POST-PANDEMIC URBANISM

A discussion paper on planning and urban design considerations for cities during the pandemic and after.
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Introduction

On January 21st, 2020, a Washington state resident became the first person in the United States to test positive for COVID-19. Shortly after, with 13 dead and 300 afflicted, the Chinese government moved to lock down Wuhan, where the first cases were reportedly diagnosed, and take additional measures in neighboring cities to restrict the spread of the virus. Within 10 days of the identification of the first known case in the United States, the World Health Organization (WHO) issued, for the 6th time since its inception in 1948, a global health emergency with 200 known deaths and over 9,800 known cases attributed to the quickly spreading virus¹. By July 29th, approximately 6 months from the identification of the first case in the US, more than 150,000 in the US had succumbed to the virus, a toll exceeding that of any other country². With 2020 coming to a close there have been more than 18.9 million confirmed cases in the United States with over 331,000 deaths and more than 80.5 million cases globally taking the lives of over 1.7 million people³. While 2021 brings some hope with two vaccines recently having received emergency use authorization from the U.S. Food and Drug Administration and several more potentially on the way, some medical experts estimate that 60% to 70% of the population will likely need to be vaccinated before herd immunity can be achieved, a process that will likely not be completed until mid to late 2021. A daunting prospect at a time when, on average, more than 500,000 cases are being reported globally every day³,⁴.

Sars-CoV-2 (COVID-19), which causes the disease COVID-19, is a highly infectious respiratory virus, primarily spread through close physical contact (usually defined as within 6 feet) via respiratory droplets that are dispersed when someone with COVID-19 talks, breathes, coughs, sneezes, or sings and is commonly associated with fever, chills, cough, shortness of breath, difficulty breathing, fatigue, loss of taste or smell, and many other symptoms that have been reported with some variability and experienced with widely ranging levels of severity⁵,⁶. While many of those who contract COVID-19 (approximately 80%) will experience only mild or moderate symptoms, with some experiencing no symptoms, more than 13%, particularly older adults or those with certain underlying conditions, will present with a severe case that can result in pneumonia, respiratory failure, sepsis, or death⁷. Of course, much of this is widely known, due to the extraordinary spread and toll this disease has taken in addition to the wide ranging impacts it has had on the daily lives of nearly all peoples across the globe. In reaction to its infectiousness, the world has responded: with mask mandates, social distancing, hygiene protocols, remote work, shutdowns, quarantines, travel restrictions, safety protocols, and countless other interventions. It has led to a nearly unprecedented change in the way people work, live, socialize, travel, shop, and congregate, and it seems increasingly likely that the extensive change it has brought about will leave a lasting mark.

Across the world, designers, architects, planners, governments, engineers, medical professionals, and urbanites have begun a still-evolving conversation about how our cities should respond, how they will change, and how our cities can be strengthened in its aftermath. Already, cities have seen marked shifts in the demands and preferences of their consumers,
residents, businesses, and institutions for housing, real estate, and transportation - changes that will undoubtedly have an effect on the way our cities are built and designed in the future. Additionally, many are asking how we can better prepare our cities for future infectious disease outbreaks and which interventions will help reduce infectiousness and better prepare residents for the massive upheavals that may accompany future natural and manmade emergencies.

While some have questioned the practicality of redesigning cities for future pandemics and have raised the prospect of a return to business as usual for dense urban areas after the spectre of the COVID-19 pandemic has faded, some experts are suggesting that we should begin to expect that disease outbreaks will become more common fixtures of a globalized world, with some scientists estimating that the world should expect to face a health emergency at least once every five years - a finding not so inconsistent with our experience with infectious disease in the 21st century, where COVID-19 marks the fifth major emergence of a zoonotic disease. Dr. Anthony Fauci, the well-known director of the National Institute of Allergy and Infectious Diseases and member of the White House Coronavirus task force has previously stated on Politico’s Pulse Check podcast that, “there’s no doubt that we're going to have outbreaks in the future.” The United Nations recently designated December 27th, 2020 as the world’s first International Day of Epidemic Preparedness, in recognition of the extensive toll the current pandemic has taken and the need to prepare for future disease outbreaks in order to mitigate their extensive costs. Additionally, experts caution that the expansion of human populations, the increasing complexity of human food systems, the increasing encroachment of human populations on wildlife habitats brought about by climate change, and ongoing changes to livestock production will result in increased exposure of humans to animals, and thusly, zoonotic pathogens, which account for 75% of new emerging human pathogens.

Of course, the cost of any preparedness interventions should be weighed in accordance with their relative benefits, but with some experts placing the estimated economic cost of the COVID-19 crisis to the United States at more than $16 trillion, through a combination of lost output and health reductions, there’s clearly an economic imperative, in addition to the human costs, which support evaluation of potential mitigation strategies and to take preventative actions. By the time our lives begin to return to normal, and the world slowly begins to pick up the pieces, cities and planners will find themselves in the position of asking how they can prepare for the next health crisis and how to prepare for the many changes to cities that this crisis has brought about. This will undoubtedly involve taking stock of the many ways in which cities have responded to the current crisis and making thoughtful predictions about how these changes will continue to impact cities after the current crisis has abated.

A Brief History of City Planning and Infectious Disease:

City planning, urban design, and architecture have long been closely related to the field of public health; there are many examples throughout history of how disease and health considerations have shaped our current urban environments. The frequent and disruptive cholera, typhoid, yellow fever, and malaria epidemics of the 19th century in Europe are cited as key causes for the implementation of modern urban sanitation systems. In the mid-19th Century, John Snow of London would conduct investigations that identified contaminated sewage as a primary driver of elevated cholera infection rates and the sanitation changes that would be implemented as a result of his investigations led to the end of an epidemic in London. The discoveries of John Snow and changes implemented by the London’s Metropolitan Board of Works underscored the importance of the sanitation movement, sewage drainage systems, and water purification systems that would become widely adopted in many urban centers in the following decades.

As a result of the Industrial Revolution in the late 18th and early 19th centuries, people flocked to cities in droves creating overcrowded and unsanitary conditions that would become a major vector of respirato-
ry disease, such as tuberculosis. Building standards were implemented during this period to increase the amount of light and air for residences and land use regulations were implemented to separate residential areas from noxious uses. Zoning regulations implemented during the 18th century in cities such as Baltimore, Boston, Philadelphia, and New York would restrict the proliferation of slaughterhouses, pig farms, and dairies within cities, cementing the alignment between the fields of urban planning and public health.

In the urban design arena, we see that the characteristics and fixtures of some of the world’s most well-known cities had their origination in public health considerations. The wide boulevards and open parks of Paris, France were conceived by Georges-Eugène Haussmann in response to the overcrowding and high death rates from disease and they helped usher in an urban environment with more light, green space, modern housing, and improved sanitation. The propagation of urban parks was strongly influenced by the belief in the medical community that squalor and filth created noxious gases that were the source of all disease and that urban parks provided an oasis that offered protection against these ills with New York City’s Central Park, one of the America’s first great urban parks, being cited by Fredrick Olmsted as “The Lungs of the City”.

St. Louis’s Forest Park, which officially opened on June 24th, 1876 and exceeded the size of New York’s Central Park by more than 500 acres, was created with similar concerns in mind at a time when acid rain and heavy smog were common environmental issues with local health professionals praising Forest Park for the benefits that fresh air would bring to city residents. St. Louis also negotiated public transport to Forest Park from Downtown with the park initially receiving thousands of visitors each day.

Many of the principles of modernist architecture have been cited as being influenced by the assumptions about the curative properties of light and air and this architectural movement incorporated many design features of the sanitariums where tuberculosis was treated such as flat roofs, terraces, balconies, and large windows. In St. Louis’s 1947 Comprehensive Plan, the importance of enacting minimum housing standards was addressed as a vital component of ensuring public health. The plan describes the importance of eliminating overcrowding by prescribing space minimums per household and per person; recommendations on the number, area, and openness of windows to provide fresh air and natural light; the importance of screens on doors and windows to restrict flies and mosquitos; heating standards; the removal of outdoor privies in sewered areas; and the necessity of keeping residential dwelling sanitary and free from infestations.

In 1918, the Spanish Flu infected a third of the world’s population and killed 50 million worldwide, however St. Louis, with a population of 687,000, saw approximately 31,500 cases with only 1,703 mortalities. St. Louis was lauded for their response to the 1918 Influenza pandemic, as Dr. Max C. Starkloff, the St. Louis Board of Health Commissioner, aggressively moved to close schools, churches, theaters, dance halls, and other public spaces to reduce transmission - a crucial move generally regarded as the cause of lower transmission and mortality compared to other comparably large U.S. cities at the time. The St. Louis Health Department also issued guidance promoting sleeping in well-ventilated rooms, sneezing and coughing into handkerchiefs, frequent hand washing, and avoiding gatherings and other crowded spaces. Other public health measures such as plans that assigned nurses and volunteers to various districts throughout the city, moving some commercial activities outdoors, and limiting the use of public transportation were also seen as vital compo-
ponents of St. Louis’s 1918 pandemic response\textsuperscript{[20,22]}.  

