The adaptive capacity of public space under COVID-19: Exploring urban design interventions through a sociotechnical systems approach

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Abstract
The coronavirus disease 2019 (COVID-19) pandemic has had a dramatic impact on the way in which the community interacts within public spaces. Consequently, the design of these urban environments requires new approaches. It is our view that Human Factors and Ergonomics approaches can be used to provide these insights. This article explores the opportunities for making public spaces safer and more accessible for community use under pandemic conditions. The study utilizes a sociotechnical systems model of an archetype public space, developed pre-COVID-19, to explore the infrastructure and activities that are impacted by the introduction of the virus to the public space system. The aim was to identify those elements of the system that are completely unavailable under pandemic conditions, those elements that become limited in use, and those which remained unaffected by the presence of the virus. The findings show that under pandemic conditions pre-COVID-19 public spaces were surprisingly resilient with proportionally few elements within the model completely unavailable. They also demonstrate that overall, the public spaces system, while still operating, is significantly constrained in achieving and optimizing community and individual health and well-being. The insertion of five (5) urban design interventions within the system model presented unique insights into the possibilities for optimizing adaptive capacity. These interventions revealed design opportunities across several levels of the systems model. Such insights are argued to assist in not only re-establishing community access under pandemic conditions but also more inclusive access to a broader range of the community under all conditions.

KEYWORDS
adaptive capacity, COVID-19, public space, sociotechnical systems, urban design

1 | INTRODUCTION

In truth, public space is all around us. Jan Gehl (2011) calls it the “life between buildings,” and it is often recognized as public parks and outdoor recreational areas, privately owned public plazas at the forecourt of inner-city buildings; and indeed, the streets, footpaths, and cycleways that help us navigate our cities and towns. Gehl (2011) identifies three broad requirements of public space—desirable conditions for the necessary outdoor activities—desirable conditions for the optional, recreational activities—and desirable conditions for the social activities (p. 51).
It is well established that public and outdoor recreational spaces are important public health assets and offer significant contributions to social and community well-being, as well as physical and mental health (Lee & Maheswaran, 2011; Maas et al., 2006).

In recent times, the opportunity to apply Human Factors and Ergonomics (HFE) theory and methods to support the design of public space has been proposed (Patoniti et al., 2018; Stevens et al., 2018). In particular, sociotechnical systems theory and associated methods have been applied to the design and analysis of public spaces such as main streets and cities (Stevens, 2016). In this study, public space is presented in an archetype sociotechnical systems model which represents equitable and accessible open spaces within urban settings (Stevens & Salmon, 2015). These are conceived as locations such as town squares, public parks, or open space recreational areas; however, they are spaces that have been purposefully designed with the intent of community use and social activity.

A resilient sociotechnical system is one that has the emergent capability to absorb shocks and be adaptive (Van Der Merwe et al., 2018). Accordingly, the adaptive capacity of systems is usually assessed by observing how they respond to disruptions or unexpected events (Salehi et al., 2020). The current coronavirus disease 2019 (COVID-19) pandemic is highlighting the limits of public space to be adaptive, and this study allows for more detailed explorations of the system and the possibilities for reinforcing the adaptive capacity of public space.

1.1 Public space and the current crises

There is an emerging literature regarding COVID-19 and public space. Low and Smart (2020) consider that public space "as places where we encounter other people and contact and connection occurs in open, democratic, inclusive and yet unpredictable ways" will have to change as a result of the pandemic, and public space may not survive as we know it (p. 2). While Honey-Roses et al. (2020) ask "will 2020 define a before and after in planning and design?" (p. 3); as they seek to highlight a range of emerging questions at the interface of COVID-19 and public space. They argue that globally there is an "unprecedented opportunity to examine the links between urban planning, public space and wellbeing" (p. 16). Indeed, there is growing consensus that the impact of COVID-19 on public space will be, and already is, transformational. Further that it will be the responsibility of the cohort of health, design and development professionals to work with communities to build healthier cities during and beyond this crisis (Honey-Roses et al., 2020; Tavares & Stevens, 2020a, 2020b). It is our view that HFE can and should be involved in this evolution.

To demonstrate, the present study aims to explore public space design interventions which will minimize virus transmission under pandemic conditions; yet also still allow community and individual access to the benefits of public space. This study seeks to draw upon systems HFE approaches to ensure that long-term lessons for the design of safe, resilient, and healthy urban spaces can be established from the challenges of the current pandemic.

1.2 COVID-19 restrictions and the community

In the Australian context, there have been four levels of pandemic restriction. It is important to note that each state or territory health department is largely responsible for the details of each level of restriction and for determining what constitutes a trigger for implementation or relaxation. The state or territory is also responsible for the determination of its border closures and restrictions to each other state in the country.

Regardless of the level of restriction there are several prevailing risk minimization strategies including: physical distancing of 1.5 m; stay at home orders and testing orders if you are unwell; a fortnight of (self-funded) hotel quarantine for incoming international travelers, or arrivals from a national location with "hot spot" community transmission; a prioritization of tracking, tracing, rapid response; and requirements for the frequent cleaning and disinfection of public and commercial infrastructure and premises (Queensland Health, 2020). Across the states and territories, the restrictions generally represent four levels of accumulating severity:

- Level 1: caution—physical distancing and increased sanitation;
- Level 2: service industries, food, and beverage outlets may operate under sanctioned "COVID-safe" guidelines and plans.
- Level 3: work and study from home orders are in place, travel distance restrictions apply, and many service industries are closed, retail food businesses, and hotels can offer takeaway service only;
- Level 4: travel permits are required, all retail is closed, only grocery stores, chemists, off licence bottle shops, pharmacies, petrol stations, banks, newsagencies, post offices, remain open; and there is also a night-time curfew.

