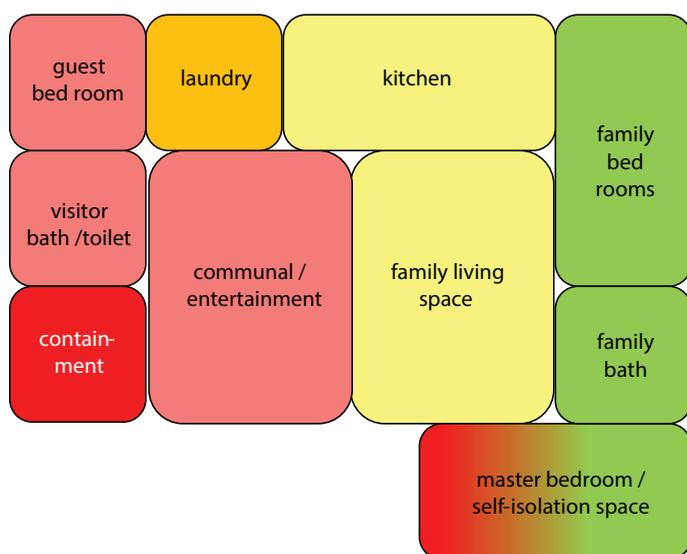
established between the uncontrollable external world and the internal personal universe. In the ideal world, this containment space would allow the opportunity to create an airlock with the ability to exchange and expel air brought along by the people entering from the outside. This is considered excessive, both in terms of costs of installation and operation as well as logistics and human movement. Irrespective of the concept of an airlock, the direction of the airflow is critical to minimise the ingress of airborne particles and aerosols. Thus, any airflow needs to be directed from the internal residential space into the containment area and from there to the outside world (Figure 4).

The documented long viability of SARS-CoV, MERS and possibly also SARS-CoV2 on dry surfaces of several hours and even days (see above) poses a substantial risk of introducing and distributing virus deposits inside the home, with infection occurring well after the introduction event. Thus, potentially, any item and piece of clothing that was exposed to aerosols in the uncontrollable external space can act as a transmission pathway.

At present, in most cases clothing worn outside, unless heavily soiled, is carried indoors and into the living spaces, with some clothing hung on a hook or coat rack in a hallway, if the latter exists. This containment space allows the occupants of the house to shed and store external clothing and footwear as well as external shopping bags. In situations of severe cases of community-transmission, the containment space also allows the opportunity to transfer any acquisitions/shopping (following disinfection) from external shopping bags to receptacles restricted to internal use.

High intensity (far) UV-C light is used to sterilise medical and surgical equipment and has been documented to be effective against SARS-CoV (Darnell et al., 2004) and other coronaviruses (Buonanno et al., 2020, Goldust et al., 2020). While UV radiation is harmful to humans and has been implicated in cell ageing (Panich et al., 2016) and in the development of malignant skin lesions (Cadet and Douki, 2018, Svobodová and Vostálová, 2010), it is certainly possible to conceptualise UV-C cupboards for external clothing and footwear. Such sterilisation methods

FIGURE 2. Spatial and social distancing.



may not be suitable for all fabrics, given the degrading effects of UV-C on tensile strength and colours (Smith and Thompson, 2017).

Personal hand hygiene has long been recognised as a major influence on the ability of any virus to spread (Goldust et al., 2020, Dietz et al., 2020). Washing hands with soap for a minimum of 20 seconds under warm water has been shown to degrade the viability of the various coronaviruses (WHO, 2020c). In present configurations people have to traverse much of the living space to access the wet cells located well inside the building envelope (Figure 5, Figure 6). Given the critical nature of hand hygiene, the containment space must contain a sink with running warm water, allowing the occupants of the dwelling to wash their hands upon arrival and again prior to entering the domestic space after shoes and external-universe clothing are removed and stored. When designing the functionality of the containment space, priority should be given to contactless options, such as motion-activated lights and water taps/faucets.