St. Louis has long been at the forefront of addressing public health issues, especially those regarding air and water quality. In 1940, St. Louis’s Smoke Elimination Committee recommended an ordinance addressing coal smoke pollution that reduced toxic coal smoke in the city by 75\% by 1945\textsuperscript{23}. In preparation for the 1904 World’s Fair, a water cleaning process developed by a City of St. Louis water department employee, John Wixford, was implemented to remove silt from the city’s water supply, providing fresh clean water to the City’s residents\textsuperscript{24}.

While the focus has shifted from infectious disease in recent years, we have seen that the urban planning profession continues its long preoccupation with the public health of urban citizens. It is not uncommon for present-day planning efforts to contain elements on public health that seek to promote healthy behaviors, such as exercise, and access to healthy food options in the face of rising concerns about obesity. Additionally, the impact of low-density sprawl and automobile reliance on respiratory health as asthma has proliferated in recent years, due to poor air quality, have also long been a concern of planners who seek to promote density and more environmentally sustainable transportation options\textsuperscript{25}. The importance of these long-standing concerns with promoting built environments that bolster resident health outcomes has been amplified by the current pandemic as pre-existing conditions such as obesity and asthma have been shown to lead to worse health outcomes for those infected with SARS-CoV-2.

While many can point to the influence of infectious disease on planning and urban design over history, since the advent of germ theory and the development of medicines and vaccines for combatting infectious diseases, the built environment has often been relegated to a less significant role in disease control. While, recent disease outbreaks such as the 2003 SARS outbreak, the 2012 MERS outbreak, the 2009 H1N1 outbreak, and the 2014-2016 Ebola outbreaks have not led to significant changes in these areas, they also have been far more limited in their geographic scope, spread, and overall mortalities. COVID-19 has exceeded all of these infectious disease outbreaks in the aforementioned measures and its severity has many professions questioning what preparations will need to be made for a new post-COVID world.

A Framework for Discussion:

In light of the striking impact of COVID-19, the potential for future outbreaks, and the long history of planning and urban design responses to infectious disease, there exists a compelling obligation to consider how its practitioners have responded to these circumstances and how they will react in the future to better meet the needs of urbanites before and during times of crisis, mitigate the spread of infectious disease, and adapt to the structural changes that will predominate after the pandemic. This discussion surveys and contextualizes existing discussions surrounding potential policies, existing solutions, and potential changes to the following areas in the medium and long-term: buildings & architecture, urban design, open space & green space, transportation, land use & zoning, planning, infrastructure, and to some degree municipal operations.

This discussion will center around exploring policies, design solutions, and proposals that have been implemented or advanced as potential approaches for mitigating the spread of disease, for adapting to life during a pandemic, and for preparing for a world changed by the current crisis. It will also involve an examination of the effects that the pandemic and its attendant restrictions have had on tastes, preferences, and demand in areas that have the potential to impact any of the aforementioned subjects. While certain interventions, such as mask mandates and quarantines, have been important tools whose implementation has aided in slowing the spread of COVID-19, they will not be the focus of this discussion because their anticipated long-term impact on urbanism will likely be small or insignificant. However, changes that have been implemented that impact the built environment, infrastructure, etc., such as pedestrianization, digitization, and antiviral design measures will be important points of consideration. This discussion will also briefly explore other perti-
nent considerations for cities such as the impact of COVID-19 on fiscal operations and revenue, supply chain resiliency, and the role of equity in pandemic response and preparedness.

As a function of the evolving response to the pandemic and the ambiguous landscape concerning the post-COVID impacts on urbanism, this discussion will seek to utilize a variety of sources and also prioritize the inclusion of a wide array of concepts and solutions seeking to elucidate the many potential and anticipated changes. As further research and evaluation is carried out, it is likely that formal guidance on many of these subject areas will continue to be refined. This discussion seeks to focus as a survey of emerging trends and solutions for the development of more resilient cities. Reflecting on the actions taken by cities during the pandemic will improve preparedness for future pandemics and emergencies. Additionally, while disease transmission is complex and future outbreaks may have different transmission modes than COVID-19, this discussion will focus primarily on how we have responded to the current pandemic and how the transmission of SARS-CoV-2 has and will continue to affect the future of urbanism.

Changing Demands, Preferences, Tastes, and Behaviors:

Before delving into the many interventions and the many implications for urbanism in a post-COVID-19 world, it’s pertinent to explore how the pandemic has affected the tastes and preferences of individuals and enterprises, and how those changes impact real estate, transportation and other areas. While there remains ambiguity on how many of these potential changes currently being observed and theorized to occur in the future will materialize after the COVID-19 pandemic comes to a close, it is important to understand these current observations to help orient any discussion of post-pandemic urbanism.

One of the major behavioral shifts that’s occurred as a result of the pandemic is people are spending more time at home. Residents are working from home, learning from home, socializing from home, and even shopping from home with the use of teleworking, teleconferencing, and e-commerce solutions. As of June 2020, 42% of the US workforce was working from home, and a Harvard and University of Illinois survey tracking companies that allowed their employees to work from home during the pandemic, found that companies expect 40% of their employees will continue to remote work after the pandemic; a figure that roughly translates to 16% of the US work force, (estimates from the University of Chicago cite that nearly 40% of jobs in the United States can be done from home)\(^\text{26}\). Large tech companies have spearheaded this shift with companies such as Facebook declaring their intention to reconfigure their workforce so that half of their employees could permanently work from home within the next decade, and Twitter declaring that they will allow their workers to work from home indefinitely\(^\text{26}\). Additionally, many consumer-facing companies are increasing their digitization efforts in order to make their offerings more accessible to consumers over the internet and without in-person interaction - as we rely more heavily on digital space, we may see a reduction in the demand for physical spaces\(^\text{27}\). However, this lowered demand for physical space will also play out in a world where spacing and distancing considerations are increasing.
tain features such as accessory dwelling units, swimming pools, and swing sets\textsuperscript{28,29}. While there was an initial downturn in pending home sales in the early spring, with U.S. metro areas seeing on average a 33% decline, favorable mortgage rates and low inventory prevented declines in median housing prices, which have remained stable\textsuperscript{29}. By August 2020 many housing indicators had recovered and according to an analysis of Redfin data by the St. Louis Federal Reserve Bank, the St. Louis metro area saw median sales price up 12% and home sales up 7% compared to the prior year\textsuperscript{29}. These trends continued into the fall and winter months with November 2020 closed sales in the St. Louis metro area up 22.3% compared to the prior year; a trend that real estate agents largely expect to continue into early 2021\textsuperscript{30}. Since the early months of the pandemic, housing supply has remained constrained with few expecting any significant increases in the near future\textsuperscript{30}.

Another factor to consider is that with the increased acceptance of remote work there may be increased migration away from larger market cities where housing prices are high and the supply of affordable housing is constrained\textsuperscript{31}. Housing has been experiencing a steady recovery and many large metropolitan areas have seen an increase in home searches outside of the buyers’ current area as well as increased demand for workers seeking to relocate to the suburbs due to the shift in working from home\textsuperscript{32}. These moves will benefit areas with relatively more affordable housing and the single-family home market and some have proposed that inner-ring suburbs will likely face higher levels of demand\textsuperscript{32}.

The commercial sector has experienced persistent challenges particularly in the office, retail, and hotel sectors, although not all commercial sectors appear to be struggling with industrial, health care, and digital uses (such as data centers and cell towers) experiencing positive outcomes during the pandemic\textsuperscript{33}. The commercial sector entered the pandemic at a time of relative strength although it is anticipated that the industry will have to contend with increasing vacancy, declining rents, and debt management as a result of both the negative economic impacts of the pandemic and changes in demand, particularly in office space.

Currently, there are some opposing forces playing out in the office space sector and the future of the commercial office market faces significant uncertainty. The pandemic has lead to persistent declines in demand for office space, with transaction activity down 47.3% compared to 2019, some suggest that an anticipated increase to the industry standard 125 square feet allocation per employee as well as other social distancing considerations may ameliorate instability in the commercial office sector\textsuperscript{34,35}. At the same time, trends such as the decentralization of companies with large centralized campuses, either to different cities or throughout their current metropolitan areas, and hub-and-spoke models, whereby a company would have a downtown headquarters (at a reduced size) connected to a network of smaller offices in nearby suburbs in close proximity to employees and customers, may become increasingly popular\textsuperscript{36,32}. There will also likely be an increase in hybrid work models where individual work is conducted at home and more collaborative work is performed in office, allowing for reduced office footprints. CBRE Group, a commercial real estate services and investment firm, estimates that remote work may reduce office space demand by 15%, but that continued economic recovery and anticipated workforce growth will ameliorate decreasing demand\textsuperscript{37}. These countervailing forces and other considerations make it difficult to assess the post-pandemic outcome in office space demand, and uncertainty in this sector remains high. Additionally, some features such as

![Amenities such as accessory dwelling units have become increasingly in demand as residents spend more times in their homes](image)
state of the art HVAC systems and other pandemic preparedness measures such as flexible space options and touchless technology, will help new class A office space garner a competitive advantage in the coming years. St. Louis ended 2020 with nearly 550,000 square feet in occupancy losses, the first time the market has seen occupancy declines since 2018, although JLL, a global commercial real estate services firm, estimates that 2021 will see occupancy gains in the St. Louis market.

