Article

How Might the COVID-19 Pandemic Affect 21st Century Urban Design, Planning, and Development?

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Abstract: As the COVID-19 pandemic continues to transform lives and ways of living across the globe, it is becoming increasingly clear that adaptations involving both physical and institutional infrastructure are warranted. Cities are at the forefront of these adaptive changes as dense urban environments are particularly vulnerable to the spread of contagious airborne diseases such as the novel coronavirus. This paper considers how COVID-19 might influence where and how people live, work, recreate, and move about the city, and how these changing patterns might in turn shape future development trajectories. We also discuss how cities are currently responding to the public health threat posed by COVID-19, and how they might use planning and design strategies to improve resilience in the face of future pandemics.

1. Introduction

From the devastating cholera outbreaks in mid-19th century London to the infamous "Typhoid Mary" epidemic just over a century ago in New York City, diseases have had a significant impact on modern urban planning, design, and development. At least within the last two hundred years, our responses to the outbreak of such diseases have largely resulted in healthier, safer urban environments. The construction of modern sewer systems, water treatment facilities, hospitals, and clinics, and the establishment of zoning codes, health boards, and a plethora of regulations designed to improve sanitation and limit the spread of disease have contributed profoundly to public health. Yet, COVID-19 has demonstrated that cities (and indeed suburbs and rural communities as well) are still very much vulnerable to airborne contagious diseases. How might this most recent pandemic shape the way we build our homes, communities, and cities over the coming years and decades? To what extent can we "build and manage our way out of infectious diseases" [1], and can dense cities be healthy cities, even during a pandemic? In this paper, we attempt to address these questions, while also identifying key areas for future research. We also highlight global cities on the forefront of COVID-19 mitigation strategies to stem the spread of the disease. Table 1 depicts the major cities and notable mitigation strategies they have implemented.

Table 1. COVID-19 mitigation strategies.

City	Notable Mitigation Strategies
Auckland, New Zealand	•Business closings and lockdowns as part of central government strategy. [1]
Berlin, Germany	•Subsidized bike sharing program.
Chicago, USA	•Enhanced sanitation of public transportation vehicles (electrostatic sprayers, increased cleanings, ridership demand app).
Guangzhou, China	•Passenger temperature check screenings and thermal imaging. •Outdoor socially distanced queuing for public transit. •Contact tracing. •Lockdowns as part of central government strategy.
Houston, USA	•Slow Street program.
Jakarta, Indonesia	•Deployment of low-cost water containers and soap dispensers.
Kigali, Rwanda	•Sinks and handwashing stations at public locations.
Melbourne, Australia	•Permitting of restaurant seating expansion into laneways and sidewalks to de-densify patrons.
Milan, Italy	•Conversion of some streets into bicycle and pedestrian paths.
New York City, USA	•Enhanced sanitation of public transportation vehicles (electrostatic sprayers, research into antimicrobial materials and cleaning strategies).
Oakland, USA	•Repurposing/closing streets into recreational areas (Slow Street program). •Making streets more pedestrian friendly (Slow Streets: Essential Places program).
Oslo, Norway	•Closing of schools and businesses as part of central government strategy. [2] •Restrictions on indoor recreation activities.
San Francisco, USA	•Slow Street program. •Shared Spaces program.
Seattle, USA	•Stay Healthy Streets program.
Seoul, South Korea	•Advanced contact tracing, surveillance, and notification system. [3] •Mobilization of rapid testing kit production as part of strategic plans of national strategy. •Strict patient isolation as part of national strategy.
Shenzhen, China	•Mobility restrictions. [4] •Contact tracing and isolation.
Tokyo, Japan	•Increased teleworking. •Staggered work hours.
Vienna, Austria	•Lockdowns as part of central government strategy. [5] •Building of temporary hospital facilities.

[1] [2]; [2] [3]; [3] [4]; [4] [5]; [5] [6].

2. The Home

One of the most profound and decisive questions that needs to be addressed is how COVID-19 will impact where people live. Over the last two to three decades, there has been a clear shift in support and demand for more dense urban environments in the U.S. and elsewhere [7–9]. While suburbanization has not subsided on the outskirts of most U.S. cities, there has nonetheless been a rise in population, as well as an increase in investment within older, more walkable neighborhoods and urban centers [10,11]. The desire to live and work in close proximity to urban amenities such as shopping, entertainment, and transit is often reflected in residential and commercial land values [12,13].

Given the impetus to social distance and the risk posed by contagious diseases, particularly among vulnerable groups such as those who are older or immunocompromised, COVID-19 may very well have a significant and lasting impact on the "back to the city" movement seen in many cities of the Global North over the last few decades [14–17]. For older adults that are retired or can work remotely,

the threat of disease could outweigh perceived benefits of urban life and lifestyles (e.g., socialization, access to healthcare). Even prior to the pandemic, an examination of U.S. American Community Survey (ACS) census data from 2008 to 2016 reveal that older adults, particularly those in the 55–74 age range, are preferring suburban, exurban, and rural areas to inner-suburban or central urban neighborhoods (Figure 1). This trend is likely to accelerate in the post-COVID-19 era. Less predictable at this stage is the probable impact of COVID-19 on the residential decisions of younger age groups. Those in the younger, 18 to 34 age range appear to be just as likely to choose the inner city as the outer suburbs, though this may change. Recent reports out of England indicate an increase in demand for suburban and rural housing with more home office and personal space [18,19]. Going forward, research should focus on changing residential preferences, most notably changing perceptions of urban neighborhoods and housing as suitable living environments, as well as actual demographic shifts.
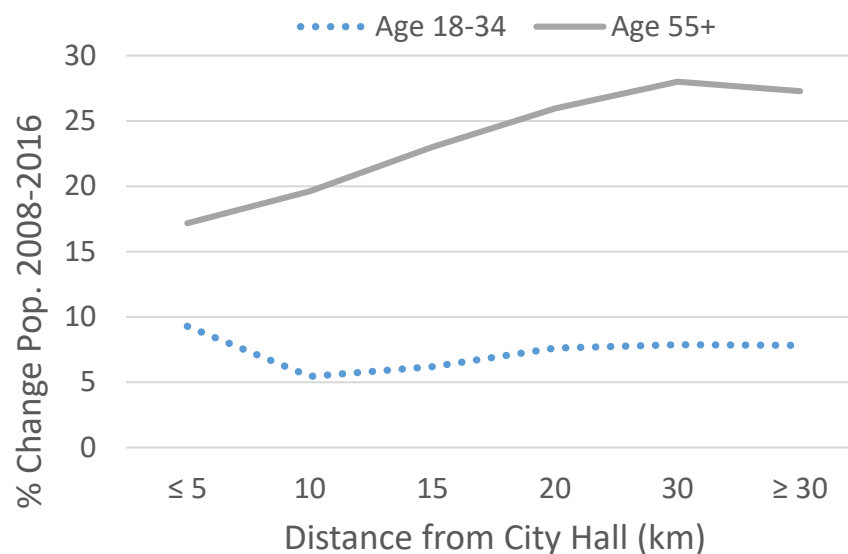