The threat-reduced internal residential space

As a gregarious species, humans interact and socialise with each other at various levels of intimacy, frequently mixing formal, work and private spheres. Such socialising in the confines of a private residence potentially exposes the occupants to pathogens unintentionally introduced by visitors. One of the insidious aspects of COVID-19 is not only that people infected with SARS-CoV2 were infectious prior to symptoms manifesting themselves (Li et al., 2020), but also that many carriers spread the infections while they themselves were wholly asymptomatic (Long et al., 2020). Both are particularly worrying as normal, inter-personal cues of illness are absent. Any post-pandemic home design needs to take this into account through functionally differentiating and compartmentalising the internal spaces (Figure 2).

Space suitable for self-isolation

Starting with the internal, threat reduced space, the residence will require a bedroom with an *en suite*. While this has become *de rigueur* in most new builds, this is critical for functioning in a pandemic environment. One or two people need to be able to safely self-isolate without putting other occupants at undue risk. Given that the required self-isolation period for most coronavirus infections is 14 to 21 days (Salathé et al., 2020), the room needs to be large enough that a temporary workstation can be added to allow the occupant to carry out work functions to the extent that their health permits. From a technical perspective, any centrally ducted air-conditioning that services that bedroom will require an extra, individual filter system (Morawska et al., 2020) servicing that room alone, while the humidity exhaust of the *en suite* has to be vented externally rather than into the roof cavity. Any non-ducted airflow needs to be such that air is allowed ingress from the internal residential space and from the outside but is expelled to the outside. Air movement from the bedroom into the remainder of the internal residential space needs to be prevented, or at least minimised.

COVID-19 showed that isolation in small confined spaces (e.g. hotel rooms), as a quarantine measure mandated for arrivals from overseas locations (Moloney and Moloney, 2020), often caused mental health issues (Zhu et al., 2020). Access to open air spaces was desirable. To allow the isolating occupant safe access to the outside environment, the bedroom should open to an external, but self-containable courtyard/open space. This space can also function as a transition zone, allowing, for example, for laundry servicing within the-isolation space without the need to enter the self-isolation space or to carry the laundry through the house (Figure 3).

Communal spaces accessible to visitors

During the COVID-19 pandemic recommended social distancing ranged from establishing minimal inter-personal distances of a minimum of 1m (WHO, 2020a), to 1.5 m in Australia (Williams, 2020) and 2 m in Korea (Kim, 2020), even though some voices noted that this needed to be greater (Setti et al., 2020) as modelling showed dispersal of up to 8 m (Sun and Zhai, 2020). While this social distancing primarily applies to external environments, it should also apply in the home environment when guests are hosted for social occasions. When governments first eased lockdown restrictions, allowing residents to host a set number of guests, these permits came under the condition that social distancing would be observed (MHMR, 2020). While the adherence to, as well as practicability and enforceability of such conditions is doubtful, post-pandemic housing design should create spaces that facilitate this if the hosts are so inclined. This entails, *inter alia*, larger room spaces that allow guests to spread out, but that are also contained so that the sleeping section of the residence can be shielded (using doors) from aerosols emitted by the guests.

Since aerosol emissions during speech tend to increase with voice loudness (Asadi et al., 2019, Anfinrud et al., 2020, Alsved et al., 2020), the design of interior spaces needs to consider sound dampening. While this particularly applies to restaurant settings, it has applicability in domestic spaces, in particular those used for entertaining friends and visitors.

Similar to the stipulations for centrally ducted air-conditioning servicing the master bedroom/self-isolation space, the communal dining/guest spaces need to be separately zoned with individual filter systems. The concept of centrally ducted but individually filtered conditioning zones extend to the guest bedroom as well as the guest toilet/bathroom.

During the nineteenth century, residential architecture separated a family's public sphere from their private sphere. The front of the house was defined by two living rooms, the formal drawing room, into which visitors would be shown, and the family's drawing room (Figure 5, top row). Although sharing a common front door, the access doors to the rooms were offset, with the first door off the corridor leading to the formal drawing room and the second to the family space. The spatial separation was also further visually delineated by a small decorative arch in the hallway set commonly between the first and second door, but certainly between the two front rooms and the bedrooms in the rear. While the nineteenth century concept of spatial separation was focussed on social representation and 'image management', the spatial separation between private and semi-public spheres in residential homes may be worth revisiting in the post-pandemic world as it restricts the dispersal of pathogens.