In other realms, public health advice cautioning against indoors socialization has led many residents to flock to the green and blue spaces of their cities, engaging with their parks, bodies of water, and other green/open spaces at numbers far greater than those in recent history. Many are theorizing that this shift in behavior will lead to greater demand for more outdoor spaces, better outdoor spaces, better outdoor amenities, and more equitable access to outdoor amenities.

In terms of transportation demand, there has been an increased demand and preference for individual modes of transportation such as walking, cycling, scooter shares, and private vehicles while public transit and paratransit services have seen significant declines. This has proved detrimental to public transit which has seen plummeting ridership and in some cases, faces existential challenges in the absence of federal aid. This increased preference for individual modes may prove beneficial if on balance a preference for bikes and pedestrianism proliferate more than a preference for cars, bringing with it the associated health, ecological, and infrastructural benefits that these modes entail. Where an increase in preference for cars predominates, this can increase congestion, pollution, infrastructural costs, negative health outcomes, and space allocated to parking. Analyses of previous crises have shown that they can create long-term changes in transport preferences when additional factors support these changes, potentially creating opportunities for vested actors to promote their preferred modes. Additionally, other transportation-related behavior changes that have been observed during the pandemic include shopping becoming the primary reason for trips outside the home, and a reduction in trip duration and frequency indicating potential areas of focus for transportation planning during a pandemic.
COVID-19 Interventions and Post-Pandemic Cities

There have been a host of adaptations, policies, proposals, and new ideas that have been endorsed or put into practice to adapt to the current demands of life with COVID-19 and to prepare for future outbreaks. This discussion is an attempt to provide an overview of these solutions and practices. The interventions have been generally organized into one of the following categories: Adaptive Solutions, Architectural, Transportation, and Additional Considerations for Cities, which have been further delineated below:

Adaptive Solutions:
Adapting existing spaces and environments for the new rules and requirements of life during a pandemic has been one of the most omnipresent changes affecting urbanites. This section provides an overview of temporary and adaptive solutions that have been implemented to help visualize and understand transmission risk, modify our daily lives to conform with health guidelines, and transition and deploy resources in a manner that meets the shifting needs of our communities.

Architectural & Design:
The new risks of indoor spaces have prompted architects and designers to rethink the layout and construction of our buildings and indoor spaces. This section highlights some of the changes to residential, commercial, office, and other types of buildings that are expected to be incorporated in new construction or retrofitted into existing buildings as a result of the pandemic with a focus on mitigation strategies for the risks associated with indoors transmission.

Infrastructure:
Transportation infrastructure has seen significant changes during the pandemic as city residents opt for modes of transportation with lower transmission risks and as existing systems and components adapt or are redeployed to meet changing needs. Important considerations for other infrastructure such as wastewater management systems and digital infrastructure are also discussed.

Additional Considerations for Cities:
The pandemic has popularized new paradigms in city planning, land use and zoning, and has impacted an array of other issues that may have implications for urbanism such as in the areas of economic relief, fiscal impacts, supply chain resiliency, and equity. The relevant impacts of these additional considerations are discussed in this section.
The most prevalent changes that have resulted from the COVID-19 pandemic concern the temporary adaptations and changes to our environment that have been used to help cities visualize risk, redeploy resources, and adapt for life where spacing, distance, and the outdoors have become a more normal part of everyday life. Many different measures have been put in place for visualizing risk and safety through the use of signage, stanchions, temporary barriers, and other methods that promote distancing and proper hygiene practices. Additionally, other adaptations have sought to improve the livability of outdoor environments during adverse conditions, promote flexibility in the face of changing economic circumstances that may precipitate shifts in real estate and land use, and the deployment of temporary structures to adjust to rapidly changing circumstances.

Visualizing Risk and Safety:
While many of us are familiar with the ever present signage encouraging us to maintain 6 feet of distance from others, wear our masks, and to practice good hygiene through the use of hand washing and hand sanitizer; cities, businesses, and other institutions have deployed other temporary visual cues and barriers to help encourage compliance with health guidelines, protect employees, and keep residents safe. Cities and businesses have utilized floor markings, stanchions, and temporary barriers to physically separate people and indicate safe distances between individuals in certain areas\(^{42}\). The CDC has recommended that physical guides such as tape on floors be used to create one-way routes and that physical barriers such as sneeze guards and partitions be installed in areas where it is difficult for individuals to remain at least 6 feet apart, in locations such as cash registers, between bathroom sinks, in restaurant kitchens, host stands, at food pickup areas, and separating employees and visitors in office buildings\(^{43,44,45}\). In San Francisco’s Dolores Park, painted circles have been placed in the grass to encourage social distancing and manage larger crowds in outdoor spaces and similar strategies with either visual or physical barriers have been implemented elsewhere for managing crowds at events and other crowded areas\(^{46}\).

Circles painted in Düsseldorf, Germany to encourage social distancing in public areas.
tions included implementing a host of visual aids, design nudges, risk zones, and mental anchors for performing disease mitigation activities such as donning PPE or hand sanitizing. Their case study identified several ‘design hacks’ and noted some key considerations for conceptualizing spatial risk in hospitals that included making invisible risks more visible through the use of visual cues (such as different colors of paint, tape, and film) at key moments of risk or transition, the inherent difficulties in adapting a hospital that was not necessarily designed for spatial flexibility, the importance of taking additional precautions in connecting areas such as stairwells and elevators, and the importance of developing spatial literacy through partnerships between healthcare workers and designers. Their case study also included practical recommendations on assessing and understanding healthcare workers perception of disease risk in various areas of the hospital through the use of heat maps to annotate risk, which revealed that individual perspectives on risk may differ. While this discussion does not seek to provide guidance on safety practices in healthcare settings, which usually have comprehensive compliance standards to which they must adhere, the case study highlights relevant points about implementing design cues to promote certain disease mitigating behaviors and improving spatial literacy surrounding disease transmission risk that have potential applications in other settings. In a panel convened by Stantec to explore the role of planning and design in pandemic prevention, planner Valentina Zanoni proposed applying similar measures for reviewing the layout of bars, restaurants, and offices in order to make them more suitable for reopening and for improving flexibility of use. This practice of spatial and temporary use review could also be used to assess compliance with distancing and other health measures in businesses and other locales.

Designers in other arenas have also put forth a wide array of temporary visualizations and adaptations to better highlight spatial risk. The Where we Stand initiative, organized by editor David Michon was a design challenge borne of COVID-19 that invited various individuals and design agencies to create solutions that responded to the need for physical distancing and resulted in proposals for colorful speakers and receivers to facilitate communication at longer distances in outdoor spaces, football fields with brightly colored areas demarcating spaces that players could occupy to minimize contact, and applications that could project shifting patterns onto the ground of various plazas and open spaces to break them up organically. The many design proposals have emphasized the ways in which creativity has been widely deployed to meet the challenges of the pandemic in many cases with a particular discernment towards their aesthetic value in public spaces. In St. Louis, local artists and other organizations have adapted certain cultural activities to accommodate for disease transmission concerns. The St. Louis Shakespeare Festival abandoned plans for a mainstage performance of Much Ado About Nothing in favor of a self-guided walking tour, developed in consultation with the St. Louis Health Department, through Forest Park with 14 arch installations by local artists and serving as venues of live performances from A Midsummer Night’s Dream. Utilizing walking tours for various recreational activities that are no longer feasible due to concerns about crowd size has been a popular method for organizations adapting to the concerns of the pandemic.