Figure 1. Percent change in younger and older adult populations in the U.S. between 2008 and 2016 by distance from city hall. Source: authors' analysis of U.S. Census American Community Survey (ACS) data.

While many are willing to forgo lawns, gardens, and private patio space when urban amenities are both open and accessible without significant personal health risk [20,21], they may not be otherwise [22]. Cognizant of these deficiencies and the evolving demands of residents, developers and architects are likely to implement building designs that prioritize private outdoor living space [23,24]. Though often a crucial selling point before the pandemic, the size and quality of private balconies and terraces may take on renewed importance in the COVID-19-era, even at the expense of interior living space. In addition to simply providing access to the immediate outdoors, balconies—particularly those associated with moderate-density developments (perhaps three to six stories)—offer an outlet for casual socialization at a distance. As Zacka [25] explained in a recent New York Times article, "the balcony is [ideally] close enough to the street to greet someone down below, but just too far to hold a prolonged conversation; close enough to witness a dispute, far enough not to have to get personally involved. It offers company without the demands of intimacy." More crucially for those who live alone, however, balconies may offer one of the few opportunities to alleviate the isolation often imposed by strict quarantines [24]. Other building- and site-level design elements such as windows that open, re-engineered ventilation systems (from building-wide to unit-specific, for example), wider staircases, and partitioned common areas may become more prevalent due to concerns over indoor air quality and social distancing [26]. Green spaces integrated into buildings including rooftop and vertical gardens can also make urban living spaces more attractive as well as possibly help meet physiological and psychological needs.

Access to greenery as well as daylight has been shown to reduce stress and improve health outcomes [27]. "Biophilic architecture" or "biophilic design" can have many other benefits as well such as providing habitat for flora and fauna, reducing energy consumption, and removing pollution from the air and water [27–29]. Crucially, biophilic design can also be integrated into neighborhood, and even city-scale, plans to best utilize and support local green spaces and amenities [30].

3. Public Green Space and Corridors

The importance of public outdoor recreational space, including parks, riverfronts, and greenways, has become particularly evident during the COVID-19 pandemic. Quarantined in their homes for extended periods, city dwellers have flocked to public green spaces as soon as restrictions have lifted, balancing the risk of infection with the physical and mental health benefits these spaces are expected to confer. In cities around the world, greenways and bike paths have recently experienced a surge in use, serving as crucial outlets for millions experiencing pandemic-induced "cabin fever" [3,31,32].

There is perhaps opportunity here too for planners to re-consider the importance of these public spaces. Acting essentially as "public backyards", well-connected parks and green spaces that allow for proper social distancing are particularly crucial. Wide and well-maintained bike and walking/running paths, if well executed, can encourage active transportation (i.e., commuting to work and other destinations on foot or bike) as well as support recreational physical activity. Many cities in the U.S. lack utilitarian (rather than purely recreational) pedestrian infrastructure, particularly bike lanes and functional greenways that connect residences to employment centers, shopping, and other daily destinations [33]. Cities that already have an abundance of green spaces and corridors spread throughout the urban fabric are likely at an advantage amid the current need to social distance and may serve as examples for other cities. In Oslo, Norway, for example, the city's generous 60 m^2 of green space per inhabitant experienced a swell in use during the COVID-19 lockdown, with the highest increase observed in greener (i.e., higher tree and vegetation coverage) and more remote areas [3]. Indeed, despite their relatively high population densities, many cities in Europe (e.g., Freiberg, Germany; Vienna, Austria; Valencia, Spain; Nantes, France) contain a large number and wide variety of green spaces, such that there is about 18 m^2 of public green space per urban resident in Europe, twice the amount recommended by the World Health Organization [34]. Increasing not just the amount but also the accessibility of green spaces would likely help more residents connect with nature on a frequent basis, potentially resulting in psychological and physiological benefits [27,35].

Some cities have repurposed public space for recreational purposes. Early in the pandemic, the city of Oakland began temporarily closing some streets to through traffic to promote physically distanced pedestrian and cycling activity during the shelter-in-place orders [36]. Known as the Oakland Slow Street program, the temporary plan designates up to 74 miles, or 10% of the city's streets to be closed to through traffic [37,38]. As of 10 July 2020, approximately 21 miles of streets had been established as slow streets with signage and cone barriers alerting drivers of the closures. Streets remain open to emergency vehicles and residents living along the closed routes [37]. To help promote pedestrian safety, the city of Oakland also instituted the Slow Streets: Essential Places program. Improved lighting and signage, repainted crosswalks, and the addition of cone medians at dangerous pedestrian intersections close to essential services are some of the highlights of the program [39,40].

Whether or not these changes are simply temporary modifications during the pandemic or are likely to persist long-term is yet uncertain. City leaders of Oakland are surveying residents regarding their programs' utility, and other cities, including San Francisco [41], Houston [42], and Providence [43], have instituted their own slow street pilot programs. The increased use of these corridors during the pandemic is likely to highlight their utility even under "normal" conditions. As part of the "Stay Healthy Streets" effort in Seattle, for example, 20 miles of roadway throughout the city have been permanently closed to through-traffic, providing additional space for cyclists and pedestrians [44]. In addition to active transportation, these streets are expected to be used by local residents for a variety of socially distanced activities, taking pressure off local parks. Data on the use of these newly

pedestrianized spaces should be tracked and analyzed over time to determine how best to manage and appropriate them. Surveys and interviews with residents could also help pinpoint concerns and opportunities moving forward.