2 COVID-19 AND PUBLIC SPACE

During Level 3 restrictions people are permitted to move freely within their neighborhoods and evidence suggests the use of parks and public spaces has increased (Australian Broadcasting Corporation [ABC], 2020). While public spaces are in demand and largely accessible, authorities have limited access to much of the recreational and public amenity infrastructure within them. Items such as play equipment, bike racks, seating, rubbish bins, and often bathroom facilities are closed, as they are deemed to pose a risk for virus transmission (Queensland Health, 2020). Such measures are largely necessary as the enduring design of public spaces is to facilitate community gathering and interaction (Figure 1).

Despite their curtailed capacity, the important public space functions and contributions to social well-being and physical and mental health have never been in more demand. Freeman and Eykelbosh (2020) highlight this as a key reason why any limits to access of parks and green spaces can be detrimental for community. They further identify the health inequities for those living in higher density residential neighborhoods with limited access to private
Key considerations for exploring the adaptive capacity of public spaces must consider virus transmission and stability, and the influence of outdoor environmental conditions. Two factors are highlighted by Freeman and Eykelbosh (2020), and of relevance in this study—crowding of the space (and taken here to include directional movement and destination), and the environmental conditions, including wind, temperature, humidity, and sunlight, also important here for its sanitation benefits (Tang et al., 2021).

2.1 | Pandemic public space and lessons from other crises

The impact of other disaster events on public space design provides some useful pointers as to how public space could be modified to cope with pandemic conditions. For example, following the destruction of more than 800 buildings within the central business area of Christchurch, New Zealand, in 2011, the city had to rethink safe public space (Carlton, 2013). There was an imperative to make public open spaces more resilient through urban design and from this emerged a range of adaptive outcomes. While temporary and pop-up interventions were popular, it is what they offered the community that mattered—choice. In particular, the use of urban retreat spaces, which were away from streets and tall buildings offered people a way of being there and being safe (Figure 2).

In review of the urban design outcomes from the Christchurch disaster, five unique aspects of urban design emerged in the period of postearthquake reconstruction to build community confidence and permit access to public space (Tavares & Swaffield, 2017; Tavares et al., 2019). The following urban design interventions were identified as contributors for the restoration of community confidence, choice, and safety.

- **Urban retreats and personal space**: Spaces with the main activities focused on people alone or in small groups and quiet environments, rather than social interaction.
- **Environmental comfort**: The user comfort in public space is managed actively and passively through a quality project that responds to the local climate.
- **Optimize the ability to enter and leave**: The users of public space are not at risk related to adjacent buildings, structures, or crowds and have options to leave safely if necessary.
- **Protection against built structures**: Public space offers users several opportunities for use, including the possibility of distancing themselves from structures that can generate risk.
- **Maximizing landscaping**: Landscaping is implemented to coordinate movement in space and offers users access to nature.

These areas of redesign present as useful for exploring the design requirements associated with pandemics. Accordingly, this article will investigate their use in the context of resilient public space under pandemic, by reviewing their impact within a systems model of archetype public space.
This study involved reviewing an existing sociotechnical systems model of a public space to identify the extent to which urban design interventions are likely to minimize virus transmission under pandemic conditions. Development of the existing model was a cooperative research project with community stakeholders and urbanists in South-east Queensland, Australia in 2015. The aim was to explore the impact of sensory design elements to build an in-depth understanding of the potential for public space to become more accessible, engaging and inclusive (Stevens & Salmon, 2015). The result was a work domain analysis (WDA; Naikar, 2013) abstraction hierarchy model which described an archetype public space across five (5) levels of abstraction:

1. **Functional purpose**—The overall purpose(s) of the system. For example, an inclusive and connected community.

2. **Values and priority measures**—The criteria that the system uses for measuring progress toward its functional purpose. For example, maximize safety.

3. **Purpose-related functions**—The general functions or activities within the system that are required for it to achieve its functional purpose. For example, allow social interaction.

4. **Object-related processes**—The processes associated with the physical objects within the system. For example, sitting.

5. **Physical objects**—The physical objects and resources within the system that afford the required processes. For example, seating.

The output provides a model of what activities can be performed within the system, and also how and why they are performed, and with what. Through a series of “means-ends” links it is possible to model the what, why, and how interactions of the system components and their influence on the overall system performance. These links are not weighted but simply represent a relationship between the nodes at each level. They indicate that
the operation of the system will follow these pathways and have these interactions and interdependencies in its operation. Figure 3 provides a summarized version of that model.

3.1 The functional purposes

The functional purposes of public space were identified as “a healthy and happy community,” “an inclusive and connected community,” and “a healthy and active individual” (Figure 3).

3.2 Values and priority measures

There are fourteen (14) values and priority measures identified in this model (Figure 3). They range from “communal space,” “community connectedness,” “actual safety” through to “enable individuality of design.” How these values are achieved is supported by the purpose-related functions on the level below.

3.3 Purpose-related functions

Public spaces are complex and this model has established twenty-seven (27) different purpose-related functions that are required for the system to achieve its overall purposes. Here it was possible, and useful to aggregate or summarize the primary categories (Figure 3). This middle level of the model links the more strategic, goal-oriented levels above it; with the physical resources and processes on the levels below. For this reason, it is here where this article first explores the implications and impacts of the new urban design interventions.