Outdoor Adaptations:
Another measure that has been implemented to help combat the COVID-19 response has been the migration of our commerce, education, and social gatherings into the great outdoors. Residents, shoppers, and school children have fled the relative comfort of higher risk indoor spaces, instead opting for playgrounds, parks, streets, and other parts of the outdoors. Restaurants and businesses have taken advantage of outdoor space wherever they can find it, expanding their businesses to nearby parking, vacant land, sidewalks, and even streets. The widespread use of pedestrianization defined as the transformation of city streets into public spaces, (see Transportation, pg 17) has also been deployed as an adaptive measure for outdoor spaces. However, a primary concern of adapting to a way of life centered around the outdoors has been preparing for adverse conditions, particularly concerning the weather, and businesses, individuals, and institutions
are now seeking new ways to navigate the unpredictable whims of mother nature. A retail revitalization project by WXY in the Hudson Square Business Improvement District in New York, proposed erecting awnings above sidewalks so that small retail stores that did not have enough space to accommodate social distancing would be able to sell their wares outside on the sidewalks. The same design firm also designed a sidewalk scaffolding system called Urban Umbrella, that utilizes tree-form supports to hold up a translucent ceiling to protect pedestrians from the rain.\(^47\)

While preparing for precipitation can be more easily addressed with overhead coverings, preparing for the cold weather is an issue that has caused persistent vexation. Our northernmost cities have provided some insights on how to handle the needs of residents in cold weather. Edmonton, one of North America’s coldest cities, implemented their Winter-City Initiative in 2013 to facilitate winter commutes and create opportunities for residents to find activities they can do outside the home in the winter months. Their plan, which emphasizes physical and mental well-being during the winter months, has included online toolkits on how to properly dress for colder weather, year-round farmers markets, and guidance on retrofitting outdoor spaces for comfort during the winter months.\(^50\). Some outdoor space solutions include supplying various heating sources, considering sun orientation, creating wind breaks that also allow for adequate ventilation, and creating seating out of higher insulation value materials such as wood or straw.\(^48\) There are also those who have advocated for creating and improving outdoor spaces for both loitering and recreation during the pandemic, which can include solutions such as outdoor fire pits in public parks; outdoor bars and music venues with adequate windbreaks; protected bike networks; well-lit sheltered pedestrian pathways free of snow; public spaces with roofed areas and heaters, and opportunities for winter recreation activities such as tobogganing, skiing, ice skating, and others.\(^48\)

Many restaurants have innovated in the face of the prospect of poor winter conditions by deploying temporary structures, such as a brewing company in Detroit that constructed a large wooden pole barn with windbreaks, and through the deployment of enclosed tents and geodesic domes.\(^51\). However some health agencies have put restrictions or conditions on the use of enclosed tents, such as sanitation and ventilation requirements, and supply and pricing issues with geodesic domes and portable heaters have also been increasing concerns as many rush to adopt these temporary adaptations for winter weather.\(^51\)

Outdoor dining bubbles in Manhattan, NY utilized to enforce social distancing.

**Changing Uses and Adaptive Architecture**

Another response to the pandemic has been the reorganization and redeployment of existing assets in the built environment both as a concerted part of the pandemic response and also to deal with the need for reallocating resources in response to quickly changing economic circumstances. Adaptive use was a concept that had been gaining prevalence prior to the pandemic and its adoption has only been hastened in response to quickly changing circumstances in many cities. While use changes have long been a part of the ways cities grow and adapt, the volume of use changes during the pandemic has been remarkable. In response to the immediate needs of the pandemic, many cities have made extensive use of hotels to house the homeless, emergency workers, and individuals who need to quarantine separate from those with whom they live such as those who regularly live in dormitories, other group quarters, or even those who live in overcrowded conditions.\(^52\). Trailers have also been utilized to provide shelter to the unhoused when social distancing requirements have had the additional effect of
decreasing capacity at existing shelters.

In addition to addressing the immediate needs of the pandemic, adaptive uses have been utilized in response to the changing economic circumstances of the pandemic. The economic impacts of the virus have created challenging circumstances for businesses across the country with many closures. Facilitating adaptive uses is a tactic that is already being implemented in many major cities. There have been significant projects dedicated to converting department stores into office spaces and distribution centers, commercial spaces to office spaces, and hotels into retirement communities as individual communities grapple with their unique economic circumstances. Use conversions have been touted for their lower costs, relative to new construction, although zoning and technical design challenges have been cited as obstacles, and the difficulty of obtaining financing during a pandemic also poses a potential challenge.

Finally, the need for redeploying resources during and in response to crises, not just pandemics, is a design trend that may become prevalent in the coming years as adaptivity in architecture increasingly becomes the norm. The design of nonmedical settings such as hotels, convention centers, and community spaces may be increasingly considerate of adaptivity and these facilities may be designed with the intention for alternative uses such as emergency medical facilities or temporary shelters. In a webinar discussing Urban Design after COVID-19, the Olympic Village in London was cited as an example of new construction that failed to account for use flexibility; while the first floor of the Olympic Village was intended for residential use during the Olympic Games, the low residential ceiling heights made the conversion of the first floor residential to commercial uses post-Olympics a particular challenge, highlighting a need to consider convertibility during construction.

**Temporary Structures**

Another strategy that has been implemented as part of the pandemic response in many cities suffering through significant outbreaks of COVID-19 is temporary buildings and modular architecture. As some cities, and even states, have faced the scenario of overwhelmed health systems and insufficient hospital capacity, temporary structures have been deployed to meet the overwhelming demand.

The pandemic has underscored a need to rapidly deploy temporary architecture for use in expanding the available capacity of emergency facilities such as hospitals, quarantine centers, and temporary lodging. In the city of Beijing, temporary hospitals that had been mobilized in response to the SARS epidemic were reactivated in response to COVID-19. Modular construction, the process in which a building is constructed off-site in a controlled manufacturing facility and then assembled at a building site allowing for faster completion than standard site-built methods, has also been deployed in a variety of settings – in Wuhan, builders used modular construction to quickly create two hospitals in February 2020. FEMA has also utilized its National Mobile Disaster Hospital, a collection of portable tents and modular structures that can be transported and erected within 72 hours in response to the pandemic and some hospitals have employed CURA, connected units for respiratory ailments, which are prefabricated pods that are connected to inflatable corridors and fitted with biocontainment systems. The need for swift expansion of capacity in response to dire circumstances has underscored the proliferation of modular architecture and other temporary architecture and also highlight another way in which the pandemic has challenged cities and health systems to find new ways to adapt to a variety of situations.
Another important consideration for urbanism during and after the pandemic is how it will affect the design of new commercial, office, and residential buildings. While slowly gaining traction prior to the pandemic, building design standards that focus on the health and well-being of their occupants have grown more popular during the pandemic and some have even adapted to include COVID-19 specific mitigation strategies. Additionally, the importance of indoor ventilation has gained significant attention and some of the country’s leading heating, ventilation, and air conditioning organizations have issued papers and guidance on strategies for the reduction of airborne pathogens.

**Antiviral measures:**
There are several major interventions that could have significant impacts on reducing the ability of a pathogen to spread in indoor environments that have been proposed and in some cases are currently being implemented. While some of these are still in the process of being tested and evaluated, it has not prevented their adoption in schools, offices, restaurants, and other indoor settings. Other methods have been evaluated by professional organizations such as the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and are being recommended as expanded measures of disease control in certain settings.

One area that has been of particular interest is in the realm of ventilation. While the disease prevention protocols of the earlier 20th century gave us buildings with greater light and air requirements, with the advent of new technologies, the next few years may see an expansion of certain air filtration and disinfectant technologies to further reduce the spread of airborne pathogens. In ASHRAE’s Position Document on Infectious Aerosols, the following strategies were recommended at the highest level and were rated as having good evidence to support their use in certain circumstances:

- Enhanced filtration (Higher minimum efficiency reporting value [MERV] filters over code minimums in occupant dense and or higher risk spaces)
- Upper-room Ultraviolet Germicidal Irradiation (UVGI), with possible in-room fans, as a supplement to supply airflow
- Building and transportation designs that promote cleaner airflow patterns for airborne particulates to exit spaces

Enhanced filtration, such as through the use of HEPA (high-efficiency particulate air) filtration, can efficiently capture particles the size of the COVID-19 virus that are drawn into their filters and the CDC has noted that when used properly, these filtration methods can reduce airborne contaminants in confined spaces. Many school systems have also been using HEPA filtration, including the New York City public school system and Chicago Public Schools, which recently acquired 20,000 HEPA air purifiers. However, HEPA filtration may not be 100% effective at preventing disease transmission and has been recommended as part of a broader strategy for addressing COVID-19. HEPA filtration can be helpful in reducing transmission risk for buildings where multiple areas share the same central HVAC system.
that uses recirculated air.

Germicidal UV radiation has commonly been employed in the healthcare industry for its use as a passive sanitization feature that can reduce transmission risk within buildings and has safely been used as lamps inset within return air ductwork, as lamps directed at heating & cooling coils, by robots to treat surfaces in unoccupied spaces, and above head height in occupied spaces. Upper-room UVGI involves UV fixtures that are mounted in occupied spaces at heights of 7 feet and above, which is done to reduce exposure by occupants to UV light that can be potentially harmful to building occupants.

Promoting cleaner airflow patterns has also been recommended as a potential ventilation solution for reducing disease transmission. This can involve the increased use of operable windows in some settings, as well as displacement ventilation where cooler air enters from below and lifts contaminants, and clean air ventilation that brings in fresh air, rather than recirculating existing air.

Additional air filtration protocols have also been recommended with a high level of evidentiary support by ASHRAE, although these other interventions are primarily focused on targeted approaches for handling specific areas with significant risk of transmission or through source control, which is less germane in non-health building settings for the control of airborne infections. Ventilation measures for improving outcomes in infectiousness and mortality will depend heavily on the building environments and should be implemented in consultation with qualified engineering professionals and in accordance with guidance from the Centers for Disease Control, ASHRAE, and other qualified heating, ventilation, and air conditioning professional standards organizations. Additionally, ventilation standards and practices will likely continue to be evaluated as research in this area continues.