4. The Urban Streetscape

Nearly 60 years ago, the celebrated urban theorist and activist Jane Jacobs [14] made an eloquent and convincing case that much of the vibrancy and vitality of urban life centered around diversity at the level of sidewalks and blocks. She observed that a fine-grained mix of mutually supportive businesses, public spaces, and civil buildings (particularly those offering cultural and entertainment amenities), in combination with well-designed and well-maintained sidewalks and streets, would support pedestrian activity at all times of the day, ensuring a bustling social scene with plenty of "eyes on the street" to thwart crime and other nefarious activity. Most importantly, perhaps, without a robust street life a city tends to lose much of its vibrancy and vitality; one of cornerstones of urban life and, to many, an attractive amenity in its own right.

Small businesses often play a critical role in establishing and maintaining a vibrant street life. Cafes, restaurants, and even clothing stores, often spill out onto the sidewalk, allowing people to casually mingle and observe the "ballet" or rhythm of everyday life. The closing of these businesses has multiple effects at a variety of scales, not only leading to mass unemployment (as we have already seen in the U.S. during the first few months of the COVID-19 outbreak), but the creation of "dead zones" within urban neighborhoods where pedestrian activity slows to a trickle. As of August 2020, however, many small businesses have re-opened—some, no doubt, out of absolute necessity—while taking pre-cautions such as requiring customers to wear face masks and spacing tables and chairs as to meet social distancing guidelines (i.e., typically keeping unaffiliated individuals and groups at least 6 feet or 2 m apart) [45].

In the near term, businesses will continue to come up with creative ways to try to keep patrons and employees safe while also generating enough revenue to stay afloat (a delicate balance!). A street café in Paris, for example, received some media attention for placing human-sized teddy bears in about half of the available chairs, thus keeping actual humans spaced apart. For some businesses (particularly restaurants), however, filling only perhaps half of the available seats may not be a viable long-term solution. Customers may also be less willing to go out to the local street café or corner pub if they are unable to casually socialize with other patrons. Many restaurants and their patrons are currently relying on take-out ordering, facilitated by a rise in on-demand food delivery services accessible via smartphone applications such as Uber Eats and Door Dash [46]. Although these "delivery apps" have served as a lifeline for many small businesses (and those customers that rely on them), there is concern that a concomitant rise in "virtual kitchens" or "dark kitchens" may replace or out-compete regular brick-and-mortar establishments [47,48]. Often constructed out of low-cost pre-fabricated materials such as shipping containers and operating discretely in underutilized locations such as parking lots, virtual kitchens are restaurants that prepare food solely for delivery. Of course, the threat to brick-and-mortar establishments extends well beyond the restaurant industry, with online retail giants such as Amazon.com reporting record sales in 2020 [49], while many small businesses relying on in-person sales are struggling to survive [50]. The further consolidation of eBusiness, and retail business in general, therefore, appears likely, with potentially significant consequences for the viability and vitality of the urban commercial landscape.

An effective and widely adopted vaccine is likely the only means by which Jacob's street ballet may be restored to any significant degree in many locations. Yet, the threat of the next pandemic (a question of when, not if) behooves us to consider a more resilient streetscape design that is intimate and inviting, while also capable of supporting social distancing when needed. One of the potential solutions, quite simply enough, is providing more outdoor sidewalk space for pedestrians and customers. More pedestrian space would allow businesses to spread out; some would be able to provide outdoor seating or market venues for the first time, while others would be able to further separate outdoor

activities, improving the capacity for social distancing. In addition to the hard infrastructure approach of widening the sidewalk, space could be shifted on a more ephemeral basis away from parking spaces and lots to pedestrian zones in the form of "parklets" (Figure 2). Parklets are former parking spaces that have been converted into miniature public spaces, often adjacent to the sidewalk [51]. They are frequently adorned with planters and seating areas that often function as aesthetic elements as well as protective barriers. While these spaces are technically public, they are often constructed in partnership with local businesses who help fund and maintain the parklet in exchange for enhancing and expanding their outdoor commercial space.
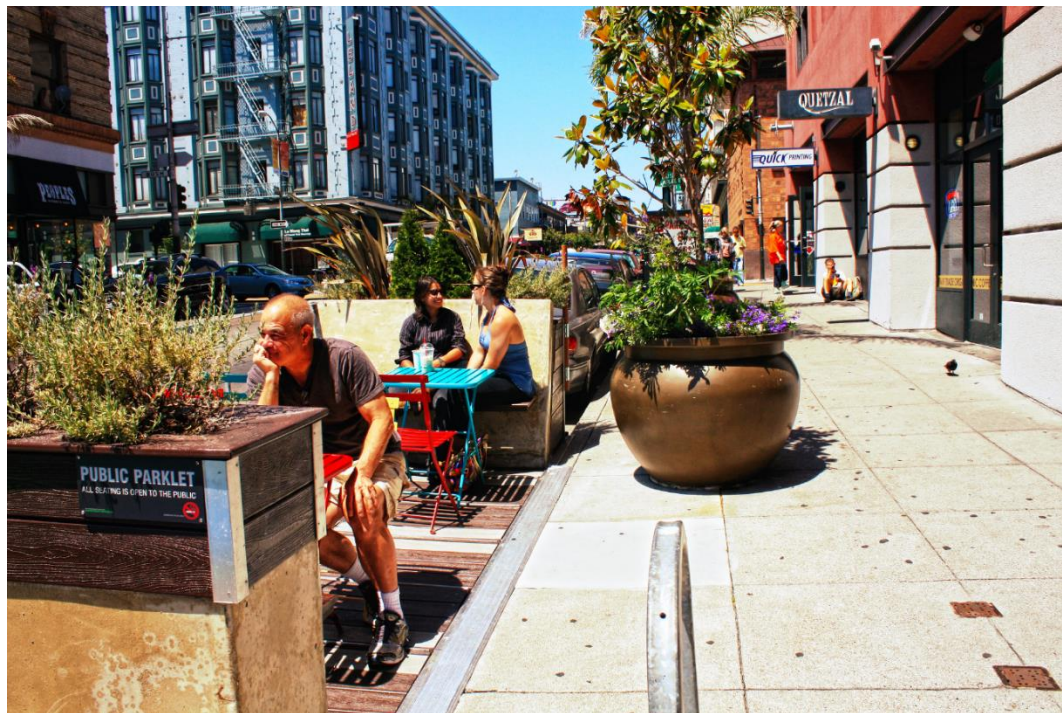

Figure 2. A "parklet" on Polk Street in San Francisco, CA, USA. Photo by sfplanning (Flickr), licensed under CC BY-NC-SA 2.0.