The internal layout of the built environment and the associated or necessitated movement patterns have an influence over the proximity with which people pass each other and thus enter another person's aerosol cone. Here the width of the corridors and the positioning of doors as bottlenecks is of significance. While this primarily applies to office environments (Dietz et al., 2020) and apartment blocks (see below) it has relevance in the design of residences. Thus, particular consideration should be given to the flow of visitors admitted to the residence.

Communal spaces in apartment buildings

High density housing in the form of workers' dormitories, apartment blocks, tenements and entire estates bring about not only a high concentration of residents, but also a concentrated flow of people through well-defined bottle necks, such as building entrances, lifts and corridors. Not surprisingly, during the pandemic, such structures featured prominently as hotspots

FIGURE 3. Components.

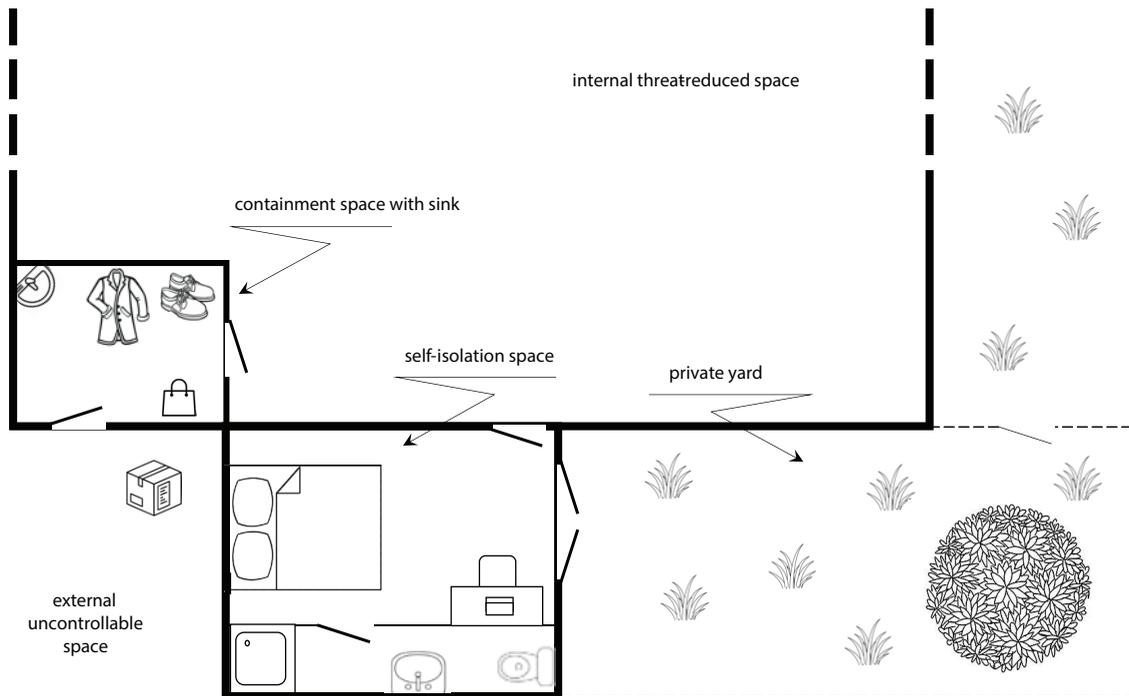
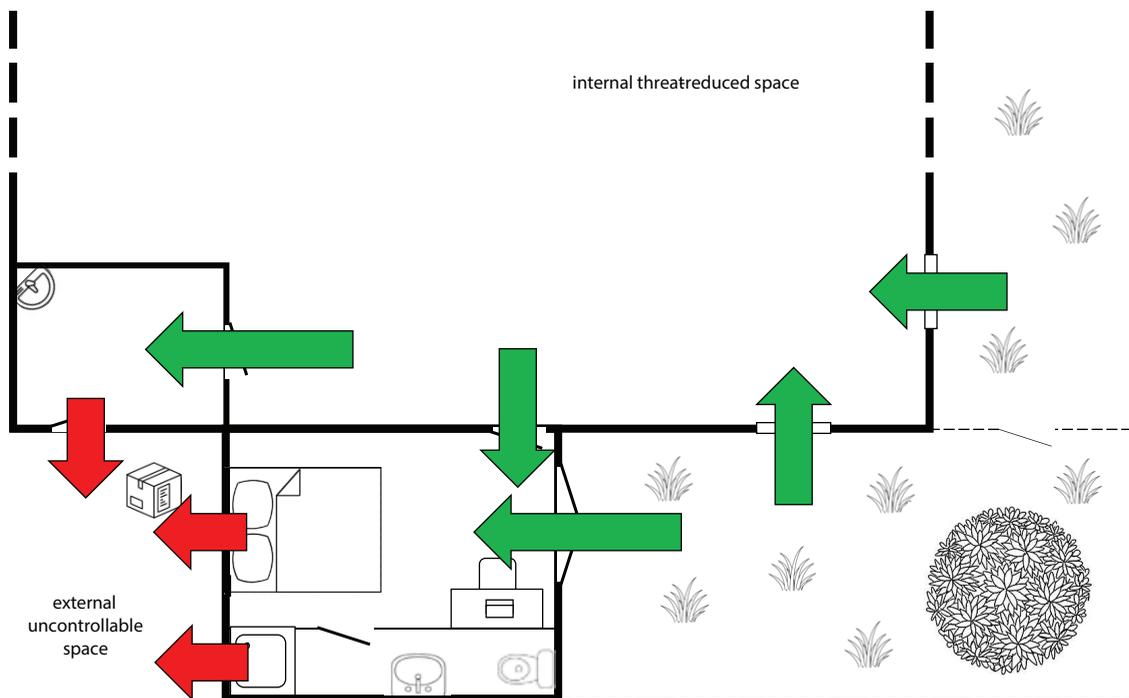