Health-Oriented Building Standards
Another area of focus that has seen increased attention as a result of the pandemic is the propagation of health-oriented building standards, much in the same vein as green building certifications, such as LEED, that have experienced growing popularity over the last decade. Two of the most notable standards are WELL and Fitwel. The WELL standard is often viewed as comparable to LEED in its requirements for site visits and in many cases has stricter specifications than the Fitwel standard, although both were designed to address the gap in building standards that are concerned with human health and well-being.

While not solely intended to address the propagation of infectious disease, both standards have recently been amended, incorporating new strategies and resources to address more directly the spread of infectious disease, or explain how the standards

UV Mobile Disinfection Units are commonly employed in healthcare settings.
directly address infectious disease.

The WELL Buildings Standard®, produced by the International Well Building Institute identifies 100 performance metrics, design strategies, and policies that can be implemented in building design and construction to directly address health and wellness. This standard primarily involves interventions surrounding the following building principles: air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community. While the most recent version of the standard, WELL v2™, was slated to be released in March 2020, the release was delayed in light of the pandemic to incorporate additional tools and strategies aimed at addressing prevention, preparedness, resilience, and recovery in relation to COVID-19 and other respiratory infections. The COVID-19 strategies that have been incorporated center around the key themes of promoting clean contact, improving air quality, maintaining water quality, managing risk, creating organizational resilience, supporting movement and comfort, strengthening immune systems, fostering mental resilience, community resilience, and recovery. Some of the strategies more specifically targeted at disease mitigation included ventilation strategies, such as bringing in fresh air from the outside through mechanical or natural means, enhanced ventilation, demand-control ventilation, displacement ventilation, advanced air distribution, ultraviolet air treatment, humidity controls, adequate air filtration, and operable windows. The strategies being implemented in the WELL Building Standard v2™ also indicate that designers may be considering not just disease mitigation and prevention strategies but a wide array of interventions to address the fallout from the pandemic including those targeting comfort and mental health.

The Fitwel Building Standard has also released multiple resources to address the pandemic including a research guide, “Building Health for All® in the Face of COVID-19,” addressing multiple topics on aiding designers, employers, building owners, and others to respond to COVID-19. Their research guide focused on the following topics: leveraging buildings to mitigate viral transmission, workplace trust, mental health, density, and resiliency. For strategies that mitigate viral transmission, the Fitwel research guides propose limiting physical interactions, cleaning, handwashing signage, improving ventilation, air filtration, and humidity controls. The Fitwel guides also discuss how specific interventions in these guides relate to Fitwel Building Standard interventions. Their approach also emphasizes how designers and builders are taking a holistic approach to building design and construction that incorporates broad themes beyond the scope of disease transmission such as mental health and promoting trust in the workplace.

**Other Design Considerations:**
Design professionals have also weighed in on other potential configurations and changes that could be expected outcomes of designing with the pandemic in mind. For office environments, design changes and proposals have proliferated. While potentially costly, more spacious elevators and elevators with reduced maximum occupancies have been recommended as potential options for mitigating risk. Design professionals, in an article from the Guardian, cited a reduced favorability for open plan layouts in offices, better ventilation, and more operable windows. In the same article, Arjun Kaicker head of analytics and insights with Zaha Hadid Architects also cited the following as potential office space design changes: less flow between spaces, larger lobbies to accommodate spacing, an increased minimum area per person for workspaces, contactless pathways that allow employees to navigate offices without touching surfaces, and the ability to activate various functional items such as blinds, coffee machines, and lighting, from their phone. In a panel on design and urban planning post-COVID-19 convened by Stantec, an engineering consulting firm, interior designer Gwen Morgan commented that we may see increased use of non-absorbent materials; germ-resistant surfaces, such as antimicrobial polymer surfaces and copper alloy surfaces; and surfaces that are designed for easy cleaning and disinfecting. Additionally, some have suggested that thermal imaging technologies to monitor employees for fevers may also experience greater adoption.

The impact on office buildings is likely to be profound
as many employers have been forced to adapt in ways that would have seemed inconceivable only a year ago. As of June 2020, nearly 42% of the US labor force was working from home, nearly double the amount of people who were working in-office, accounting for more than two-thirds of U.S. economic activity\(^6^6\). Such a massive shift will likely precipitate more concrete changes in the way that people work, and how we design the buildings they work in. Some of these design considerations such as increased spacing and wider spaces, in conjunction with potentially reduced future demand for office space, may diminish city skylines as taller buildings may become less economical for developers\(^6^7\).

Some cities have seen increased demand for office spaces and buildings that expand horizontally rather than vertically, informally dubbed ‘groundscrapers’. While not explicitly defined, groundscrapers have been described as “a building as horizontal as a skyscraper is vertical” or as buildings with a million or more square feet but that encompass only a few stories\(^6^8\). Groundscrapers, such as the Old Post Office in Chicago, have several pandemic-friendly design advantages over skyscrapers, such as larger outdoor rooftops for outdoor meetings and recreation, more entrances and exits to assist with enhanced social distancing, and ease of travel throughout the building through the use of stairwells and fewer floors rather than through centralized elevator banks\(^6^8\).

Additionally, some of the design practices that have been implemented in hospitals and healthcare settings have potential applications in office, commercial, and residential construction. MASS Design Group, has designed clinics to increase sunlight and fresh air in interior spaces in countries where airborne pathogens are more common and where HEPA filtration and UV light disinfection are not as accessible. It’s possible, that some of these designs that utilize natural light and ventilation will be incorporated into the designs buildings that are not primarily used for healthcare purposes. A survey by the American Institute of Architects on Home Design Trends, released Q3 2020, has also delineated anticipated changes in home design. Their survey revealed that special purpose rooms, such as offices, mud-rooms, outdoor living spaces, and other flexible spaces are in high demand. The survey also revealed that products that improve indoor air quality have become increasingly popular\(^6^9\). While many of these design proposals have not yet been rigorously evaluated for their usefulness in disease mitigation, it is important to be cognizant of how designers, architects, and planners are considering post-pandemic design in interior spaces.
Infrastructure has been an important consideration during the pandemic as cities have adapted to changing preferences for transportation, redeployed streets as public spaces, grappled with the rise of digitization and its attendant impact on digital infrastructure, and evaluated new alert systems for COVID-19 involving wastewater management. In many areas, there have been accelerated changes with potential long-term consequences for the future, as the temporary solutions of the pandemic influence future investments, expectations, and behaviors.

**Transportation**

Transportation has experienced many changes in the face of COVID-19. Cities have been forced to reconceptualize and reconfigure public transit in order to make it safer for those who ride it, make wholesale changes to other transportation infrastructure in order to comport with the requirements of social distancing, and adapt to changing preferences in specific modes of transportation. On public transit systems, many cities have made use of enhanced hygiene infrastructure to help alleviate concerns about safety and promote ridership; Hong Kong and Washington D.C. have increased their cleaning protocols and installed portable hand washing systems; action has also been taken in Kigali, where portable handwashing stations have been installed at bus stops, taxi queues, and other transportation-related locations. Other soft changes have also been made such as a prohibition on passengers boarding buses through the front door, ending onboard ticket sales, the separation of drivers from passengers with temporary barricades, and enhanced use of floor markings to indicate safe distances between riders.

Cities have also experienced marked reductions in ridership, with many cities operating at a fraction of their capacity during the pandemic. A McKinsey & Company publication on restoring public transit during COVID-19 has recommended limiting ridership, staggering ridership throughout the day, adding reservations to light rail train systems, and suspending access to certain stations to limit crowding.

Increasing frequency of service also presents another option for reducing overcrowding on public transit, although this option is constrained by availability of vehicles, drivers, and financial capacity. Decreased ridership has also posed existential threats to many large transit systems as reduced ridership has created massive deficits and transit operators are being forced to weigh service cuts in response to these shortfalls.

There also has been an increased focus on individual transportation modes in response to the public perception that public transit may not be safe and as...
governments around the world work to promote individual modes, such as bicycling, walking, and scooter shares, as a public health measure. Many countries in Europe have accelerated and/or increased investment in biking infrastructure and other projects to promote bike use. While this transition may have already been occurring, its implementation has been hastened in response to the global pandemic. Paris residents have been able to obtain subsidies to buy electric bikes or repair old bikes, and public bike rental projects have seen record demand. Paris Mayor Anne Hidalgo has appropriated freeways next to the Seine for cyclists and pedestrians. Italy has also introduced a 70% subsidy for bike purchases. In Britain, $310 million has been allocated to redistribute space to cyclists and pedestrians by widening pavement and creating bicycle only corridors. While there have been some criticisms related to traffic and route planning for cycleways, cycling has generally been seen as a healthful and ecologically friendly transportation option whose expansion was already being encouraged by many European cities and governments. Car pools with masked passengers have also been encouraged in cities where public transit capacity has been reduced.