San Francisco is currently a leading hotspot of parklet activity in the U.S., with over 50 permanent, and several more temporary, parklets scattered throughout the city [52]. During the COVID-19 pandemic, these spaces have proven an important component of San Francisco's "Shared Spaces Program", in which businesses can apply for a temporary permit (with an expedited two-day review process) allowing them to use adjacent sidewalk or parking lane space for "business operations, like seating, dining, or retail pickup" [36,53]. Melbourne, Australia recently instituted a similar permitting system allowing restaurants to expand onto footpaths, on-street parking areas, and adjacent laneways if possible [54]. Melbourne is particularly well-poised to take advantage of outdoor seating given the conversion of dozens of underutilized alleyways or laneways over the past three decades into pedestrian-only zones fronted with a variety of shops, apartments, and restaurants [55]. Parklets, laneways, and other reclaimed pedestrian spaces, while providing greater flexibility during a pandemic, may also have the benefit of improving the social, economic, and aesthetic conditions of the streetscape during "normal" conditions. It is crucial, however, that these spaces are designed and executed such that they are safe and accessible for everyone, including those with sensory or mobility constraints [56].

Admittedly, the efficacy of enhancing outdoor social and retail space depends to some degree on the local climate. In cities with prolonged, severe winter seasons, for example, the ability to replace or augment indoor activities using outdoor venues will be limited. There is widespread concern among business owners in cities with cold-winter climates that they will not be able to remain profitable

during the 2020–2021 winter season [57,58]. Some owners have considered installing outdoor heaters and tarps (including stand-alone "dining pods") to provide shelter from the elements, though these measures are likely to be more effective in more moderate climates [59]. Developing the mindset to enjoy time outdoors even in winter, and dressing appropriately for freezing temperatures—a concept known as "friluftsliv" in Norway—offers a behavior-based approach that can potentially augment the benefits of outdoor heaters and wind breaks [60].

5. Transportation

With a highly contagious airborne disease such as COVID-19, the density of human bodies within enclosed, confined spaces becomes a—if not the—primary public health concern. This can make public transit rather problematic, as the physical and economic efficiency of trains and buses lies in their ability to move many people together at once, often in close physical proximity. Not surprisingly, many cities around the world have experienced a sharp decline in transit ridership since the beginning of the pandemic. Transit ridership in New York City, for example, fell precipitously during the height of the pandemic, falling by as much as 92% relative to 2019 [61]. Despite a rapid and sustained decline in new COVID-19 cases within the city, New York transit systems remain well below capacity (−75% as of August 2020 relative to 2019) (Figure 3). Significant reductions in public transit ridership have been observed elsewhere including Columbia [62], Seoul, South Korea [63], and A Coruña, Spain [64]. Unemployment, though on the rebound, remains high and is likely responsible for much of the decrease in demand. Preliminary surveys indicate significant concern about transit sharing, including car-pooling and ride-sharing services such as Uber and Lyft, amid the COVID pandemic [65]. Fear of contracting the coronavirus is thus another factor keeping people away from public transit [66,67], though more data and time are needed to accurately gauge the extent and impact of these concerns.
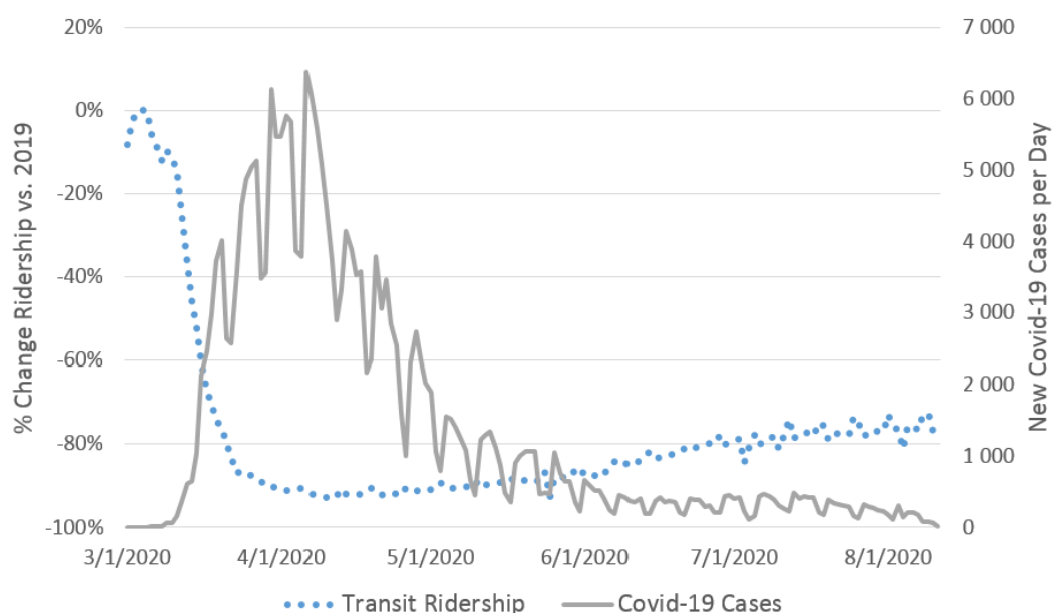

Figure 3. Percent change in ridership on the New York City subway system compared with 2019 versus daily new COVID-19 cases from 1 March to 11 August 2020. Data source: New York Metropolitan Transit Authority (MTA).