3.4 Object-related processes

These nodes represent the object-related processes afforded by the physical object on the level below. For example, “a surface for sitting” is a process that may be afforded by lawn, chairs/benches, garden walls, or play equipment. This idea that a process can be achieved from a range of physical objects is important for the resilience and flexibility of public spaces. The forty-seven (47) object-related processes have been aggregated into related categories (Figure 3).

3.5 Physical objects

The range of physical objects and resources identified within the model should be wide-ranging. It will include all elements that may be usually found in public spaces, for example, trees, shrubs, grasses, garden beds or, for example, stairs, seating, pavements. It is important that it also includes those objects that are critical to operation of the public space, but exist away from it—for example, rules and laws, engineering standards, design guidelines, and budgets for maintenance. To allow for the optimization of public space design it is important to acknowledge that any object may also afford multiple processes. A tree, for example, provides greenery, fruit and flower, shelter, shade and shadow, it is a landmark, and if endemic to the area offers both habitat and cultural knowledge. The fifty-one (51) physical objects included within the model of archetype public space have been broadly categorized (Figure 3).
In Australia community access to public space has been permitted under all levels of restriction. However, in the context of this study, the restrictions scenario is aligned to that of Level 3 in Queensland, Australia (Queensland Health, 2020). The community are restricted in the distance they can travel, and their reasons for traveling, while a stay at home order is in place. It is under such conditions that residents are being schooled, studying and working from home, and are exploring and utilizing local parks and public spaces for physical and psychological respite from the confines of their residence.

The three authors, an urban design and HFE expert, a post-disaster and public space urban design expert; and a systems HFE expert, initially undertook a review of the Stevens and Salmon (2015) public space model. They considered all of the nodes in the model under pandemic conditions to explore the impact of the virus on the availability of that node to the system. Following this, they used the five (5) design interventions (Tavares & Stevens, 2020b; Tavares et al., 2019) to explore the possibilities for increasing the adaptive capacity of the postpandemic public space.

The archetype public space abstraction hierarchy model was reviewed by the first author, considering each node across all five levels of abstraction from the top level to the bottom. A traffic light system of coding review under current pandemic conditions was utilized as follows:

- **red**—the node would be completely unavailable to the system;
- **amber**—the node would still be available to the system but its performance diminished;
- **green**—the node would be unaffected and still available to the archetype public space system.

The public space pandemic assessment was then reviewed by the coauthors, and the three took part in a workshop where each node and its coding was considered and discussed until consensus was met. The workshop analysis also included the consideration of the five (5) urban design interventions at the purpose-related functions level of the model. Each of these was considered in turn and to assist in this task a modified version of Read et al. (2016) "prompt questions" for WDA were applied Table 1.

### RESULTS

#### 5.1 | Assessment of the existing public space system under pandemic conditions

The findings of the public space pandemic assessment are presented in Figure 4.

The results show that for the most part public spaces are robust under pandemic conditions. In applying the traffic light assessment of red, amber, and green, there were surprisingly few nodes that were completely unavailable to the system, only sixteen (16) of the total one hundred and forty-two (142). In fact, across the functional purposes and values and priority measures it was agreed that none of these elements were completely unavailable. Conversely none of them were unaffected with all nodes identified as being impacted by the virus—still available to the system, yet with a diminished performance (amber).

#### 5.1.1 | Functional purposes, values, and priority measures

For the functional purposes, the analysis suggests that the impact of the virus on public spaces will not remove the community or the individual from the system. However, in jurisdictions with strict restrictions the presence of the community within public spaces will be heavily reduced. The analyses confirm that the virus will influence the health, happiness, and sense of inclusiveness of the public space system. The "amber" ratings for all functional purposes are a consequence of the impact from the levels below, again all the values and priority measures were agreed to have diminished performance.

At the values and priorities level issues such as safety are impacted, in addition to the systems role as communal space, and its
capacity to offer a reflection of community values. Interesting however is the impact on the more objective measures in the systems such as "conform with universal design standards" or "conform built environment standards." Under pandemic conditions, the system cannot fully achieve these measures—universal access is now denied within the space, while building standards are compromised when maintenance and repairs can no longer be carried out or are restricted. The adherence to many rules and standards no longer applies under pandemic conditions, and the measures of success for a quality public space are conceded and impacted throughout this level of the system.

5.1.2 | Purpose-related functions

Of the twenty-seven (27) purpose-related functions, three (3) were identified as unaffected by the pandemic. These were "optimize seasonal change indicators," "minimize water surface ponding," and "provide protection from travel way." Seasonal indicators refer to the use of nature to demonstrate the changing seasons, for example, spring flowering, or autumnal leaf fall, these functions of the public space are unaffected by the pandemic. The functions associated with water ponding and travel way protection are attributed to fixed infrastructures and are also unaffected. That is, the stormwater drainage system and the barriers