FIGURE 4. Airflow.



in Singapore (Bouffanais and Lim, 2020, Koh, 2020), Melbourne (Bouffanais and Lim, 2020, Power et al., 2020) and various cities in the United Kingdom (Power et al., 2020).

In the post-pandemic world, communal spaces in multi-storey apartment buildings will require a conceptual rethink. As the internal layout predicated movement patterns, the design and width of the corridors and the positioning of doors as bottlenecks will have an influence on the proximity with which people are forced to pass each other and whether they enter another person's aerosol cone (Dietz et al., 2020).

External corridors, as were common in 1960s and 1970s social housing estates (Coleman, 1984b), have become the exception, driven by considerations of privacy (Coleman, 1984a) and increased window to floorspace ratios. As ventilation of corridor spaces has been shown to be a factor restricting the spread of COVID-like disease (see above), external communication corridors should be reconsidered with design solutions that provide privacy by shielding users from being viewed from the street or neighbouring apartment blocks.

In modern apartment buildings the overwhelming majority of inter-storey communication and transport is facilitated by elevators. Stairs have been relegated to fully enclosed window-less stairwells whose primary function is that of a fire escape. In a pandemic environment where social distancing is required, the standard carrying capacity of a 2x3m elevator cabin of 10 persons is reduced to merely two persons. This creates either transport bottlenecks, in particular during peak demand, or causes users to disregard social distancing rules. Thus, multiple elevators will be required to meet the demand. A side-effect of once again making stairs the main mode of inter-storey communication is a public health benefit as it increases participant's personal fitness. The emphasis on stairs does not, however, discriminate against persons with mobility or health issues, as the elevator system is still available. It is also possible to limit the use of one of the multiple elevators to that cohort (for example through key card access), thereby ensuring that transport options are available even in times of higher demand.

Implications for Adapting Existing Building Stock

As the previous section has shown, design principles can be included in new builds that reduce the risk of transmission to the occupants. The major problem with pandemic proofing residential housing, however, is that the existing building stock needs to be retrofitted, and here, in particular, heritage buildings where drastic modifications are subject to permitting procedures. In this section we will be concerned with purpose-built residential suburban architecture, setting aside church and warehouse conversions (Velthuis and Spennemann, 2007).