At least in the short-term, cities are faced with the task of frequent sanitizing of their public transportation vehicles and stops and have developed innovative measures for deep cleaning. Even if private automobile use increases in the near future due to the pandemic, public transportation is nearly an inelastic good for a large portion of the urban population—especially for the poor that cannot

afford their own private transportation [68]. Urbanites in large cities, across all incomes, are attracted to public transportation for mobility convenience in cities notorious for traffic congestion and high parking fees. New sanitation measures may simply be a short-term phenomenon due to the pandemic, but long-term sanitation practices could become the norm as people become more aware of just how many people use seats, handles, turnstiles, and fare card machines.

Several cities are taking the lead in cleaning methods and service changes to help stop the spread of the coronavirus. The Chicago Transit Authority (CTA) purchased innovative electrostatic sprayers that apply disinfectant to all surfaces of buses and rail cars. Worn like backpacks, these electrostatic sprayers allow workers to deep clean 300 of these vehicles every night [69]. During times of service operation, workers routinely clean commonly touched areas of the vehicles by hand. In what appears to be a move towards long-term bacterial and viral sanitation resilience, CTA is also researching the use of germ-resistant materials for commonly used/touched items in buses and railcars [70]. The CTA also uses smart technology to provide riders with information on peak travel times and transit crowding. It launched a ridership dashboard depicting times of peak demand by route based upon existing ridership data [70]. New York's Metropolitan Transit Authority (MTA) has taken similar steps as Chicago's CTA with the use of electrostatic sprayers and research into antimicrobial materials and coatings for interior surfaces [71]. Additionally, the MTA is researching the effectiveness of UV light and new air filters to kill bacteria and viruses. Other cities such as Boston placed hand sanitizing stations in high traffic areas of the public transportation system [72].

In Guangzhou, China, health officials took the extra step of screening subway passengers at entrances using infrared thermometers to check for elevated body temperatures and ensure compliance with mask wearing requirements [73]. Passengers were required to queue outside the entryway in open air and with sufficient room for social distancing. Since the initial outbreak, several thermal imaging cameras have been installed at congested entry points to reduce wait times. If a passenger is found to have a fever they are escorted to an isolation area where contact tracing is initiated if needed and any surfaces the passenger was in contact with are disinfected. Guangzhou also increased train service during peak times, adding express trains where needed, to reduce congestion and support social distancing [73]. In many Japanese cities, staggering work hours during the initial outbreak also helped reduce congestion in some of the busiest rapid transit systems in the world [74].

What remains unclear is the permanency of these sanitation and safety protocols. Sanitation stations and daily deep cleaning of public transit vehicles were not the norm prior to COVID-19 and may just be temporary stop-gap measures. The purchase of electrostatic sprayers and city officials researching and investigating the efficacy of antimicrobial materials, air filters, and UV lighting suggests some thought to the future. These measures could become permanent pending cities' willingness and/or ability to budget for these items in the long-term. As the pandemic progresses and hopefully slows, researchers should monitor cities' actions for long-term sanitation practices. Certainly, the measures described could be useful not only in the event of a new pandemic but could aid in limiting exposure and transmission of seasonal influenza. This includes the practice of staggering work hours and adding transit capacity during peak times to reduce crowding, particularly on subway trains and platforms. The political, cultural, and budgetary landscapes of cities may dictate adoption of these public health measures, and we are likely to see much variation in such adoptions.

Similar sanitation issues emerge with popular bike sharing and e-scooter programs. New York City's bike sharing program, Citi Bike, had a surge in use during the early phase of the pandemic. Officials in Berlin subsidized bike sharing user fees, making the bicycles free of charge [75]. Often viewed as relatively affordable transportation options for mobility-restricted individuals, cities worldwide have been increasingly adopting and promoting bike sharing and e-scooter programs and partnerships. Bicycles and e-scooters also offer a form of socially distanced transportation, potentially safer than buses, subways, and automobile ride-sharing. We may see cities attempt to promote these options in the future. However, for these programs to be successful during pandemics, potential users must feel confident in their cleanliness. Extremely popular in Austin, Texas, dockless e-scooter ridership dropped

precipitously in March 2020 compared to March 2019 [76]. Omaha, Nebraska's city council initially balked at starting an e-scooter pilot program in part due to concerns about viral transmissions on e-scooters [77] but reconsidered the program once sanitation questions were clarified [78]. Fiscal commitment to cleanliness of these programs is predicted to be an important aspect that cities must take into consideration if these forms of micro-mobility are to be viable forms of transportation during pandemics [79].

During the COVID-19 pandemic, tens of millions of workers are forgoing the commute altogether and working from home [80–82], further reducing transit demand and ridership. It is unlikely that all those workers who are now working most if not all remotely from home will return to the office full time post-pandemic. Yet many will, at least in the short term. The question then is whether transit demand will continue to lag, and, conversely, will there be a renewed interest in private transportation, particularly among those with the physical and economic capacities to purchase, store, and maintain their own vehicle? Among lower income groups, particularly those living in developing countries and dense urban centers, this option will remain unrealistic. However, for wealthier communities and those with more moderate densities where travel by transit is more choice than necessity, support for public transit systems—particularly light rail and streetcar lines—might begin to wane. Cities that prior to the pandemic were planning to initiate or expand rail lines may elect to curtail or reduce those plans. In addition to slumping demand for transit, cities will also be facing constrained budgets, limiting their financial capacity to invest in both new and existing transit systems. The consequences may be far reaching, with densification/infill efforts tied to the success of transit systems and vice versa [83,84].

While the private automobile may be the clear choice for some wishing to limit their exposure to COVID-19 and other contagious diseases, it is important to consider the many environmental, social, and economic costs of auto-dependency [85]. In fact, one of the most widely cited benefits of the many lockdowns that went into effect during the first half of 2020 was a dramatic reduction in air pollution due to less automotive traffic [86]. In China, where air pollution is normally quite severe and the COVID-19 lockdowns were heavily enforced, it is estimated that the reduction in air pollution may have saved more lives than were lost due to the virus [87]. While this is not likely the case everywhere [88], the public health benefits of reduced automotive use are no less evident.