### FIGURE 4 Public space pandemic assessment

| Functional Purposes | Values and Priority Measures | Purpose Related Functions | Object Related Processes | Physical Objects |
|---------------------|-------------------------------|---------------------------|-------------------------|-----------------|
| A. Happy and healthy community | A. Maximize community comfort | R. Provides public amenity | G. Deters vehicles | G. Kerb and channel |
| A. Inclusive and active community | A. Maximize physical safety | R. Provides tactile (sensory) experience | R. Sanitation fixtures | R. Drinking fountains |
| A. Healthy and active individual | A. Maximize actual safety | A. Provide scent sensory activity | A. Bike storage | G. Garden beds & garden edging |
| R. RED Node would be completely unavailable | A. Conform with universal design standards | A. Provide visual sensory activity | A. Area to wait safely & comfortably | A. Public art |
| A. AMBER Node still be available but diminished | A. Optimize community connectedness | R. Provide taste sensory activity | A. Shelter | A. Tactile maps |
| G. GREEN Node would be unaffected | A. Enable individuality | A. Provide proprioception sensory activity | A. Landmark | G. Planning regulations |
| A. Maximize achievability | A. Conform built environment standards | A. Provide vestibular sensory activity | G. Prevents water Entering footpath | A. Budget |
| A. Maximize perceived safety | A. Adhere to rules | A. Minimize motorised traffic speeds | A. Surface for objects | G. Road rules |
| A. Maximize environment values | A. Integrate community values | Under pandemic conditions, the system cannot fully achieve these measures—universal access is now denied within the space, while building standards are compromised when maintenance and repairs can no longer be carried out or are restricted. The adherence to many rules and standards no longer applies under pandemic conditions, and the measures of success for a quality public space are conceded and impacted throughout this level of the system.

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between roadway and walkway will continue to function as intended, unimpeded by the virus.

There were only three (3) purpose-related functions that were determined as becoming unavailable under pandemic conditions. These were "provide public amenity" as it related to the closure of public bathrooms and drinking fountains; "provide taste sensory experience" under the assumption that to eat or utilize plants from the public space may present an unnecessary health risk in a pandemic. Third was "maximize community & civic functions," in the acknowledgment that all registered or organized functions within the public space will cease under pandemic conditions.

The remaining twenty-one (21) functions of the public space model where all determined to have been impacted in some way by the pandemic. This was true across each of the aggregated categories (Figure 3), sensory-related functions—for example, tactile sensory experiences remain underfoot and in nature, but not as directed touch activities; visual and aural sensory experiences are diminished by virtue of the reduced public and community activity within the space. Safety-related functions, such as "protection from climate" are diminished by the restricted access to park shelters; as is the function of "provide places to meet and wait." Additionally, for this function restrictions on seating, and the need to not congregate in the environment diminished its capacity under pandemic conditions. Service-related functions, in line with "utilities maintenance" and "delivery of utilities and services to need" were impacted in that they were reduced in the requirements, while overall the "quality of the public realm design" was adversely impacted in that barriers, hoardings, signage, and tape were used as means to achieve public health compliance. The design of the environment was not able to adapt in such a way that these functions and the quality of the public space was able to be retained and enjoyed. User enhancement-related functions refer to those which permit the community to better utilize or engage with the public space. These include the maximization or optimization of wayfinding, fun and adventure, walkability, vibrancy, and local character. The assessment of these functions was that they are all still present, but adversely impacted in the system (amber). In this model assessment, there are several important nodes in the object-related processes level, below the functions, that have significant influence on the how the functions are available to the system.

5.1.4 | Physical objects

The analysis revealed that ten (10) of fifty-two (52) physical objects from the original model are unavailable to the system under pandemic conditions. Physical objects deemed to be unavailable include bike racks, toilets, tables, chairs, playground equipment, and tactile maps. Conversely this level also has the most unaffected nodes with twenty-eight (28) of fifty-two (52) not impacted by the pandemic. Examples here include, road crossings, traffic signals, street signage; and trees, shrubs, water features, lawn, and grasses (Figure 4). Interesting objects that remain in the system but are impacted (amber) included elements that were often fixed in place, but now either present as a risk (or as inaccurate) to the users of the systems. For example, stairs and ramps now perhaps congregate people in closer proximity than recommended; while fences, public art, railings, and balustrades, still partially function as intended but also present as a surface which may have previously been touched and is now a transmission risk. The inaccuracy of the information provided within the system is also a challenge, for example, signage may direct people to facilities that are no longer available or offer misinformation about the appropriate use of the public space.

5.2 | Insertion of urban design interventions to the public space pandemic assessment

The five (5) urban design interventions where first placed at the purpose-related functions (middle) level of the model and their influence explored from there. The first consideration was, do these interventions support the overall purposes of the system? The overall
purposes of the system are a healthy and happy community, an inclusive and connected community, and a healthy and active individual.

Urban retreats and personal space—yes, such locations offer necessary choice in public space that is presently not well supported. These types of public space and their design elements allow for activities focused on individual use or in small groups and quiet environments, supporting the use of public spaces while keeping physical distance from others (Figure 5).

Environmental comfort—yes, the users’ (human) comfort in public space needs to be prioritized and managed actively and passively through quality design outcomes that respond to the local context and climate. While the main attraction in social spaces is social activity and human interaction, in retreat spaces the place itself becomes the reason "to be there." In social spaces users adapt to the climate to be part of the social scene and to be with others, while in retreat spaces the place itself and the environmental comfort it provides become key factors in its use and success.

Optimize the ability to enter and leave—yes, the system needs to offer choice in the ways and means to move safely through and to leave the public space. Users have options to avoid crowds and remain physically distanced as they enter or exit the space.

Protection against built structures—yes, the design of the public space and the surrounding environment does not crowd or corral users. It permits the necessary minimum physical separation—both person to person and person to buildings—and does not create drivers for riskier behavior elsewhere in the urban environment, such as bringing people together in pathways or making public space users unintentionally touch built structures.