Another commonly discussed concept in the transportation arena has been that of pedestrianization, which has been widely adopted for a variety of purposes in cities across the country. Pedestrianization is the targeted closure of streets to vehicles for the purpose of creating additional spaces for use by pedestrians, residents, businesses, cyclists, etc. New York City has closed more than 70 miles of streets in order to facilitate social distancing, biking, and outdoor dining. And, as the number of cyclists and pedestrians swell, there has been increased demand for safer transportation corridors for those utilizing individual modes of transportation. Pedestrianization has also raised some important considerations for cities. In some places, residents are seeking to permanently maintain their newly transformed streets, such as in the case of a neighborhood lacking parks in Queens, NY where residents are seeking to keep a promenade that was recently established through pedestrianization. While pedestrianization has for the most part enjoyed wide popularity, there also have been some criticisms that cities have not implemented a well-planned and connected series of open streets, although many cities have prioritized evaluating the impact of street closures on traffic patterns over the creation of interconnected pathways for cyclists and pedestrians. Additionally, bike infrastructure can be costly and has been hampered by decreases in municipal revenues. While nationwide, parking demand has declined with a survey by Smarking, a parking analytics and software company, estimating that commuter parking facilities have seen declines of 50-70%, some denser cities that rely more heavily on public transit have also seen an increase in car use and demand for parking. In New York, car ownership has increased while pedestrianization and associated street closures have sharply cut available parking spaces with many competing for limited spots. Additionally, the increased use of delivery services has also been at odds with pedestrianization.

**Digital Infrastructure:**

Digital infrastructure has traditionally been defined as the services and physical resources; such as fiber optic cables; cell towers; and signal transmitters. This digital infrastructure underpins the information technology capabilities of a particular locale and it has been remarkably important in pandemic survival and response. At the same time, the pandemic has highlighted trends and concerns regarding; digitization, the optimization and conversion of analog processes to digital ones; digital government services infrastructure, the interfaces and digital frameworks that facilitate the provision of benefits and government
services; and smart city solutions, the use of digital and telecommunication technologies on increasingly efficient networks for the benefit of residents and businesses\textsuperscript{78}. Digital capabilities and digital spaces continue to grow in their influence on matters critical to planners and designers, and the factors and infrastructure that underpin them should be a significant concern.

Telecommunication networks and digital infrastructure have exhibited resiliency, despite marked shifts in traffic, due to the propagation of accessible ultra broadband and the significant investments by cloud-based platforms such as Amazon and Zoom in scalable digital infrastructure prior to the pandemic\textsuperscript{79,80}. However, our reliance on these networks for business continuity has been highlighted as a result of the pandemic and the need for continued investment in digital infrastructure has been underscored. Economic experts have widely recognized the significance of digital infrastructure in enhancing social and economic resilience in the face of the pandemic and predict that countries with top connectivity infrastructure will mitigate much of the negative economic impact\textsuperscript{80}. Digitization efforts have also accelerated with a McKinsey Global survey of executives finding that companies have accelerated their investments in digitization of customer and supply chain interactions and internal operations by three to four years and have accelerated the share of digital or digitally enabled products as a share of their portfolios by seven years\textsuperscript{81}. In addition to the significant investments that also have been made in remote work, the investments in digitization efforts reflect what may be a permanent change in the way companies do business.

While companies have committed to digitization, the pandemic also has highlighted some of the shortcomings in government services digital infrastructure. The circumstances of the pandemic have put stress on digitized government services infrastructure, such as state unemployment benefits websites and other relief efforts, such as the Paycheck Protection Program (PPP), to provide aid to citizens and businesses during these times of economic distress. As unemployment surged, many faced crashing websites and downed web portals with some estimates in April 2020 that for every 10 people who were successfully able to apply for unemployment benefits, three or four more attempted, but were unable to, apply, primarily because of systems that couldn’t handle the increased traffic\textsuperscript{82,83}. Additionally, technical glitches impeded the ability of lenders to begin processing PPP loans due to technical issues with Small Business Administration (SBA) systems designed for processing the loans\textsuperscript{84}. At a time when more governments are digitizing processes and services, the prospect of modernizing legacy systems and prioritizing appropriate resources for emergency situations should be of foremost concern. These digitization efforts will continue to demand more of the networks that support them, and investments in digital infrastructure to support them will continue to be a priority.

While digital infrastructure has for the most part been able to meet the demand for additional bandwidth, other issues have impeded the ability of digitization and digital infrastructure to effectively overcome the particular challenges of the pandemic. A lack of equitable access to computer equipment and high-speed internet, more colloquially known as “the Digital Divide”, have curbed the ability of low-income residents to access remote learning, remote work, e-commerce, and telemedicine. Some cities have implemented programs to help bridge this gap: Washington D.C. has provided free internet access to 25,000 students in low-income households, Chicago has implemented a plan to provide internet access to 100,000 public school students over the next four years, and several cities have implemented “Wi-Fi on Wheels” programs where school buses are outfitted with Wi-Fi capabilities and dispersed throughout their communities\textsuperscript{85}. St. Louis Public Schools, with the assistance of private donors, has invested $5 million in laptops, tablets, and internet access for families that need them for virtual learning as well as working with other local organizations to distribute technology and internet hotspots\textsuperscript{86}. Some have raised concerns about ensuring that populations have the capabilities and skills to take advantage of our expanding use and reliance on technology. The Minnesota Department of Employment and Economic Development has implemented a program focused on training, reskilling, and upskilling that has enjoyed considerable popularity, particularly among the
Smart city solutions - defined by Cisco as the use of internet of things (IoT) sensors, video cameras, and other tools to monitor activity and provide city operators and citizens with constant feedback to make informed decisions - have also propagated in recent months:

- In Varansi, India a GIS-based dashboard was used to identify quarantine violations and deliver essential commodities where needed.
- Contact tracing apps have proliferated in China, South Korea, and Taiwan to alert citizens when an infected individual is in close proximity and to enforce lockdowns.
- Real-time heatmaps of crowding in public spaces have been implemented to ensure appropriate distancing.
- Drones and robots have been used to disinfect areas and act as “safe-distance ambassadors”.

However, some of these surveillance uses are fraught with privacy and cybersecurity concerns. Guidelines exist for the ethical and responsible use of some of these surveillance applications emphasizing anonymization and, where appropriate, complying with informed consent agreements in order to provide assurances against misuse of data. However, fear of abuse of these technologies will likely impede their deployment, particularly in areas where government distrust runs high. Furthermore, while digitization and digital infrastructure will likely emerge as continuing priorities for cities post-COVID, municipal budget constraints will likely continue to pose technical and fiscal challenges, thereby impeding investment in smart city technologies post-COVID.

Wastewater Management:
One epidemiological tool that has gained increasing prominence during the COVID-19 pandemic has been the use of wastewater surveillance systems to monitor the presence and prevalence of COVID-19. While wastewater testing has been available for many years and has been used in the past to monitor polio and other diseases, it has not enjoyed widespread use until recently. As viral traces of COVID-19 can be detected in sewage as early as a week prior to the onset of physical symptoms, wastewater testing for the RNA of COVID-19 can be a leading indicator on both the total level of infection and changes in the total level of infection within a community. While having been deployed by many local and state governments, and becoming an area of focus for the federal government with the advent of the National Wastewater Surveillance System created in partnership between the CDC and the US Department of Health and Human Services, wastewater testing is being recognized as an important tool in the fight against the virus, although it’s not without its weaknesses. The CDC has cautioned that it is not possible to reliably and accurately predict the number of infected individuals in a community based on sewage testing and has also noted that sewage testing does not capture homes or residences served by septic systems or decentralized sewage systems such as those commonly used in universities, prisons, and hospitals. However, wastewater based epidemiology has also become a popular topic of research and recent publications suggest that there may be methods for improved detection (through the testing of settled solids and through the use of tree-searching algorithms that uses sewer network data to potentially hone in on neighborhood-level hot spots. One can expect that wastewater management systems may become increasingly integrated with public health functions for the purposes of disease detection.
Additional Considerations for Cities

In addition to architectural and design considerations, COVID-19 has ignited significant discussion about the way our cities are organized, touching on issues such as density & overcrowding; decentralization, supply chain resiliency, equity, and the fiscal impacts of the pandemic on local governments.

Density
One of the key themes that has been discussed at length during the pandemic is the role of cities and the relative pros and cons of density. At the onset of the pandemic, dense urban areas were the early epicenters of disease and the largest cities had higher concentrations of COVID-19 than other places. Initially, many called density destructive, including New York governor Andrew Cuomo, who initially called on New York City to develop plans to reduce density. This has been troublesome to proponents of dense urban areas, particularly in light of the well-established socio-economic benefits that density can bring. As the pandemic has raged on, additional research has shown that the drivers of COVID-19 transmission are more complex and there are other factors that lead to higher rates of infection. A neighborhood level analysis conducted by the New York University Furman Center found that areas with more overcrowded housing, relatively higher levels of transit ridership, relatively higher levels of the population unable to work from home, and where the population had a relatively higher population share of Black and Hispanic individuals saw more infections – and that these factors, especially overcrowding, were more influential in disease transmission than density alone. While this may be good news for the proponents of density, it underscores other issues that need to be addressed in order to improve the resiliency of our cities, such as equity and affordable housing. Some cities have begun to handle this issue by renting trailers to quarantine those who live in apartments, which are too crowded for isolation. While not all research has been supportive of density in cities, there seems to be an emerging consensus that density is not an effective indicator of infectiousness and mortality, at least not in regards to COVID-19. While density can be a factor that enables transmission, there is support for the idea that high-density cities also possess the resources, facilities, and technical capability required to most effectively combat the spread of infectious disease, leading to the inconsistent linkages between density and COVID-19 infectiousness in the academic research.