Thankfully, walking and cycling constitute two excellent alternatives to automotive transportation that are particularly well suited to urban spaces and can often accommodate sufficient social distancing. Similar to the "Stay Healthy Streets" campaign in Seattle, several cities around the world are expanding (or planning to expand) corridors devoted to cyclists and pedestrians, often at the expense of automotive space [76,89–91]. While in Seattle these changes are expected to be permanent, it is unclear whether such measures to increase pedestrianized space are politically and logistically sustainable long-term. Closing streets altogether, however, is just one of multiple strategies cities can employ to encourage residents to leave their car at home. The expansion of walking and cycling routes, construction of dedicated bike lanes (which can contribute significantly to both perceived and actual safety for cyclists [92,93]), and the use of street calming or road-dieting tactics can help facilitate and encourage active transportation. The latter strategy involves slowing or otherwise impeding the flow of automotive traffic to make it safer and easier for pedestrians and cyclists, while at the same time often making driving less appealing [94–96]. More holistically, the "complete streets" movement seeks to accommodate all types of transportation safely and equitably [97]. Prioritizing a more inclusive, multi-modal model of transportation is likely to serve cities well, providing built-in resilience during public health crises and other emergencies. If cities are to be more adaptive to these forms of mobility long-term, sidewalk and bicycle lane additions must be addressed. For pedestrians, most cities struggle to have wide enough sidewalks to allow for socially distanced pedestrian activity [68,98]. Without adequately wide sidewalks and bike lanes, pedestrians will have to traipse into busy streets to remain socially distanced and cyclists will have to navigate traffic or encroach on sidewalks [65]. Even relatively dense, historical cities, such as those in Europe, could benefit from expanding and improving pedestrian infrastructure. In Milan, Italy, for example, 35 km of streets will be converted

into walking paths and cycling lanes to reduce automotive traffic and improve the city's air quality [99]. Similar plans have been made (if not instituted) in Berlin, Dublin, Budapest, and Rome [100].

6. Work

For decades now, academics and professionals have touted the power of modern telecommunications— particularly broadband internet and cellular service—to nullify distance, effectively allowing anyone to work on nearly anything from nearly anywhere [101–103]. The ability to communicate seamlessly, collaborate, and share large volumes of data over significant distances at the speed of light has indeed transformed the way we live and work in countless ways. Yet, until the advent of COVID-19, in many industries there has been substantial resistance to the spatial decoupling of work and workplace. The occurrence of COVID-19, just as online conferencing and collaboration platforms such as Zoom, Microsoft Teams, and Webex have reached maturity, may finally herald the "death of distance" [102], at least to an extent. A large proportion of workers, primarily of the Millennial and Z generations, have been particularly quick to adopt these platforms, having grown up using the internet and digital technology more broadly—the so-called "digital natives" [104]. Thus, 2020 may simply be the right time, socially and technologically, for a watershed moment in the geography of work.

If remote work becomes more widely accepted in the post-COVID era, the high cost of living—particularly that of housing—in many cities of the Global North are likely to push people to live and work remotely in cheaper suburbs, exurbs, or perhaps even in other metropolitan areas altogether [105–107]. When combined with concern about contracting contagious diseases such as COVID-19, flexible working conditions and the availability of more affordable housing outside the city may indeed result in a discernable exodus to less populated areas. Early evidence suggests that, in some markets, the pandemic may have already initiated a decline in demand for high-density neighborhoods [108,109].

In addition to catalyzing a general dispersion in population, the growth in remote work (along with a desire to keep work environments "de-densified") may reduce the need for commercial office space. Although the benefits of face-to-face communication and collaboration cannot yet be fully replicated at a distance, millions of employers and employees are discovering that a significant proportion of service-based tasks can be accomplished effectively with minimal in-person contact. This will not pertain to every job, task, or position, even within a standard office environment, but it may be extensive enough to have a transformative impact on commercial development in the coming decades. Just as corporations have trimmed the employee payroll to improve profit margins (with many positions likely lost forever to automation), they may do the same with underutilized office space.

What office space does remain may become increasingly horizontal. Located in either urban or suburban locations, horizontal skyscrapers, or "groundscrapers", are low-rise office buildings that nonetheless provide ample floor space [110]. The sprawling floor plans often offer companies the benefit of locating on a single floor, which may improve communication and collaboration. More relevant to the present discussion, however, "groundscrapers" often have more stairwells and are less reliant on elevators, thus improving the capacity for social distancing. Green space incorporated at ground level or on rooftop terraces can provide additional space for employees to spread out. The Vanke Center mixed-use building in Shenzhen, China is a prime example of the horizontal skyscraper design; it is as long as the Empire State Building is tall and floats above a manicured campus on several large columns [110] (Figure 4). Unfortunately, with a relatively large footprint and preference for suburban, "greenfield" locations, horizontal developments such as these tend to contribute to the many social, environmental, and economic costs of urban sprawl [111].

Figure 4. Vanke Center in Shenzhen, China, an example of a "groundscraper". Photo by trevor.patt (Flickr), licensed under CC BY-NC-SA 2.0.

Though it is far too early to tell just how significant these trends may be, the potential impact of large-scale commercial dispersion on urban centers could be considerable. Millions of businesses rely on the daily patronage of office workers, as well as residents and tourists drawn to the urban core to access employment and entertainment opportunities. Loss of customers due to a hollowing-out of urban commercial real estate in combination with restrictions and fears triggered by the COVID-19 pandemic, could, as mentioned earlier, be devastating to the diverse, fine-grained retail/service sphere that gives urban space much of its vitality [14,112]. This already appears to be happening in Manhattan, New York, where otherwise lucrative restaurants and retail stores are buckling under the pressure of exceptionally high rents and dramatically reduced foot traffic [113].

7. The End of New Urbanism?

Many of the themes we have discussed may call into question the future of cities and neighborhoods planned from a New Urbanist framework. Creating the 24-h city or neighborhood has been a hallmark of the New Urbanist paradigm of planning, with a focus on high density mixed-use planning, walkability, and transit-oriented urban development. With COVID-19 disproportionately affecting large, dense cities compared to rural and suburban communities, de-densification planning would not be surprising. High density, public transit oriented, mixed-use designs could be perceived as too risky if the pandemic sustains beyond a year and/or people begin to question the benefits and cleanliness of urban living in the event of a future pandemic. However, cities are generally resilient to the emergencies they have faced and usually respond to these challenges. A probable worst-case scenario might involve older populations and families with school-aged children leaving cities while the younger population remains [114]. This younger population tends to be driven to cities not only for professional opportunities, but for amenities such as bars, restaurants, sporting events, and cafés, along with diverse cultural experiences. The urban poor, constrained by lack of mobility options and less likely to be able to work from home, could also remain in cities. Cities could therefore become demographically younger, but still face the same inequalities in poorer neighborhoods. Such changes would be drastic and result in political, budgetary, educational, and planning challenges. On the other hand, Honey-Rosés et al. [79] suggest that perhaps the immediacy of the pandemic is resulting in scholars predicting drastic changes and that cities may in fact return to a state of previous normalcy, albeit with some modifications in planning and preparedness.