Maximizing soft landscaping—yes, the use of planted landscape areas can coordinate movement in the space, offer a means to separate uses and users, and offer important access to nature and greenery. It can also add life to otherwise bare and empty spaces (Figure 6).

In the initial consideration of the urban design interventions to the existing public space system, all were established as valuable and supporting the functional purposes. In deliberating on the more detailed roles, location and connections of each intervention within the system the prompt questions (Table 1) were considered and discussed by the authors. The outcomes of those deliberations and resultant systems outcomes and modifications are now considered in turn.

5.2.1 | Urban retreats and personal space

It was agreed that "retreat spaces" could become a new physical object and is connected to a new object-related process of "retreat." This process could then also be afforded to existing objects and offer possibilities for the arrangement of a range of objects for that retreat process, for example, tables, chairs, and awnings. The retreat space as a physical object was also related to several existing process, including "surfaces for activity and play," "provides shelter," and "provide area to wait safely and comfortably."

The process of retreat also supported a number of existing purpose-related functions on the level above. These included, "provide protection form climate," "maximize diversity," "place to meet and wait," "allow (passive) social interaction," and "provide protection from the travel way" (Figure 7). Following from both the intent of this intervention and the new approach to public space, an additional purpose-related function was proposed and included in the model—separation. This function, as a significant new contribution to the understanding of public space, will be explored in further detail later in the discussion.

5.2.2 | Environmental comfort

Environmental comfort was established as an object-related process and was agreed to represent the variety of acoustic, lighting, thermal, and ergonomic processes associated with the appropriate physical objects on the level below. It was then linked to a new purpose-related function—"provide human comfort," while also making
connections to existing functions including, "provide protection from climate," "optimize seasonal change indicators," "maximize local character," and "maximize quality of the public realm."

The new function of "provide human comfort" further connects up the system to support a number of existing values and priority measures, including "maximize connections to nature," "enabling individuality of design," "maximize physical comfort," "maximize perceived safety," and "maximize actual safety" (Figure 8).

The provision of human comfort underpins the use of any space but is even more significant in regard to the use of retreat spaces, where users are not there for the interaction, but for solace, and to feel comfortable and safe. To further support the importance of this aspect of public space it was agreed to also include a new object in the archetype — bioclimatic design guidelines. If the design of public space is underpinned by the principles of appropriate climatic design, no matter what country or cultural context, it will better serve the users of the

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**FIGURE 7** Urban retreats and personal space systems influence

**FIGURE 8** Environmental comfort systems influence
space. Furthermore, it may also offer important affordance for sanitation, and in the case of COVID-19 specifically the virus is sensitive to environmental variables such as sunlight and humidity (Tang et al., 2021).

5.2.3 | Optimize the ability to enter and leave

Optimize the ability to enter and leave is about not being in crowded spaces, and intuitively knowing how to enter and leave the public space, even if the users are unfamiliar with it. “Optimize the ability to enter and leave” has been included in the model as a new object-related process. The findings suggest that it can connect to a range of existing physical objects, including “pavements,” “garden bed and edging,” “ramps,” “stairs,” “road crossings,” “laneways,” “information signage,” “tactile surface indicators,” and “pedestrian lighting.” Its inclusion highlights the role that these objects need to play in establishing a safe public space system. It is a process that connects also to a number of existing and counterpart purpose-related function on the level above, including “maximize wayfinding,” “maximize walkability and inclusivity,” and “optimize use of obstacles” (Figure 9).

5.2.4 | Protection against built structures

The protection from adjacent built form in the earthquake setting was focused on two aspects, the provision of enough space and distance from a building; and the identification of safe assembly points. Here too it is about optimal spacing and ensuring there is enough room in the built environment to minimize the crowding and ensure that appropriate levels of physical distancing can be maintained.

To support the intent of this intervention, two new object-related processes could be included: “protection” and “optimal spacing.” Protection connects to the functions of “minimize motorized traffic speeds,” “provide protection from climate,” and “provide protection from the travel way”; while “optimal spacing” supports “maximize vibrancy,” “provide places to meet and wait,” “allow social interaction,” “maximize community and social functions,” “optimize use of obstacles,” and “maximize walkability and inclusive mobility.” Physical objects associated with both processes include “doorways and windows in adjacent built form,” “building line and setbacks,” and “retreat spaces” (Figure 10).

5.2.5 | Maximizing soft landscaping

“Maximize soft landscaping” has been added to the model as an object-related process that recognizes garden beds and hedges as true design devices, which provide movement guidance and structure. At this level of the model it supports and links to the functions of “separation,” “provide visual sensory experience,” “maximize local character,” “allow social (passive) interaction,” “provide protection from the travel way,” and “maximize wayfinding” (Figure 11).
FIGURE 10  Protection against built structures systems influence

FIGURE 11  Maximizing soft landscaping systems influence
This role of the soft landscape can be additionally fortified via the inclusion of the process of “provide direction.” This is a new node which directs the adaptive capacity of objects such as greenery elements to support and manage crowding and the flow of people. It is also a process of signage, and tactile surface markers which then also link to the function of separation.

Using greenery as directional infrastructure helps prioritize it and make connections to the buffers and the wayfinding processes needed to keep people safe. It also helps to enhance other functions that already exist in the model. The greenery can help shape and separate the spaces and keep the users of these space distanced. It has the capacity to offer visual connection without affording physical connection, as it presents as an important element of separation.