While density isn’t necessarily considered a good indicator of disease spread in the pandemic, there are also many forces that now threaten it. If one can work and live anywhere, as digitization proliferates,
and if reductions in demand for brick-and-mortar commercial and office space materialize, dense urban areas will be faced with the prospect of making a value proposition for their own survival. Cities may not only have to prove density has value but also ensure that they are safe and prepared for disaster, especially disease outbreaks, when they arrive.

**Decentralization:**
Decentralization has also been gaining traction as a potential intervention to improve the resiliency of cities in response to the pandemic. One such plan is Paris Mayor Anne Hidalgo’s “15-minute city” – a proposal developed by Professor Carlos Moreno of the Sorbonne Business School in Paris that envisions more self-sufficient communities with lower pollution and an improved quality of life, the underscoring principle of which is that amenities, shops, offices, schools, etc. are all within a 15 minute walk or bike ride of where a resident lives\(^97,98\). While originally proposed as an ecological solution, it has also gained traction as a green stimulus plan focusing on job creation and as a way to improve local resiliency\(^99\). While the recent past has seen a focus on organizing cities by clustering specific uses, the 15-minute city envisions a series of connected independent villages that are able to provide for all of a resident’s needs. At a time when public transit is facing a crisis of confidence due to the pandemic, this focus on creating a more pedestrian-oriented approach to city planning is a response to the increasing reliance on cars that has been observed during the pandemic. While many are now faced with increased risk from their daily commutes, and with resiliency being a chief concern, the proposition of decentralization offers a potential solution to some of the issues posed by both COVID-19 and other potential disruptions.

**Zoning**
Zoning is also undergoing changes as a result of the pandemic with a focus on flexibility and preparations for the new realities of a post-COVID world. While adaptive use has already experienced some discussion (see Changing Uses and Adaptive Architecture, pg. 11), it’s also necessary to explore what zoning proposals have been suggested to facilitate responsiveness to present conditions. In the commercial realm, some have suggested that zoning codes be updated to allow the temporary use of parking lots for outdoor dining, permitting pop-up retail and outdoor displays without a temporary use permit, relaxing sign restrictions so businesses can advertise that they are open, ensuring that zoning allows for neighborhood stores within residential areas, and permitting curbside pick-up lanes, to-go parking spaces, kiosks and vestibules without a use variance in areas where such uses are restricted\(^100,101,102\). Suggestions concerning adaptive reuse have suggested that localities should find ways to permit, facilitate, and incentivize these changes by expediting the review of adaptive reuse projects when conditions for mitigating adverse environmental impacts are met, providing density bonuses, and expanding allowed uses for commercial areas to include all commercial uses, non-polluting light industrial, and residential\(^103,104\). Additionally, in light of the anticipated demand for logistics and distribution centers, municipalities may want to identify and designate areas with good road access and vehicular circulation where these larger supply chain uses can be accommodated, as well as accommodating smaller uses in or adjacent to residential areas through form-based or hybrid codes\(^103\).

Proposals on zoning regulations concerning parking have suggested a reduction or elimination of parking requirements, bike space requirements in lieu of parking requirements, maximum parking limits, permitting the payment of fees in lieu of parking spaces, using shared parking lots, allowing for parking spaces to be land banked, and not requiring parking.
spaces for accessory dwelling units100,103,104. In the residential realm, suggestions include relaxing the restrictions on home-based businesses that would enable residents to have 1 to 2 outside employees at a business operating out of a home, removing restrictions on accessory structures for business use, and allowing buildings that were originally built for neighborhood commercial to support home-based businesses101. Additionally, suggestions have included reducing restrictions for growing food and raising small animals in residential areas and permitting accessory dwelling units as long as they don’t encroach on or drain stormwater on to adjacent properties101,104.

The Long Island Regional Planning Council (LIRPC) also released a study, specific to Long Island, focusing on changing land uses in the near and long-term with some applicable insights for other locales. The study anticipates that zoning for “Missing Middle” housing will become more common, including housing types such as duplexes, triplexes, fourplexes, courtyard apartments, bungalow courts, townhouses, small multiplexes, and live/work spaces105. The report also recommends that zoning and development professionals revisit use restrictions within existing retail zoning districts, identify office and retail locations that would best be suited for conversion to light-industrial and mixed-use residential, reduce parking requirements for light industrial zoning areas, and create expedited and streamlined variance processes for commercial kitchen operations (for pop-ups in recently vacated restaurants) and vacated office space105. In the longer-term, the LIRPC expects that property owners will begin to petition planning boards for overlay and form-based code zoning to permit redevelopment of obsolete retail sites105. While the LIRPC report was specifically tailored to the community needs of Long Island, many of its recommendations reflect zoning changes that are applicable in a wide variety of locales based on the anticipated conditions after the pandemic.

**Supply Chain Resiliency**

Despite initial difficulties at the beginning of the pandemic, suppliers adjusted away from their standard lean (Just In Time) inventory strategies towards a more resilient approach. Aside from some ongoing issues with shortages of certain consumer goods (such as toilet paper, tissues, hand sanitizer, some food items, and other cleaning supplies) and Personal Protective Equipment (PPE) (such as masks, gowns, and gloves), urban supply chains have not experienced critical long-term disruptions as suppliers have adapted to the current need for additional flexibility and redundancy. However, it should be noted that the supply chain has been put under enormous pressure and consumers have experienced increasingly long lead times for some non-critical goods. The current crisis has exposed and highlighted areas of concern for future disruptive events, particularly concerning food supply and in the manufacture of critical health goods. Proposals at the national level have called for reshoring some of the foreign production of critical medical supplies over the next decade and improving American manufacturing capacity106. In a similar vein, some have proposed that urban agriculture should receive more attention as a result of the supply chain risks that have been brought to light during the pandemic, such as the outbreaks that have plagued farms and food processing facilities. Some have also proposed that urban agriculture is a potential strategy for creating more resilient food systems and for alleviating food insecurity during adverse events through the use of vertical farming, hydroponics, home gardens, and community gardens107. Additionally, with millions of Americans turning to local food banks as they struggle with economic and food insecurity, urban agriculture provides options for providing low-cost fresh produce to indigent families at the local level.

**Equitability**

Another notable consequence of the COVID-19 pandemic is the heightened attention it has brought to the issue of equity. Significant disparities have occurred in health outcomes for members of the Black and Hispanic communities underscoring what multiple public health studies have long confirmed: racism breeds health inequities108. As of August 2020, multiple analyses have shown that people of color are experiencing large disparities in COVID-19 cases and deaths when compared to their White counterparts. As of August 4th, 2020, COVID-19 related death
rates among Black people were more than twice as high as for White people and nearly twice as high for American Indian and Alaska Natives (AIAN). County-level analysis also found that Black and non-White Hispanic people were nearly three times as likely to contract COVID-19 and other analyses have shown that Black, Hispanic, and AIAN people were also roughly 5 times more likely to be hospitalized with COVID-19 than White people. These disparities in health outcomes for COVID-19 have been largely attributed to structural racism and the various pathways by which it manifests as social determinants of health including: social deprivation from reduced access to employment, housing, and education; environmental exposure; inadequate healthcare access; overrepresentation in essential work settings; discrimination; and income and wealth gaps. In addition to divergent health outcomes amongst people of color, disparities in economic outcomes have also greatly affected the ability of people of color to weather and endure the current crisis. Among African-Americans, 48% have had problems paying rent, mortgage, utilities, credit card bills or medical costs as a result of the pandemic and that figure has been 46% among Hispanic people. Early estimates from the Center on Budget and Policy Priorities forecast that unemployment among Blacks will peak at just below 30% and for Hispanic people will peak at approximately 20% while estimates for White people indicate that their unemployment rate will peak at 14%, likely erasing much, if not all, of the progress in Black unemployment that has occurred since the last recession. These disparities illustrate the role that structural racism has played in exacerbating both the economic and health outcomes of the pandemic, to disastrous effect.