8. Scenario Planning, Resilience Strategies, and Their Integration into Public Health Planning

Having revealed weaknesses in urban health scenarios and pandemic planning, Honey-Rosés et al. [79] see the COVID-19 pandemic as an opportunity for the integration of public health more broadly into urban planning. Scenario planning will likely include the advent of urban public health and community resilience strategies. The rapid spread of COVID-19 in hotspots throughout the United States revealed the importance of access to hospitals, health centers, and other medical services. From a comparative perspective, South Korea appeared to adapt to the pandemic, while Italy and the United States struggled to address the spread. Kang et al. [19] note South Korea's experience with previous viral outbreaks and their resilience planning by having pandemic plans, health facilities, personal protective gear (PPE) stockpiles, and smart technology for contact tracing. Additionally, they argue that South Korea's community health centers played an integral role in COVID-19 screening and mitigation. How might cities become more prepared?

Many cities around the world, including those in wealthy countries such as the U.S., appeared ill-prepared for the COVID-19 pandemic. Of the fifteen largest cities in the U.S., only San Diego makes publicly available its pandemic plan, and many of these other cities' plans are unavailable and/or have not been recently updated [115]. County and municipal governments and departments have been instrumental in public health legislation and implementation such as mask mandates, school operations, public gathering sizes, and events planning in response to COVID-19 rates within their jurisdictions. Emergency and disaster planning in U.S. cities often appear to take on a reactionary or after-the-fact approach [115]. One need to look no further than to the changes in homeland security and emergency management after the 9–11 terrorist attacks and Hurricane Katrina, respectively. COVID-19 represents the largest health emergency in recent history for the U.S., especially for urban areas. Therefore, contingency planning and resilience strategies using new decision-making approaches based upon simulations and uncertainty models may become key tools for designing pandemic plans for a future outbreak. Transportation planners sometimes use simulations to engage in exploratory scenarios [116] and robust decision-making (RDM) planning [117] to model challenges to the urban transportation infrastructure. Similar approaches involving scenario planning, worst-case scenarios, and simulated urban health system stress-tests using data and computer simulations will likely become more important for urban health planning and for emergency managers developing pandemic plans and resilience strategies.

Resilience strategies could focus on short-term and long-term capacities to address pandemic scenarios. Studies in community resilience focus on the capacity of organizations and individuals [118] in a community "to respond, recover and accommodate external shocks and stresses" ([119], p. 217). One example could be the development of contingencies for the rapid construction of short-term medical facilities, along with the potential of long-term plans to promote the building of permanent community health clinics. The availability of modular construction materials for the building of immediate medical care facilities such as hospitals and intensive care units (ICUs) has been identified as a potential future need for pandemic planning [120]. Rapid construction, modification, and breakdown of modular facilities can help cities quarantine and triage patients suffering from pandemic diseases. As an example, several Chinese cities quickly erected temporary medical facilities for COVID-19 patients.

Growing interest in affordable telemedicine stations/kiosks to help slow the spread of disease [121] may provide a future picture of urban public health [119]. These stations/kiosks could also provide both short-term and long-term innovative approaches to public health, not only for pandemics, but general disease such as seasonal influenza. Telemedicine stations/kiosks allow patients to virtually interact with medical professionals and a patient's vital signs are taken with equipment in the station. The private company OnMed has developed these stations with thermal temperature checks and even stethoscopes that take patients' vitals [122]. While the focus of the COVID-19 crisis has centered on urban areas, public health facilities are often more accessible for urban residents compared to rural populations. Therefore, telemedicine stations/kiosks may be especially beneficial to rural populations with limited access to health facilities [122].

To help create and promote an "anti-virus" built environment, adaptive reuse of buildings and infrastructure could become an integral component of scenario planning. Arenas, stadiums, parking lots, and convention centers were all used for temporary and makeshift hospitals and ICUs [121,123]. Existing tstructures and infrastructure will need to be retrofitted, and new buildings and infrastructure may be designed from an emergency planning perspective, with the ability to quickly and efficiently convert these spaces into medical facilities and housing for patients. Highly contagious pandemic diseases such as COVID-19 reiterate the need for these facilities to offer proper social distancing and quarantining; thus, size requirements will be large. Community centers, school gymnasiums, and shelters will not suffice. Public–private partnerships (PPPs) between governments and private hotels in emergency planning could provide adequate housing facilities for treatment and quarantine.

While there are many factors that may influence COVID-19 transmission and mortality, early data suggest that minorities, lower-income households, and those that have limited access to healthcare may be especially susceptible to the coronavirus [124,125]. The identification of vulnerable populations, combined with frequently updated case information, can help effectively deploy medical facilities and other resources. In particular, the use of geographic information systems (GIS) to analyze and map a variety of epidemiological and demographic data has proven essential in tracking the spread of COVID-19, identifying likely future hotspots, and coordinating responses at both the local and national scale [126,127]. Dozens of global positioning system (GPS)-tracked smartphone applications, such as the state-run COVIDSafe "app" in Australia, are being used to track virus exposure and transmission as well as coordinate contact-tracing [128]. Already an indispensable tool for many public health and planning agencies, GIS, GPS, and other geospatial technologies, in coordination with artificial intelligence (AI) and "big data" analytics, will only become ever more integral to the decision-making process [129].