5.2.6 | New value of “maximize cooperation”

The new social norms under pandemic conditions will require individuals and the community to be cognizant of their relationships with other people in terms of separation, and their surroundings. The design of public spaces can support this. There will be an element of teamwork required by users of public spaces, working together, rather than against each other, and the HFE design of the environment has been shown to support such interactions (Salmon et al., 2018).

Users of public spaces will rely on a sense of responsibly to one another, and ideals around a “sense of community inclusiveness and ownership” can support such interactions. If through design it is possible to foster a sense of place and place attachment, already sought after and desirable qualities of public space, such cooperation will occur (Jørgensen & Stedman, 2011).

The “maximize cooperation” value will support each of the three highest level functional purposes, and in turn be supported by a range of existing purpose-related functions. “Maximize local character,” “maximize vibrancy,” “encourage local ownership and agency,” “maximize diversity,” “provide place to meet and wait,” “allow social interaction,” “maximize community/civic functions,” “maximize walkability,” and “maximize way finding” are all linked to this new and significant value and priority measure of public space.

5.2.7 | The incorporation of technology

“Information communications technology” was identified as an additional object required for inclusion to the archetype model. This object includes the provision of internet and telecommunications services in the public space, but also personal mobile devices. Users of the space, their cooperation and the adaptive capacity of the space will be supported by technology and software applications. It may be in the form of information about public space, its facilities and use; virus tracing apps managed by health services; and network availability and bandwidth to support the recreational use of technology in public space.

5.2.8 | New purpose-related function of “separation”

The new function of separation underpins much of the shift in thinking required for public space. Public spaces that offer choice for the levels of activity and interaction are necessary—spaces that can bring community together, but also optimize separation where needed. The original public space systems model supported the design of more inclusive public space; and the present analysis also supports that notion. It recognized that to date there are segments of the community that have been forgotten by the current design of many public spaces (Stevens & Salmon, 2015). Through this new function it is possible that public space may offer retreat, a sense of safety, enclosure, and personal comfort which will make them more equitable and accessible to the broader community (Tavares et al., 2019).

The premise of public spaces as social spaces is exclusionary for many groups in society, and the addition of separation offers a more balanced and inclusive design ethic for public space.

6 | DISCUSSION

6.1 | How resilient are public spaces to pandemics?

Public spaces are recognized as public health assets and are necessary social infrastructure in our cities and towns (Low & Smart, 2020). Under the current pandemic conditions, their use and access by the community has taken on renewed significance and necessity (ABC, 2020). What is apparent from the present HFE and systems assessment of the pandemic on public space is the high levels of resilience and adaptive capacity that already exist public space systems. These important city spaces, for the most part, continue to function and offer the physical and mental respite required by a population under restriction.

What is also clear is that the context, type, and form of public space under pandemic conditions will matter. For example, large, open and green spaces, and parks, which permit distancing and freedom of movement operate as valuable self-organizing community spaces (Broudehoux, 2021). In these locations, the flexibility of the space, social norms, and health guidelines permit low risk (local) community access and use. Furthermore, such spaces do not readily offer major public conveniences, such as bathrooms, nor do they contain much of the recreational and social infrastructures like playgrounds and built shelters. This type of public space may be found in suburbia but is perhaps less common in the more built-up medium and high-density urban residential areas (Freeman & Eykelbosh, 2020). A clear adaption to this constraint under lockdown were examples of golf courses in inner city locations in Australia being made available to the community as public open spaces (golf was a banned recreational activity). This has consequently ignited a debate about permanent community access to these sometimes
more exclusive public spaces in our cities, and the lack of quality of public space more generally (Walls & Wallis, 2020).

Within these more urbanized community settings, there is a higher proportion of smaller, distinct and designed public spaces, that are ultimately less adaptive. Within inner city locations it will be necessary to identify ways to better support physical separation and the promotion of cooperation of public space users. To allow people to be together, but apart, these spaces will require more context sensitive and intensive design adaption and consideration. Importantly, such public spaces are also represented in the system sensitive and intensive design adaption and consideration. It is expected that making some physical objects, like bike racks, more readily available will result in better health outcomes, more efficient use of space, and indeed will be safer when considering the necessity for sanitation. For example, while rubbish bins were not available in many circumstances, it will be important that they remain available to the system.

6.2 | Adaptive capacity of public spaces

It is possible to recognize that in many ways, even in their current form, public spaces already possess some level of adaptive capacity. They may have been used in different ways under pandemic conditions, but they are still utilized. This adaptive capacity is in part attributable to them having fewer rules and technical elements. Such flexibility, even in highly ordered public spaces, means they demonstrate higher levels of adaptive capacity than systems with many more technical elements, such as buildings and transport systems. It is also a consequence of the “human as assets” in the public space system and a dependence on the users of the space being flexible in finishing the design, a core sociotechnical systems value (Read et al., 2016). The community showed resounding resilience and innovation in continuing to engage in daily life safely. Their regular activities required some adjustment and direction, but they were not impossible to undertake. For example, with a reduction in car traffic, many cities took the opportunity to repurpose parking lanes into cycling and pedestrian-oriented spaces. Pop-up parklets emerged as important community meeting places and indeed spaces where under pressure café owners and restaurateurs could meet spacing requirements and safely open their doors to the public (Bereitschaft & Scheller, 2020; Fernandez, 2020).

The range and diversity of the community users of public space is a necessary consideration for this study. It is anticipated that each cohort—young, old, resident, visitor, and so on, and their motivation for the use of the public space and indeed their requirements and interactions with the design interventions identified here, need to be detailed and explored to best optimize the use and design of public space.