Residential suburban architecture has undergone a range of design changes. Some of these were brought about by the introduction of town gas as a ready and safe energy source in the late nineteenth century, allowing kitchens to be integrated into the building envelope (Figure 5b) rather than as stand-alone buildings (Figure 5a). Similarly, the advent of centralised sewer systems allowed toilets and bathrooms to be integrated into the building envelope as well (Figure 5d, Figure 6a). Changes to social norms in the post-World War II era resulted in the deemphasising of differentiated living rooms with front doors leading into the common space of a living room (Figure 6b). Further changes to social expectations saw the integration of kitchen, dining and living spaces into open plan concepts (Figure 6c, d). The love affair with the motor car after World War II saw the promotion of the garage from the back of the yard to the front building line, and its eventual integration with the building envelope (Figure 6c, d). It must be stressed that the house plans shown here are examples, and that such plans exhibit a considerable variation in designs, particularly from the 1920s onwards (Archer, 1987).

Any retrofit of these buildings with the concepts of compartmentalisation advocated above, will be constrained by the formally established use patterns and movement flows inside these building designs. From a heritage perspective, most properties contribute to a streetscape, which prevents a major modification of the front (Aigwi et al., 2020), ruling out additions and extensions in that direction. Alterations to the rear or to the internal spaces are, in the overwhelming number of heritage-listed properties, permissible subject to standard development regulations.

The erection of a containment space at the rear of the property is constrained by past single or double-storey extensions which had frequently been added to the rear of late nineteenth and early twentieth century buildings to maximise living space (Dowling and Power, 2012). These extensions, providing living rooms coupled with partially covered, external dining spaces, were in keeping with a refocussing of social activities from the public frontage to a private and secluded backyard (Brindley, 1999). Concurrent was a complete reversal of the internal usage pattern, with the sun and drawing rooms at the front of the house becoming bedrooms, and the former bedrooms towards the rear being converted into kitchen and dining spaces, as well as living rooms. Often a side entrance was added at the junction between the existing house and its extension, which essentially reversed the flow of movement through the house. During the 2000s the ratio of building envelope versus building lot was maximised, leading to small, if not non-existent backyards (Hall, 2010, Hall, 2007), which did not provide space to modify or extend the building.

In most cases the extensions at the rear do not allow for a ready installation of a containment space without forgoing some functionality of the rooms and/or the garden space. While a conversion of a front room into a containment space is possible with some internal modifications, it would place that containment space right into the heart of the sleeping quarters. Comparatively, however, late nineteenth and early twentieth century buildings are more readily adaptable and convertible than buildings of 1940s and 1950s vintage where the wet cells are in the centre of the dwelling. Very recent homes, on the other hand, tend to have a double garage at the front. These designs are readily modifiable with the insertion of a containment room module, as long the owner is prepared to forgo one of the car parking spaces. While this does not address the internal flow and recommended compartmentalisation, it at least provides a transition zone.

As advocated above, a pandemic-response ready building requires redundancy in terms of bathroom and lavatory facilities so that a person required to self-isolate does not have to share facilities. In new builds this can be readily achieved by providing the master bedroom with an *en suite* (see above). In the case of modifications to existing building stock, that may pose additional problems, unless owners are prepared to engage in a radical redesign of internal spaces.