9. Cities of the Global South: Unique Challenges and Opportunities

Millions of urban residents in developing countries are particularly vulnerable to airborne contagions both at home and in public due to over-crowding, lack of infrastructure, and poor sanitary conditions [130,131]. While many of the actions and recommendations discussed above are also relevant for cities in developing countries, one of the primary challenges for impoverished households, many living in informal squatter settlements such as Dharavi in Mumbai or Kibera in Nairobi, is accessing basic services such as clean water and sanitary facilities without significant risk of COVID-19 exposure [130,132]. The risk of contracting and spreading the coronavirus is particularly acute in the poorest areas, where large numbers of residents must access a limited number of water distribution facilities and/or toilets [133]. Women, who are often tasked to collect water for the family and may rely more heavily on sanitary services and communal toilets, are particularly vulnerable [134]. Narrow streets, few green spaces, crowded markets, and congested apartment buildings make it exceptionally difficult to properly social distance [130]. Furthermore, many impoverished residents have no choice but to work in conditions that offer little or no protection from exposure and rely on public transportation that may be crowded and unsanitary. Yet, despite these challenges, many cities in developing countries, some with the help of outside organizations such as The World Bank and the World Health Organization (WHO), have taken steps to address and mitigate local impacts of the pandemic.

With relatively limited financial resources at their disposal, it is particularly crucial that cities of the Global South make use of the best data available to target locations and select effective strategies. Researchers at the World Bank, for example, identified hotspots of COVID-19 exposure and contagion risk using data on population density, floor area, and access to basic services [135]. When applied to 15 cities in developing countries, the model suggested several "containment zones", with a high degree of overlap with squatter districts. Identified priority areas could then be targeted by city leaders with the suggested goals of (1) improving the quality and accessibility of water, sanitation, hygiene, and nutrition (it is difficult to prevent the spread of COVID-19 if you cannot properly wash

your hands, cover your face, or nurture a robust immune response) and (2) improve awareness about basic hygiene and best practices for limiting the spread of the coronavirus both individually and collectively [130]. These efforts have already resulted in numerous actions including the deployment of additional low-cost water containers and soap dispensers in Jakarta, and the provision of portable sinks and handwashing stations at bus stops, restaurants, banks, and other retail locations in Rwanda's capital of Kigali. The formation of local emergency planning committees, generally one per informal settlement, could further help effectively distribute resources and pinpoint areas of the greatest need by leveraging knowledge of the local community [136].

In addition to improving sanitary services and health education, it is important to acknowledge the need to address the physical limitations and challenges imposed by the built environment. Though often difficult and expensive to make substantive changes to urban infrastructure, improvements to the built environment in service of public health could result in significant and long-lasting benefits to millions of city dwellers. Among the most pressing changes is the need to increase the capacity for social distancing at home, work, and in the public realm. Investing in potable water and sanitation infrastructure should be a top priority; an increase in indoor plumbing would reduce the need for communal taps and toilets, thereby reducing opportunities for virus transmission [130]. Here, again, the targeted use of resources is crucial. In Indonesia, for example, the national slum upgrading project (NSUP) has brought together a variety of national agencies, local governments, and communities to construct or upgrade water supply facilities, drainage networks, sanitation systems, footpaths, sidewalks, roads, and public green spaces in dozens of cities [137]. To reduce the spread of disease due to residential over-crowding, land use and property policy changes have been called for, most notably (1) the issuance of formal land titles to squatters with the hope that this improves tenure security and spurs investment in private property [138] and (2) the expansion of formal, state-subsidized affordable housing [139], which should allow more floor space per person and more effective social distancing [130].

10. Conclusions

Despite the proliferation of public health regulations and considerable advances in medical technologies over the past century, the COVID-19 pandemic has demonstrated that many nations and cities around the world were largely ill-prepared to confront this challenge. The pandemic has highlighted weaknesses in both our physical and institutional infrastructure that should be addressed prior to the next pandemic. For city managers, planners, and other local actors, the pandemic represents a rare opportunity to make cities more resilient and robust by elevating the importance of public health in a variety of land use, transportation, and public space design decisions. As discussed, we recommend that cities strongly consider prioritizing pedestrian infrastructure and spaces as to allow for proper social distancing in the event of a pandemic and to improve the capacity for active transportation in the long-term. Private developers should also be encouraged to implement design elements that prioritize indoor air quality and outdoor private space to make multi-unit housing both safer and more competitive with detached, single-family housing. This may be particularly crucial in the immediate post-pandemic period when anxieties about contracting the virus, coupled with greater workplace flexibility, may drive a new era of de-densification; a potential anti-new urbanism. The consequences of this demographic shift could be severe and long-lasting; future research should investigate the magnitude and consequences of such changes. Additional normative recommendations for cities to successfully combat the COVID-19 and/or future pandemics include:

- Planning, promoting, funding, constructing, and maintaining public green spaces and corridors near residences to allow individuals to exercise and maintain a healthy lifestyle during times of lockdowns and restricted mobility.
- Expansion of outdoor sidewalks/walk spaces near businesses and the easing of permitting processes during pandemics to allow businesses (especially restaurants) to use these spaces for de-densified business activities.

- Implementation of increased and innovative public transportation sanitation practices to not only mitigate the spread of pandemic diseases, but to also prevent more common viruses and bacteria such as the common cold, influenza, staphylococcus, etc.
- Designing municipal and intergovernmental strategic plans for future pandemics that focus on contact tracing, mitigation strategies, patient housing, resource allocation, information provision, and intergovernmental cooperation.

Encouragingly, many cities around the world have been pro-active about instituting new practices, regulations, and design changes to mitigate the spread of the coronavirus as well as reduce economic and social hardship. Closing streets to non-local traffic, improving greenways, and enacting new sanitation measures are all reasonable measures in pursuit of these goals. Yet, it is quite unclear whether these recent adaptions to the COVID-19 pandemic will become permanent, or, as Keenan [119] suggests, will resemble New Year's resolutions; ideas that initially have an ardent fervor, but eventually fade. It is also unknown at this early stage whether most cities will develop comprehensive plans to respond faster and more effectively to future outbreaks. This will require coordination across public agencies and private institutions to properly mobilize and deploy resources—particularly medical care, equipment, and contact tracing efforts—when and where they are needed. Follow-up studies are encouraged to summarize, document, and track the adoption of these best practices. Although COVID-19 has proven to be a considerable challenge for urban infrastructure, and indeed, an urban way of life, cities that are willing to adopt science-based best practices and regulations and plan in support of public health both now and in the future have the best chance to remain resilient and thrive in this global age.

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