While the outlined disparities will likely necessitate many systemic interventions encompassing a wide range of activities, within the context of urbanism many programs and policies are being put into place to help address these inequities. Rental assistance and eviction moratoriums have been put in place across many communities to prevent homelessness. In Seattle, the focus on equity has manifested as a focus on small-business stabilization, food distribution, housing assistance, and health tracking of unsheltered populations, and has been supported with policies that focus on mapping vulnerable populations to help target programming, equitable distribution of pedestrianization efforts, and the employment of a racial and social justice lens to focus on communities most impacted by the pandemic. Multiple cities and counties have declared racism a public health crisis and Milwaukee has implemented a budgeting tool that its agencies must use to ensure that expenditures, budget cuts, and capital investments are racially equitable. The attention being paid to equity has also underscored some disparities within planning practice, with some minority residents in cities feel sidelined by some of the responses to the pandemic, and the speed with which they’ve been enacted, citing specifically some of the pop-up pandemic infrastructure that is largely valued by wealthy white residents such as closing streets for outdoor dining. Oakland, in their data collection response to their Slow Streets program (a pedestrianization initiative), found that the majority of their respondents were white and 40% had annual incomes of $150,000 or more, statistics that were not representative of the diversity of the community as a whole. In response, Oakland sought to conduct deeper engagement through weekly meetings with community members and modified their response with their Essential Places initiative that responded to community members’ concerns that the city should focus on helping people to get to their essential places such as health clinics, schools, and grocery stores and sought to help pedestrians in low-income areas move around safely.

**Economic Relief and Fiscal Impacts**

As unemployment has grown and small businesses face dire economic circumstances, relief programs have proliferated to help manage the economic fallout from COVID-19. Some projections estimate that 54% of small businesses employing 47.8 million people are at risk of near-term closure. While job growth has made some modest gains over the summer and fall, the recovery from the precipitous declines of April 2020 is far from over. Many cities have reacted to help support families and individuals experiencing financial duress during the pandemic and have implemented programs such as rental assistance, moratorium evictions, utility assistance and
relief, utility shut-off protection, providing free laptops to students, providing internet access to students and families, cash grants for low-income families, upskilling/reskilling for the unemployed, expanding available shelter space, and food assistance programs. The financial viability of businesses continues to be an area of significant concern as well and cities, in addition to federal and state aid, have implemented many different programs to support them. In addition to direct financial support through grants, loans, and payroll protection programs that many cities have implemented, entities have moved to provide other forms of assistance. Seattle designed an interactive map to help communities see what restaurants they have access to in their neighborhoods and what delivery/pick-up options were available to residents in order to support the restaurant ecosystem. Planning professionals have recommended that cities should also engage with the business communities to assess their needs, find ways to promote local businesses and small manufacturers, provide flexibility on zoning, and offer technical assistance to businesses attempting to secure financing, perform cash flow assessments, and create emergency business plans. Additionally, the cultural and creative economies of cities are also at risk, and cities may need to support these environments as well. In Denver and San Francisco rent support has been provided to artists and art organizations to help them weather this difficult time.

Unfortunately, efforts to provide economic relief and to invest in urban resiliency are made more difficult by the financial situations in which many cities now find themselves as they face declining revenues from the current economic situation. In the near-term, cities should expect declines in sales tax revenues of approximately 13% in 2020, particularly due to the drop in spending at hotels, airports, and on fuel. Property tax revenues, which are less sensitive to cyclical changes, will lag with anticipated decreases 18-24 months after the current recession, and several factors such as near-term business closures, reductions in demand for office spaces, and the impact of eviction moratoriums on multifamily housing values may introduce additional uncertainty regarding the impact on property tax revenues.

Additionally, cities that have relatively larger shares of employment in high-risk industries such as retail trade, mining/oil & gas, transportation, employment services, travel arrangements, and leisure and hospitality may face greater financial pressures due to job loss and declining income tax revenues. However, unemployment insurance may offset some of these declines and offer a source of taxable income. Federal financial assistance, primarily through the CARES Act, has helped cover funding gaps for 2020 and the Federal Reserve has created emergency liquidity facilities to help cities and transit systems obtain emergency cash, although the latter have been used infrequently and the program has not been renewed for 2021. The majority of county-level governments have sought to cut budgets by reducing or delaying capital expenditures, cutting services, eliminating vacant position, and implementing hiring freezes, salary freezes, furloughs, and layoffs. At the same time, local governments will need to increase expenditures on public health services and economic relief programs while also remaining cognizant of the lessons gleaned from the Great Recession, which demonstrated the detrimental impacts that local government spending cutbacks had on economic recovery. Overall, counties can expect reduced revenues over the next several years, with some estimates placing the anticipated impact to county budgets to be $202 billion for FY 2021, ($30 billion from additional spending, $114 billion in lost revenue, and $58 billion in reduced funding from state governments), with real consequences on GDP and in employment. The fiscal situation in cities across the United States will be a delicate balancing act over the next several years as local governments seek to account for these countervailing financial considerations and may constrain to some degree the ability of governments to invest in resiliency and preparedness measures.
Conclusion

The COVID-19 pandemic has forced individuals, businesses, and institutions at all levels to adapt and modify their daily lives and affairs. While some may contend that a post-pandemic world will return to ‘normal’; there are many factors that are increasing the likelihood of future disruption, either from disease outbreaks or other causes, and there have been massive adaptive investments and prolonged changes in behavior that make any reversion to business as usual unlikely. In this changed world, it is necessary to take inventory of the ways in which we have responded and what measures can be implemented to alleviate the disruption from this and any future disease outbreaks or crises in order to build more resilient communities that can benefit all residents. Additionally, evaluating the ways in which the pandemic has changed our expectations and concerns about urban life will be necessary to prepare for the challenging issues with which cities must contend in a post-COVID world. In the coming years these innovations, interventions, and changes will undergo further evaluation as the world arrives at a better understanding of how best to prepare ourselves for future outbreaks. However, there are numerous considerations that should take increasing precedence in future discussions on land use, infrastructure, architecture, planning, and urban design. While this paper has discussed a wide range of changes and proposals, the following points represent highly apposite considerations that cities will need to address within this new environment:

1. Rebuilding for Resiliency

Rebuilding our cities in a post-crisis environment will require a focus on improving their resiliency and addressing some of the most pre-eminent concerns such as improving safety and equity. Practices for reducing transmission risk have been at the forefront of discussions about how the pandemic has altered, and will continue to alter, the design of cities and the built environment, and more permanent changes to improve safety and monitoring for infectious disease. Proposals have included soft design changes, improved ventilation, health-oriented building standards, smart city solutions for managing risk, and monitoring for infectious disease through wastewater. Additionally, circumstances have changed in real estate demand, resident behaviors, transportation preferences, expectations for public spaces, and in many other areas. Post-pandemic discussions should focus on how cities can change to accommodate these new developments. Finally, the pandemic has laid bare the human cost of racial inequity and it should be a primary consideration as cities recover and rebuild.

2. Flexibility:

The pandemic has shown the need for increasing flexibility when addressing transmission risk and redeploying resources in the face of rapidly changing circumstances. Cities have quickly moved to make temporary changes to physical spaces in order to comport with the new requirements of social distancing and indoor transmission risks, and may find cause to make more permanent changes that allow for the interoperability
of the built environment. Increased zoning and land use flexibility have been necessary to help businesses adapt to new requirements, and their importance in a post-pandemic environment will be paramount when cities reckon with redevelopment and reuse in the face of potential vacancies and changing demands.

3. Density at Risk:

Despite initial criticisms of density and its role in transmission risk, cities have shown that they are often best equipped to deal with the necessary public health response and economic fallout from the pandemic. However, cities face a multitude of new obstacles stemming from the many ways in which the pandemic has changed the behaviors and preferences of their inhabitants. As residents seek more spacious and affordable accommodations outside of cities, businesses re-evaluate their office footprints, and consumers rely increasingly on e-commerce, cities will face the challenge of re-iterating their importance as engines of economic growth and bastions of innovation. Additionally, cities will need to find ways to support their vibrant businesses and cultural institutions as they face economic threats in order to maintain their value as centers of culture and entertainment. Finally, cities will need to demonstrate that they have taken steps to ensure that they are places where it is safe to live and do business.

4. The Digital Environment:

Businesses have invested massively in digitization. Consumers have come to rely on e-commerce and many employers and employees have found benefit in remote work models. Cities will have to rethink land use to better support supply chain needs in the face of growing demand for delivery services and contemplate how these changes will influence the demand for physical space. Additionally, finding ways to continue digital infrastructure investment, both in the private sector and in government services, will be central to maintaining competitiveness in a world where digital services and bandwidth are in high demand. Demand for smart city solutions to address the growing complexity of city operations will also continue to proliferate, albeit in a likely constrained fiscal environment that necessitates the requirement for solid business cases to support their implementation.

Cities face a difficult task: rebuilding for new concerns and new demands in a changed world. They will need to revisit the way they do business, adapt new technologies, and do so nimbly while facing difficult constraints. However, the disruptive nature of COVID-19 has brought opportunities to revisit the way we plan and design our cities, to encourage advantageous behaviors, and make cities safer, more comfortable places to live. While certainly challenging, cities are no strangers to challenges, and they have long managed to invent, innovate, and adapt to new circumstances and novel threats. Throughout history, diseases have come and gone, and in their aftermath cities have always remained standing.
Endnotes:


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