Outlook

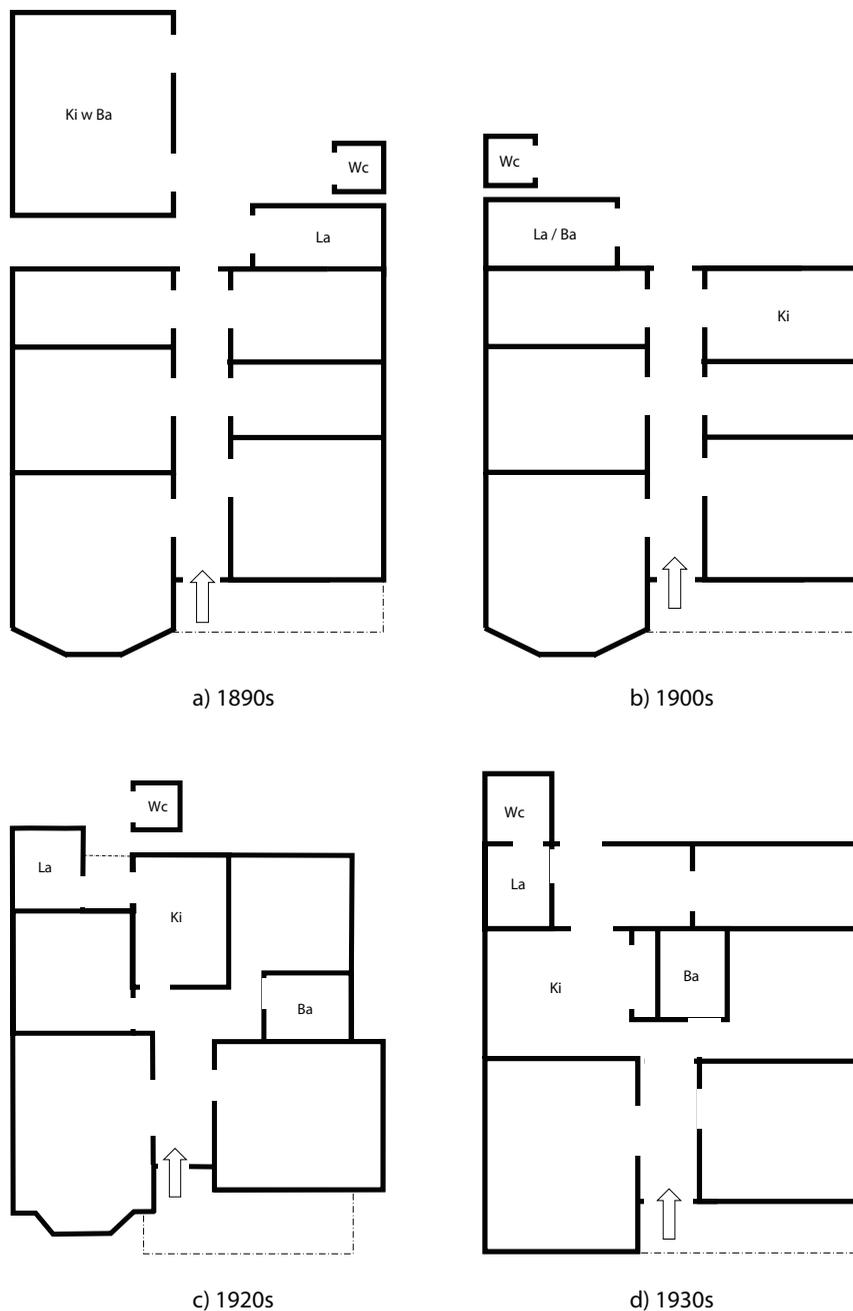
The COVID-19 pandemic has highlighted issues with the home designs presently offered by developers of suburban estates. Suggested are a containment space, additional wet cells, compartmentalisation of ingress and egress, compartmentalisation of internal usage and the installation of zoned, separately ducted air-conditioning with additional filter units. The design advocated here will not prevent owners from being infected but will reduce probabilities and will allow for infected residents to engage in self-isolation and receive home care while minimising transmission risk to other occupants and co-residents.

Architects and home-designers working for major building companies and suburban housing estate developers may want to reconsider their designs in light of the COVID-19

pandemic and integrate some or all of the design concepts advocated here. While this still leaves the extant building stock, at least new builds will be pandemic-ready.

These suggested design concepts, however, come at a cost, both in new builds and in retrofitted structures. The way COVID-19 has played out in various countries has exposed a socio-economic divide between those that could minimise the risk of exposure through working from home (Kramer and Kramer, 2020), not having to send their children to school (Van Lancker and Parolin, 2020), using private rather than public transport (Beck et al., 2020), living in single houses as opposed public housing blocks and estates, and being able to afford

FIGURE 5. House plans of Australian suburban houses 1890s to 1930s.



home delivery rather than having to shop. The same socio-economic divide will affect the ability to afford custom-built houses or to afford the retrofitting of existing buildings. Thus, from an urban planning perspective, it is critical that future affordable/social housing developments do not cut corners, else the socio-economic disadvantage endured by their occupants may again also translate into a public health disadvantage as well.

FIGURE 6. House plans of Australian suburban houses 1940s to 2010s.



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