6.3 | Implications for public space design

People have been using and exploring their neighborhoods in new and interesting ways during the pandemic. Indeed, the increase in neighborhood walking and cycling activity presented some emergent challenges—many people have taken to cycling both for recreation and local trips (ABC, 2020). In places this has led to a transformation to “slow streets” where cars are no longer given priority (Broudehoux, 2021). In the local context when bike racks were restricted, other places to lean and latch bicycles were found. Going forward for detailed design it will be important to maintain safe access to many such elements of public space infrastructure. It is expected that making some physical objects, like bike racks, more readily available will result in better health outcomes, more efficient use of space, and indeed will be safer when considering the necessity for sanitation. For example, while rubbish bins were not available in many circumstances, it will be important that they remain available to the system.

In any detailed design or redesign, it will be important to ensure that the counter influences of adaptive capacity do not make control appear completely adequate (Woods & Cook, 2006). The system will remain under stress from pandemic, and people will need to remain vigilant. In design, the success of the adaptive capacity to permit access to public space cannot mask the need for continued caution. It may be that there are cues to permit that acknowledgment in the public space that highlight changed conditions.

Overall, the intention here was to explore the resilience of public spaces to pandemics. The assessment sought to inform the design of an urban environment that can enhance interactions between people; yet also adapt to enhance separation when required. This is a shift in public space design, where to date they have largely been to bring people together and to generate communities where they can exchange experiences (Smith & Bugni, 2006).

Without a HFE and systems perspective on the proposed public space design interventions, it would have not been possible to explore, nor understand the system-wide implications for such change. The result is an expanded public space model, which offers an archetype and design template for new and existing public spaces which seek to be more resilient, inclusive and specifically respond to and identify the means to optimize their adaptive capacity. The approach and insights explored here, support new possibilities for public spaces, and more broadly our cities, to adapt and be able to enhance their role as significant and ongoing community public health assets.

7 | Study limitations and future research areas

While the abstraction hierarchy model was developed by a team of analysts with expertise in WDA, HFE and systems thinking, and landscape planning and urban design, the analysis presented in the current article was not subject to any validation via review by additional subject matter experts. Further research should explore conducting a formal model validation study through avenues such as subject matter expert workshops or a Delphi study.
Further testing of design interventions and industry workshops on design outcomes are being undertaken by the authors. This more detailed design exploration is necessary to explore the spatial relationships within public space. Ultimately the extent to which the system has adaptive capacity will be a consequence of the interdependencies of the resources available to the system.

Future research will also seek to explore the use of agent-based models of proposed sociotechnical systems public space designs under a range of conditions. It will be possible to test designs, allocate agent properties, insert pop up infrastructure, and explore a range of future scenarios. Such modeling will support the exploration of different demographic and behavioral variables which also underpin the adaptive capacity of any public space.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES
Amendolia, J., Saturno, J., Brooks, A. L., Jacobs, S., & Jambeck, J. R. (2021). An emerging source of plastic pollution: Environmental presence of plastic personal protective equipment (PPE) debris related to COVID-19 in a metropolitan city. Environmental Pollution, 269, 116160.

Australian Broadcasting Corporation (ABC). (2020). Massive boost to outdoor exercise in Sydney’s green spaces during coronavirus, survey finds. https://www.abc.net.au/news/2020-06-28/sydney-green-space-use-booms-during-covid-19/12400104?utm_source=abc_news&utm_medium=content_shared&utm_content@mail%26utm_campaign=abc_news

Bereitschaft, B., & Scheller, D. (2020). How might the COVID-19 pandemic affect 21st Century urban design, planning, and development? Urban Science, 4(4), 56.

Bravo, L., Guaralda, M., Tieben, H., Espinoza, L. A. S., & Manfredini, M. (2017). Stand up for Public Space! A networking event at the Habitat III conference and a global online campaign. The Journal of Public Space, 2(1), 163–166.

Broudehoux, A. (2021). Post-pandemic cities can permanently reclaim public spaces as gathering places. The Conversation CA-FR. https://theconversation.com/post-pandemic-cities-can-permanently-reclaim-public-spaces-as-gathering-places-150729

Carlton, S. (2013). Share an Idea, spare a thought: Community consultation in Christchurch’s time-bound post-earthquake rebuild. Journal of Human Rights in the Commonwealth, 2(2), 4–13.

Fernandez, C. (2020). New pilot parklet scheme helps restaurants reimagine outdoor eating. ARUP. UKIMEA Press Office, Leeds. https://www.arup.com/news-and-events/new-pilot-parklet-scheme-helps-restaurants-reimagine-outdoor-eating

Freeman, S., & Eykelbosh, A. (2020). COVID-19 and outdoor safety: Considerations for use of outdoor recreational spaces. National Collaborating Centre for Environmental Health. https://ncceh.ca/documents/guide/covid-19-and-outdoor-safety-considerations-use-outdoor-recreational-spaces

Gehl, J. (2011). Life between buildings: Using public space. Island press. 

Honey-Rosés, J., Anguelovski, I., Chireh, V. K., Daher, C., Konijnendijk van den Bosch, C., Litt, J. S., Mawani, V., McCall, M. K., Orellana, A., Osciłowicz, E., Sánchez, U., Senbel, M., Tan, X., Villagomez, E., Zapata, O., & Nieuwenhuijzen, M. J. (2020). The impact of COVID-19 on public space: An early review of the emerging questions–design, perceptions and inequities. Cities & Health, 1–17.

Jorgensen, B. S., & Stedman, R. C. (2011). Measuring the spatial component of sense of place: A methodology for research on the spatial dynamics of psychological experiences of places. Environment and Planning B: Planning and Design, 38(2), 795–814. https://doi.org/10.1068/b37054

Kampf, G., Todt, D., Pfaender, S., & Steinmann, E. (2020). Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. Journal of Hospital Infection, 104(3), 246–251.

Lee, A. C., & Maheshwaran, R. (2011). The health benefits of urban green spaces: A review of the evidence. Journal of Public Health, 33(2), 212–222.

Low, S., & Smart, A. (2020). Thoughts about public space during covid-19 pandemic. City & Society, 32(1). https://doi.org/10.1111/ciso.12260

Maas, J., Verheij, R. A., Groenewegen, P. P., de Vries, S., & Spreeuwenberg, P. (2006). Green space, urbanity, and health: How strong is the relation? Journal of Epidemiology & Community Health, 60(7), 587–592.

Naikar, N. (2013). Work domain analysis: Concepts, guidelines, and cases. CRC Press

Patorniti, N. P., Stevens, N. J., & Salmon, P. M. (2018). A sociotechnical systems approach to understand complex urban systems: A global transdisciplinary perspective. Human Factors and Ergonomics in Manufacturing & Service Industries, 28(6), 281–296.

Queensland Health. (2020). Queensland Government Health Department, Restrictions in Queensland. Brisbane, Australia. https://www.qld.gov.au/health/conditions/health-alerts/coronavirus-covid-19/current-status/public-health-directions

Read, G. J., Salmon, P. M., & Lenné, M. G. (2016). When paradigms collide at the road rail interface: Evaluation of a sociotechnical systems theory design toolkit for cognitive work analysis. Ergonomics, 59(9), 1135–1157.

Salehi, V., Veitch, B., & Musharraf, M. (2020). Measuring and improving adaptive capacity in resilient systems by means of an integrated DEA-Machine learning approach. Applied Ergonomics, 82, 102975.

Salmon, P. M., Read, G. J. M., Walker, G. H., Lenné, M. G., & Stanton, N. A. (2018). Distributed situation awareness in road transport: Theory, measurement, and application to intersection design. Routledge

Smith, R. W., & Bugni, V. (2006). Symbolic interaction theory and architecture. Symbolic Interaction, 29(2), 123–155.

Stevens, N. J. (2016). Sociotechnical urbanism: New systems ergonomics perspectives on land use planning and urban design. Theoretical Issues in Ergonomics Science, 17(4), 443–451.

Stevens, N. J., & Salmon, P. M. (2015, August). New Knowledge for Built Environments: Exploring Urban Design from Socio-technical System Perspectives. In International Conference on Engineering Psychology and Cognitive Ergonomics. (pp. 200–211). Springer, Cham.

Stevens, N. J., Salmon, P. M., Walker, G. H., & Stanton, N. A. (2018). Human factors in land use planning and urban design: Methods, practical guidance, and applications. CRC Press

Tang, L., Liu, M., Ren, B., Wu, Z., Yu, X., Peng, C., & Tian, J. (2021). Science of the Total Environment Sunlight ultraviolet radiation dose is negatively correlated with the percent positive of SARS-CoV-2 and four other common human coronaviruses in the U. S. Science of the Total Environment, 751, 141816.

Tavares, S. G., & Stevens, N. J. (2020a). Cities will endure, but urban design must adapt to coronavirus risks and fears. In Conversation. Conversation Media Group

Tavares, S. G., & Stevens, N. J. (2020b). A integração de valores e medidas de segurança no projeto de espaços públicos resilientes: Lições de desastres rápidos e lentos. Projectare, 1(10), 158–183.
Tavares, S. G., Swaffield, S., & Stewart, E. J. (2019). A case-based methodology for investigating urban comfort through interpretive research and microclimate analysis in post-earthquake Christchurch, New Zealand. *Environment and Planning B: Urban Analytics and City Science*, 46(4), 731–750.

Tavares, S. G., & Swaffield, S. (2017). Urban comfort in a future compact city: Analysis of open space qualities in the rebuilt Christchurch Central City. *Landscape Review*, 17(2), 5–23.

UNESCO. (2017). *Inclusion through access to public space*. Social and human services online resources. http://www.unesco.org/new/en/social-and-human-sciences/themes/urban-development/migrants-inclusion-in-cities/good-practices/inclusion-through-access-to-public-space/

Van Der Merwe, S. E., Biggs, R., & Preiser, R. (2018). A framework for conceptualizing and assessing the resilience of essential services produced by socio-technical systems. *Ecology and Society*, 23(2), art12.

Van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., Tamin, A., Harcourt, J. L., Thornburg, N. J., Gerber, S. I., Lloyd-Smith, J. O., de Wit, E., & Munster, V. J. (2020). Aerosol and surface stability of COVID-19 as compared with SARS-CoV-1. *New England Journal of Medicine*, 382(16), 1564–1567.

Walls, W., & Walliss, J. (2020, October). Our cities are full of parks, so why are we looking to golf courses for more open space? *The Conversation, Australia*. https://theconversation.com/au

Woods, D. D., & Cook, R. I. (2006). Incidents—markers of resilience or brittleness. *Resilience engineering: Concepts and precepts* (pp. 69–76). CRC Press.

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